



Climate Change and Heritage

A review of recent, current and planned research

JBA Consulting



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Foreword

Climate change is one of the most significant and fastest growing threats to people and their cultural heritage worldwide. Our historic environment is particularly vulnerable and Historic England's goal in commissioning this report is to map the landscape of current studies related to heritage and climate change. We wish to ensure that whatever new research we or others may commission is complementary to, and where possible takes account of recent and current research activity.

Our specific objectives in commissioning this research were to understand:

1. what research activity is on-going which directly relates to improving adaptation options;
2. what research activity is on-going which directly relates to threats and risks to heritage both from climate change itself and from our responses to climate change;
3. which public bodies, research institutions and charitable organisations across the UK are funding such work.

The findings of this research will inform our decision-making processes and help ensure that our research effort can be focussed where it will have most impact.

Barney Sloane
National Specialist Services Director
Historic England

Summary

Aims and Scope

This research report has been prepared by JBA Consulting on behalf of Historic England. To respond to Historic England's priority on Climate Action (no. 4) identified within their Corporate Plan (Historic England 2023), a research review of recent and current research into climate change and heritage was carried out. The scope of the research has focused on understanding the ongoing research that directly relates to improving adaptation options or relates to threats and risks to heritage from climate change and from our responses to climate change. Furthermore, an understanding of which organisations are funding this research was sought. The project aimed to identify gaps in the research landscape, novel approaches, and potential partner organisations for Historic England.

Six research areas were identified as being of particular interest:

1. Research developing models and assessing long-term impacts of climate change on heritage.
2. Research on the impact on heritage of flooding and coastal erosion and our responses to these.
3. Research on climate change and its potential impact on intangible heritage.
4. Research to inform best practice methods of maintenance, repair and adaptation (and maladaptation) of the historic building stock, including retrofit and energy performance, to meet challenges of climate change.
5. Research on heritage, embodied carbon comparative carbon accounting in relation to historic assets.
6. Research on the role of historic land and seascapes in carbon sequestration and offsetting.

Method

The project used desk-based research, online surveys, and targeted telephone interviews to populate an Excel matrix with all identified research. A rapid review was initially undertaken using desk-based research. Key activities included:

- scoping organisations likely to be undertaking relevant research
- a review of scoped organisations' websites
- database analysis of key funding sources
- review of published papers.

The online surveys targeted specific individuals within scoped organisations to understand any relevant research. Based on the desk-based research, survey response and feedback from the Historic England Project Board, the telephone interviews were used to fill information gaps and to gain further project details for case studies. The telephone interviews also collected general information on the strengths and weaknesses of the field.

Findings

A general limitation of this review was identified around how research is defined; much ongoing research in a variety of fields will be relevant to climate change and heritage but if the research is not driven by heritage, it may not be recognised as relevant. Examples include research on retrofit and energy efficiency of all buildings that will be relevant to historic buildings, or research on carbon sequestration that does not identify that the landscapes under study are historic landscapes.

Academic and Research Organisations were the most represented within the matrix (59%). Regulatory and Arm-Length Bodies and Charity and Member organisations were the second most represented (20% and 17% respectively). Government Departments and Arm's-Length Bodies were under-represented in the matrix because engagement through the surveys and interviews was low. NERC, Historic England, SPF, AHRC, DEFRA, DESNZ, the National Trust and are key funders of climate change and heritage research.

Area 1 was highly represented in the matrix (159 entries). Within Area 1, the National Trust, Historic England, DESNZ, and DEFRA were key organisations, particularly for strategic-level research. Organisations such as the Vindolanda Charitable Trust and Edinburgh World Heritage Site are undertaking location specific work; although this type of work is likely to have findings applicable more widely. Research in this Area focussed on identifying climate hazards and impacts and using this information to develop adaptation and climate resilient approaches and guidance. Monitoring hazards was less of a focus.

Area 2 was not highly represented amongst the research collated (65 entries in the matrix). The National Trust were a key organisation. Regulatory and Arm's-Length Bodies in this area were represented by Historic England, RCAHMM, Historic Environment Scotland, DEFRA, and FloodRe. The research in this category sought to identify more resilient solutions to flood and coastal erosion management. Of the research identified, the impact of coastal change appeared to be the focus; flooding was not as well represented.

104 entries in the matrix were attributed to Research Area 3. Within Area 3, Research Councils funded the most projects. Government Department involvement in this Area was notably low. Much of the work in this area had intangible heritage as a secondary focus after tangible heritage. Projects also explored using community voices and memory to inform project aims and outcomes or using heritage to engage communities in discussions

around climate change. Less research focussed on the risk/impact on intangible heritage from climate change.

Area 4 had 96 entries in the matrix. Research Area 4 was the Area in which Regulatory and Arm's-Length Bodies were most highly represented, although much of the research is by Historic England. The Open University, Cardiff University and Leeds Sustainability Institute were key Academic and Research organisations researching in this Area. Much of the work in this area was local level retrofit and energy efficiency projects of historic buildings, which will provide approaches applicable across the sector. It is thought that much research undertaken in the wider retrofit and energy efficiency sector will be relevant but was not identified. Research around flood-proofing historic buildings was notably low.

Area 5 was not highly represented amongst the research collated, with 49 entries. Research in this Area was mainly carried out by Academic and Research Bodies and Regulatory and Arm's-Length Bodies. Regulatory and Arm's-Length Bodies were mainly represented by Historic England, although the City of London Corporation, the CCC, DCMS and DEFRA were also represented. Much of the research in this area was around carbon accounting and embodied carbon assessments for historic buildings. However, one project is looking to develop a carbon calculator for archaeological fieldwork.

Area 6 was not highly represented amongst the research collated, with 58 entries. This may be because general research on carbon sequestering landscapes is not recognised in the sector as being relevant to heritage. Academic and charity organisations were the most active in this area, with representation from Regulatory and Arm's-Length Bodies notably low. This Area included both research around active carbon sequestration in functioning habitats and research around the preservation of carbon-rich deposits (stores) that are not part of active ecosystems. There was a lack of research around the monitoring of wetland (including peatland) sites to gain an understanding site conditions and their impact on buried remains and their preservation.

Further work and future research opportunities

Opportunities for further work and future research opportunities were identified. Key amongst these were:

- Engage further with Government Departments and Arm's-Length Bodies. This could involve a working group to maintain contact with these agencies, sharing knowledge that has not been or will not be published, and capturing broad cross cutting themes, approaches, and grey literature.

- There would appear to be numerous projects and partners with whom Historic England could productively engage in collaborative research to avoid duplication of effort and maximise effective use of resources. This would need to be considered and addressed within the wider strategic plan for climate change research within Historic England.
- Expansion of the search terms for Areas 4, 5 and 6 around retrofit, embodied carbon, natural capital, and carbon sequestration (rather than restricting it to just heritage) so that a full complement of relevant research can be captured.

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Front cover image: Linney Head Camp, Castlemartin, Pembrokeshire. Photo taken during JBA Quinquennial survey of the coastal promontory fort. [Kristian Evens, JBA Consulting]

Date of research

Research was carried out between November 2023 and March 2024. The report was written over this period.

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Abbreviations

Acronym	Definition
AHRC	Arts and Humanities Research Council
AIM	Association of Independent Museums
ALGAO	Association of Local Government Archaeological Officers
BEIS	Department for Business, Energy and Industrial Strategy
C20	Twentieth Century Society
CCC	Climate Change Committee
CCRA	Climate Change Risk Assessment
CIOB	Chartered Institute of Building
CREDS	Centre for Research into Energy Demand Solutions
DCMS	Department for Culture, Media and Sport
DEFRA	Department for Environment Food and Rural Affairs
DESNZ	Department for Energy Security and Net zero
DfE	Department for Education
EBC	Energy in Buildings and Communities programme
ESRC	Economic and Social Research Council
ICSM CHC	International Co-Sponsored Meeting on Culture, Heritage and Climate Change
IEA	International Energy Agency
IHBC	Institute of Historic Building Conservation
LETI	Low Energy Transformation Initiative
LUNZ	Land Use for Net Zero
MOLA	Museum of London Archaeology
NERC	Natural Environment Research Council
NI	Northern Ireland
NLHF	National Lottery Heritage Fund
RCAHMW	Royal Commission on the Ancient and Historical Monuments of Wales
SPF	Strategic Priorities Fund
UCL	University College London
UKBCEP	UK Blue Carbon Evidence Partnership
UKGBC	UK Green Building Council
UKRI	UK Research and Innovation
WHS	World Heritage Site

Introduction

Project background

Historic England's Climate Change Strategy (Historic England, 2022) describes their response to the climate crisis. The strategy recognises that climate change is one of the most challenging issues of our time and has the potential to result in negative consequences to both people and heritage. Historic England's vision as set out in the strategy is that:

“By 2040, our heritage will have played an important role in the global fight to limit climate change and its impact on people and places. We will have enabled people to live more sustainably and adapt to a changing climate, while conserving our irreplaceable heritage for future generations.”

This research report has been prepared by JBA Consulting on behalf of Historic England to support their response to their priority on Climate Action (no. 4) identified within the Historic England Corporate Plan (Historic England 2023), the scope of which is as follows:

“Commission, undertake and share research to improve adaptation options, and to better understand the threats and risks to heritage from climate change and responses to it”.

To respond to this priority, a research review of recent and current research into climate change and heritage was carried out. This report presents the results of that review. The scope of the research has focused on understanding the ongoing research that directly relates to improving adaptation options or relates to threats and risks to heritage from climate change and from our responses to climate change. Furthermore, an understanding of which organisations are funding this research was sought. The project aimed to identify gaps in the research landscape, novel approaches, and potential partner organisations for Historic England. The understanding of the current research landscape will allow Historic England to prioritise their research strategy around future research into heritage, climate change and the environment, allowing the commissioning of appropriate research that will enhance understanding of the impacts of climate change on heritage, and how we can respond to those threats.

This project contributes towards Historic England's research agenda (Historic England, 2017), in particular the ‘#adapt’ theme, which includes: local planning; national planning and infrastructure; land management; climate change; heritage crime; and societal change.

Aims and objectives

Three specific objectives were defined to achieve the scope of the project, as outlined above:

1. To understand what research activity is ongoing which directly relates to improving adaptation options.
2. To understand what research activity is ongoing which directly relates to threats and risks to heritage both from climate change itself and from our responses to climate change.
3. To understand which organisations are funding such work as is covered by 1 and 2.

Scope

To fulfil these objectives, a rapid research review was undertaken. The review focussed on research conducted by public bodies, research institutions and charitable organisations across the UK. Research by private organisations was scoped out unless the organisation was an industry partner. Research by organisations outside the UK and research with an international focus was also scoped out. The review was constrained to ongoing research commenced within the last five years and research completed within the last 5 years, regardless of start date. Planned research was included where possible.

“Heritage” is defined within this project as archaeology (including maritime), built heritage, intangible heritage, and historic landscapes (including peatlands, wetlands, and ancient woodlands). The scope also included collections and artefacts/objects within heritage sites but excluding climate-controlled museum and archive stores. Climate-controlled museums/archives are excluded as any research relating to these would be very specific collections or building-level issues rather than relating more broadly to the impact of climate change on non-climate-controlled buildings.

Documents that were purely policy or technical guidance were scoped out. However, in some cases, it was difficult to draw a distinction between “research” and “guidance”, especially where the guidance is based on original research or is proposing novel techniques. Toolkits or guidance based on research have therefore been scoped in.

Within the specific objectives, six research areas were identified as being of particular interest. Within these research areas several sub-categories were identified to further inform the research review (Table 1).

Table 1: Research Areas and Sub-Areas.

Research Area	Research sub-Areas
1. Research developing models and assessing long-term impacts of climate change on heritage.	1.1 Climate Risk/Hazard mapping 1.2 Climate Risk/Hazard monitoring 1.3 Adaptation & Mitigation resources 1.4 Policy and guidance 1.5 Other ¹
2. Research on the impact on heritage of flooding and coastal erosion and our responses to these.	2.1 Flooding and extreme events 2.2 Coastal change and sea level rise 2.3 Change in marine environment 2.4 Managed realignment and coastal retreat 2.5 No further intervention 2.6 Hard engineering (rock armour, concrete revetments) 2.7 Other
3. Research on climate change and its potential impact on intangible heritage.	3.1 Social practices including approaches to livelihoods like farming and fishing 3.2 Knowledge and practice of nature, ecology, flora, fauna and land management 3.3 Traditional craft and building skills 3.4 Oral tradition, expression and language 3.5 Festivals, rituals, events, performing arts and cultural expression 3.6 Other
4. Research to inform best practice methods of maintenance, repair and adaptation (and maladaptation) of the historic building stock, including retrofit and energy performance, to meet challenges of climate change.	4.1 Flood proofing - property flood resilience 4.2 Energy efficiency measures including insulation and retrofit of new technology, services and micro generation 4.3 Measures to prevent overheating including shading, glazing and building fabric enhancements 4.4 Material usage including low carbon materials and those which promote a circular economy, whilst also being appropriate to the heritage asset 4.5 Carbon reduction within maintenance and repair regimes for historic buildings 4.6 Low carbon and sustainable solutions for building services to respond to heating, cooling, water usage and drainage, and similar 4.7 The effect of changing biota and their growth rates on material degradation 4.8 How all the above measures interact with historic building fabric and the unique challenges that historic buildings present 4.9 Other

¹ In each Area, the sub-Area choices include an “other” category; this was assigned if a project was deemed to be relevant to the main Research Area but was not clearly defined within the sub-Areas.

Research Area	Research sub-Areas
5. Research on heritage, embodied carbon comparative carbon accounting in relation to historic assets.	5.1 Quantifying embodied carbon in heritage assets including building stock 5.2 Identifying and quantifying carbon sequestration opportunities associated with heritage assets 5.3 Comparative assessments of carbon footprints of materials used in the maintenance and restoration of heritage assets 5.4 Carbon emissions associated with archaeological techniques 5.5 Natural capital and ecosystems services approaches 5.6 Other
6. Research on the role of historic land- and seascapes in carbon sequestration and offsetting.²	6.1 Peat - upland and lowland 6.2 Wetlands (non-peat) 6.3 Ancient woodlands 6.4 Carbon capture and sequestration research 6.5 Carbon offsetting and green finance initiatives 6.6 Other
7. Other.³	N/A

2 This theme has captured both research around active carbon sequestration in functioning habitats and research around the preservation of carbon-rich deposits (stores) that are not part of active ecosystems (for example, buried peat deposits).

3 An “Other” option was included within the options for main Research Area; this was assigned if a project was deemed to be relevant to climate change and heritage generally but was not clearly defined within the six Research Areas.

Methodology

Overview

This section will outline the methodology for the research review. The project used the methodology, outlined in Figure 1 and detailed in the following sections, to populate an Excel matrix with all identified research. Upon completion of the matrix, analysis was undertaken to identify gaps and strengths of the research landscape, and to understand which organisations are funding research.

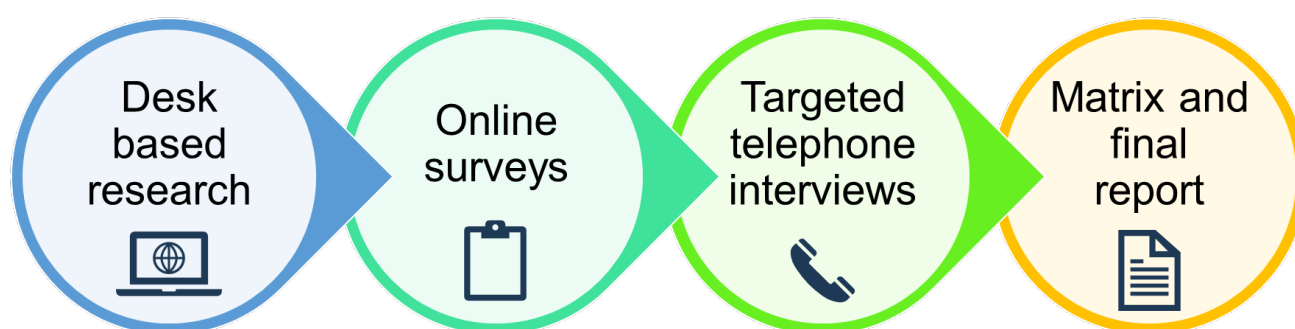


Figure 1. An overview of the methodology used to undertake the research review.

Key methodological decisions made following engagement between the JBA project team and Historic England are recorded in [Appendix 2](#).

Excel Matrix

The purpose of the Excel matrix was to record data collected from the online research, survey forms and telephone interviews in a consistent format and to allow subsequent data manipulation and display so that key trends and gaps could be identified. The required fields for the matrix were identified and agreed during the project initiation phase. As the Excel matrix will be used by both the Historic England Project Board and others in the organisation, it was essential that the data are presented in an easily digestible format that will be understandable to those not involved directly during the project. A table describing the fields in the Excel matrix is provided in [Appendix 3](#).

Each entry in the matrix was assigned a unique ID number prefixed with “CCH”. When a project is discussed in this report it is in italics and tagged with its unique ID number.

Desk based research

A rapid review was initially undertaken using desk-based research. Key activities included:

- Scoping organisations likely to be undertaking relevant research
- Website review of scoped organisations
- Database analysis of key funding sources
- Review of published papers.

The methodology for each desk-based activity is included in the following sections.

Scoping organisations

At project inception, an initial list of organisations likely to be undertaking research into climate change and heritage was collated. This list was enhanced through a desk-based review and collaboration with the Historic England Project Board. Included in this list were organisations both undertaking and funding research. A final list of the organisations identified and engaged with can be found in [Appendix 6](#).

The organisations were categorised into the following sectors:

- Regulatory and Arm's-Length Bodies
- Charities and Member organisations
- Professional Institutes
- Academic and Research
- Religious organisations
- Museum Sector
- Industry Partner

Where possible, overarching organisations were approached, as opposed to contacting many different smaller organisations, to improve the efficiency of the search. For example, in the museum sector, the Association of Independent Museums (AIM) was approached rather than approaching individual museums.

Website review

An initial review of the websites of scoped organisations identified projects visible in the public domain. [Appendix 4](#) lists the websites consulted.

An online review of research funding databases and research programmes identified ongoing research related to climate change and heritage.

Key databases and programmes consulted comprised:

- UK Research and Innovation (UKRI) and the funding bodies within it;
- Heritage Funding Directory
- Heritage Fund
- 360 Grant Nav
- Global Climate Research Portal
- International Science Partnership Fund
- Centre for Research into Energy Demand Solutions (CREDS)
- Culture and Creativity
- Heritage Research Hub
- UK Climate Resilience Programme

Due to the volume of data within the UKRI database, an additional methodology was developed to review research funded by this body more efficiently. This methodology is explained in the next section.

UKRI Database analysis

The initial desk-based research concentrated on reviews of research funding databases, as per conversations with the Historic England team. From this, the UKRI database emerged as a key source. The database lists all projects funded by UKRI and its councils, including organisations such as the Arts and Humanities Research Council (AHRC), Natural Environment Research Council (NERC), and the Economic and Social Research Council (ESRC).

The initial query of the UKRI website returned approximately 36,000 results. This was initially narrowed down by using search operators around the words 'climate change' and 'heritage', as well as scoping out certain research councils under the UKRI umbrella (see [Appendix 7](#) for councils scoped in/out), which reduced the number of results to approximately 8,000 results. This was subsequently filtered by date according to the confirmation of the timescales scoped into the project, which narrowed the number of results to 1,129.

This was deemed unfeasible to review and categorise manually. To further narrow down the results, the JBA Data Science team conducted a "scrape" of the UKRI website to obtain the abstracts for all the list entries. Using R coding (a coding language), a series of rules for inclusion or exclusion were applied. The code used three columns of search terms to scope projects in or out based on whether the abstract included at least one from the 'climate change' column, and one from the 'heritage' column, or just one from the general 'include' column (see [Appendix 8](#)). The dataset was also scoped by country,

whereby an automated search was done for names of non-UK countries which, if positive, scoped the project out. This exercise narrowed the list to 803 entries. However, some entries were still not relevant, and the entries were also uncategorised (in terms of the Research Areas), so required further scoping and categorising.

A query was raised at the mid-point meeting that the initial exercise may have been too broad. For the next stage of analysis, JBA suggested formulating a list of words that could immediately 'scope in' a project, based on keywords unique to each Research sub-Area. In collaboration with the Historic England Project Board, a series of keywords relating to climate change and heritage was developed (see [Appendix 9](#) for method and search terms). This was used to automate the categorisation of the projects by sub-category; this approach concurrently categorised the projects within the six main Research Areas. The search terms were applied to the full UKRI dataset, again using R coding, allowing projects to be attributed to multiple relevant categories where relevant. The R coding was also used to scope out non-UK countries once again and to scope out projects outside the time-frame of the project (all start dates were included, the end dates were filtered to 2018 onwards).

The final dataset comprised of 639 projects, each categorised by Research Area and sub-Area. However, as the search terms had, in some cases, picked up projects using the keywords in a context which did not relate to climate change and heritage, a final manual review was required to remove anomalous projects. A further 504 projects were scoped out through this process, three projects were identified as already being in the matrix through other means, and 132 projects were scoped in. The dataset included some entries where multiple organisations were awarded funding for the same project – these entries were merged, designating the organisation with the highest funding as the lead and adding the other organisations as partners. This led to a final number of approximately 100 projects added to the matrix.

Published papers

The methodology adopted in Orr et. al.'s 2021 systematic literature review as well as the previous literature review in 2016 it replicated (Fatorić and Seekamp 2017) was employed because it is a peer reviewed approach, previously adopted and can be replicated for consistency. Although Orr et al. referred to "keywords" it wasn't clear from the publication if they had only searched keywords or used the keywords to search by topic (title, keywords, and abstracts).

Published papers were searched for using Web of Science. Searching of additional academic databases such as Google Scholar and Scopus was not undertaken as this was limited by the time available and anticipated to result in a significant number of duplicate results.

A search of five combinations of keywords (using wildcards to capture variations) was undertaken within Web of Science:

- 'cultural resourc*' AND 'climat* chang*'
- 'cultural heritag*' AND 'climat* chang*'
- 'historic* heritag*' AND 'climat* chang*'
- 'heritag* site*' AND 'climat* chang*'
- 'historic* environment*' AND 'climat* chang*'

The above terms were searched for the period 2021-2023 (Orr et al.'s paper covered papers up to 2020) and by topic (searching across title, author defined keywords and abstract). This yielded 4,331 results, of which 4,228 were in the English language, which could not be filtered, sorted by relevance and categorised into research areas within the timescales. These have been downloaded for reference and have been provided to the Historic England Project Board for potential future use. It is anticipated that a similar approach to categorising the research to that adopted for the UKRI results would be needed requiring modification of the R code.

The search was re-run using the above keyword terms, but only searching within the author defined keywords. This reduced the number of results returned as it restricted the identification of papers to those where the authors identified heritage and cultural resources as a key focus of the paper, rather than where they may have been used incidentally within the abstract. The year range was expanded to 2018-2023 for consistency with the rest of the research project. This yielded 145 results.

After excluding non-English language papers, those conducted by non-UK institutions, and international case studies and research, the number of relevant papers incorporated into the matrix was reduced to 13. The categorisation of the research was based on the abstracts rather than a full review of each published paper. Consequently, additional detail about the nature of the research, climate hazards, and other details may not be captured in the matrix.

Online Survey

The purpose of the online survey was to target specific individuals within scoped organisations to understand any relevant completed, ongoing, or planned research that was not already captured by the desk-based review. The questions within the survey form were designed to capture key information that could be directly inputted into the Excel matrix with limited need for data manipulation. The survey forms were structured so that the recipient was invited to list multiple research topics that they were undertaking, rather than being limited to one research topic per form.

Telephone Interviews

Following both the desk-based research and the receipt of survey forms, a review of the responses was conducted and where it was deemed necessary, follow up telephone interviews were arranged. The need for telephone interviews was determined by the following factors:

- Where not enough information could be gathered from the online research or survey form and more information was needed to complete the Excel matrix.
- Where no response was received from the survey form and the area of research was deemed important enough to require a follow up call; or,
- Where more information was required to inform a case study or would provide significant additional useful information.

Data Analysis

The research matrix was frozen for analysis on 29 January 2024. The results captured within the matrix were analysed by field to allow the breakdown of individual responses and presentation of results as a percentage. This was undertaken using Excel, and the results displayed in a graphical format.

Five fields were assessed as part of this analysis: Sector, Research Area, Funding Body Type, Funding Amount and Geographic Location. These were chosen as they were identified as being particularly relevant to the overall aims of the project and contained data that could be easily categorised into a digestible number of graphs. These fields were subsequently cross-referenced against one another allowing the breakdown within each field to be assessed.

To capture the breadth and relevance of research, each research project could be assigned to multiple Research Areas if it contributed towards multiple areas in the analysis.

To enable the relative funding within each area to be accurately assessed, the amount of research within each Research Area was both expressed via the number of unique pieces of research being undertaken, and as a percentage of the overall amount of funding. This allowed an identification of whether certain Research Areas received large amounts of funding, or if there were areas where funding was insufficient.

Discussion and Case Studies

The Discussion reviews the evidence from the data analysis to comment on key trends and the general scale of research; the section is organised according to Research Area. Key organisations and funders are identified. Whilst the analysis used the frozen matrix, the discussion considers all research identified, including that identified post-matrix freeze, to give the most comprehensive picture of the research landscape. The case studies are laid out in detail in [Appendix 1](#), however, they are summarised in ‘highlight boxes’ throughout this section to support the discussion around an analysis of the nature of the research landscape. Additional mini-case studies have been added in this section, as well as in-text references to key projects to add further contextual information to the discussion.

Case studies, mini-case studies and in-text references have focussed on projects that did not involve Historic England.

The Discussion reviews the level of central Government involvement in climate change and heritage research. As Government Departments were included under the “Regulatory and Arm’s-Length Bodies” category, the Discussion draws out Government Department involvement specifically. Where a project was led by, funded by, or partnered with a Government Department, this was captured within the relevant column in the matrix. Identifying research undertaken by, or commissioned by, Government Departments was challenging. This meant that if a Government Department was not identified as the lead organisation, or where a project was part of a government project but was not identified as such, their involvement was not captured in the matrix.

Definitions, Limitations and Assumptions

Definitions

When categorising projects, a series of definitions were applied to simplify the data entry process. These are detailed below.

The definitions of the sectors used to categorise the lead organisations are as follows:

- Regulatory and Arm’s-Length Bodies includes central Government Departments (such as the Department for Digital, Culture, Media and Sport (DCMS) and the Department for Energy Security and Net Zero (DESNZ)) and Government Arm’s-Length Bodies (such as Historic England and Natural England)
- Charities and Member organisations
- Professional Institutes

- Academic and Research
- Religious organisations
- Museum Sector
- Industry Partner

Funding amounts were grouped into brackets, aligned with those used by the National Lottery Heritage Fund (NLHF), to give a broad sense of the scale of the projects. These were agreed with the Historic England Project Board and used both in the matrix and in the surveys. Subsequently, it was suggested that these categories were too broad, however, as data had already been categorised accordingly, revising them was no longer feasible. The categories are:

- <£3,000
- £3,000-£10,000
- £10,000-£250,000
- £250,000-£10,000,000
- >£10,000,000.

Indirect and direct impacts of climate change were defined using the Climate Change Committee's (CCC) (2016) definition:

“Direct impacts involve simple impact pathways, e.g. higher temperatures on cooling demand. Indirect impacts involve complex pathways, e.g. increases in flooding leading to subsequent disease or ill health. They also include wider economic impacts, e.g. where reductions in agricultural production change market prices.”

Climate hazards considered were based on the Intergovernmental Panel on Climate Change's (IPCC) terminology, as it provides an extensive list of hazards. This approach is further supported by ongoing Historic England and University College London's (UCL) work to develop a climate hazard vocabulary for cultural heritage. Some terminology was adapted to improve accessibility and clarity, ensuring that hazard descriptions were familiar to all survey recipients and telephone interview participants. Additionally, during consultation with the Historic England Project Board, several indirect hazards deemed directly to affect heritage assets were identified and included. These hazards encompassed changes in biological growth, change in species distribution and shrink-swell phenomena. A full list of hazards included can be found in [Appendix 5](#).

Limitations and assumptions

The project took place between late October 2023 and early-March 2024; the short timescales of the project introduced several limitations:

- It was necessary to progress rapidly through each stage, therefore there was limited time to follow up on potential gaps.
- There was difficulty in identifying single contact in organisations for survey. In some cases, there was a reliance on a generic email address or an online form where it was not possible to identify a named individual.
- The survey and telephone interview engagement had to take place over the December and January period; the level of engagement was affected by annual leave and Christmas shutdowns.
- Late Web of Science access meant that a full analysis of published papers by topic was not possible. It is possible that some research was not captured because of this, but also that the papers may have been outputs of projects already identified through the UKRI analysis and projects captured through other means resulting in duplication.

The format and structure of the matrix also resulted in several limitations:

- Lead organisations were attributed through information obtained through online surveys or through first publishers/lead authors if the paper was published, who may not necessarily be based at the lead organisation. This may not always capture the fact that other organisations are involved in the project or if a project has been funded by a Government Department or Arm's-Length Body.
- It was identified early in the project that both projects and published papers were within scope: both are included within the matrix. It is therefore not always obvious where a published paper may be an output of one of the named projects therefore the matrix may contain duplication, although this is anticipated to be limited.

A general limitation of this review is how research is defined; much ongoing research in a variety of fields will be relevant to climate change and heritage but if the research is not driven by heritage, it may not be recognised as relevant. Examples include research on retrofit and energy efficiency of buildings that will be relevant to historic buildings, or research on carbon sequestration that does not identify that the landscapes under study are historic landscapes.

Surveys were reliant on one individual from an organisation completing them, but this approach was necessary to minimise potential duplication of results and the burden on staff for organisations that were approached.

There was difficulty identifying research by Government Departments such as the Department for Environment, Food and Rural Affairs (DEFRA), the former Department for Business, Energy and Industrial Strategy (BEIS), the Department for Energy Security and Net Zero (DESNZ), and Department of Culture, Media and Sport (DCMS). These Government Departments were approached for survey, but the response rate was low. Furthermore, although the relevant department websites were consulted during the first stage of the desk-based review, research is not documented in one location or clearly identifiable in the government website structure. In some cases, BEIS was identified as a project partner; BEIS ceased to exist as a Government Department in 2023. If BEIS is named as a lead/funding/partner organisation, this is because the research was completed prior to 2023 or it was not possible to identify which department has taken over as project lead.

It should be noted that the exclusion of work completed by non-UK institutions (in line with the scope of the project) removed several papers and projects which included UK case studies or may have had relevance to the UK. A significant proportion of the broader published paper search results by topic may duplicate the academic work captured through the search of the UKRI database.

Assessment of the research landscape

Research landscape strengths and gaps

Reviewing the distribution of research across the six Research Areas defined by Historic England can begin to highlight the strengths and gaps within the research landscape. Figure 2 shows the percentage distribution of the identified research across the Historic England Research Areas. Within the matrix, research can be assigned to several Research Areas, so within this graph, each piece of research is counted in all Areas attributed to it.

Distribution of research across Historic England Research Areas

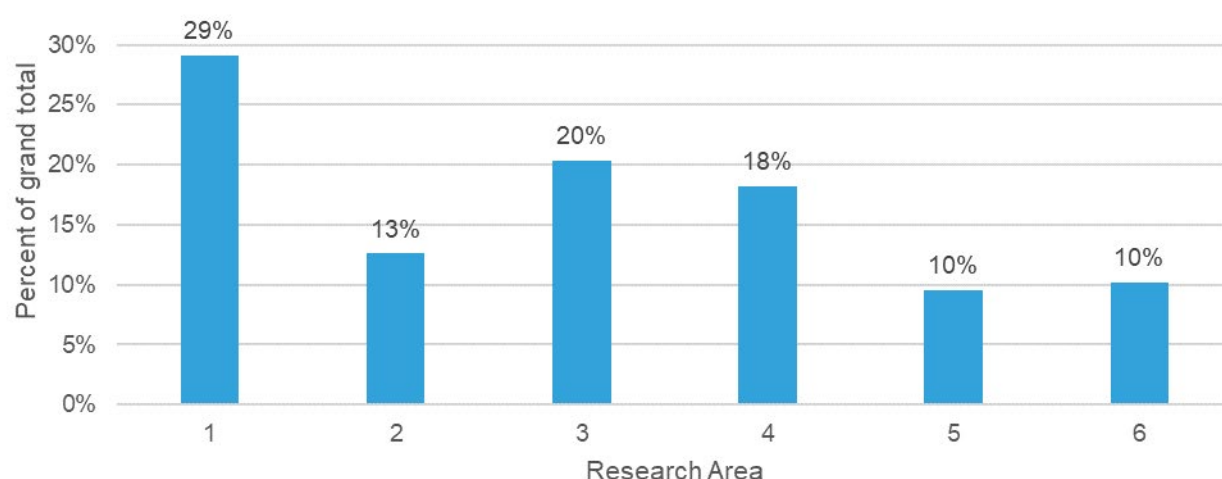


Figure 2. Percentage distribution of identified research across the six Historic England research Areas.

Research Area 1 was the most represented within the matrix, accounting for 29% of the total. As Research Area 1 is a broad category, it is likely that this has the highest representation because it is assigned as the primary Area for many pieces of research, and then a variety of secondary Research Areas are assigned (or vice versa). This is likely to be the case particularly for Area 2 – much of the research relevant to Area 2 may be carried out within Area 1 as part of projects looking at a wider variety of climate hazards. Whilst research is carried out by a wide variety of organisations, Historic England and the National Trust were strongly represented within Area 1.

Research Area 3 was perhaps better represented than expected accounting for 20% of the total. However, this is likely because each individual piece of research recorded within the matrix could be assigned to more than one research area. Therefore, whilst impacts on intangible heritage were not the primary focus of the research, it would appear as a

secondary focus on numerous pieces of research. It is also possible that the sub-Areas (for example knowledge and practice of nature, ecology, flora, fauna and land management) and associated keyword search terms used for the UKRI coding scoped-in more general research in these areas rather than intangible heritage specifically. Research in this area was undertaken by a variety of organisations, with no single organisation producing many pieces of research, unlike Area 1 and 4.

Research Area 4 was also well represented, accounting for 18% of the total. Whilst most research is by a wide variety of organisations, Historic England and the Open University⁴ were strongly represented within this Area. Research Area 2, 5 and 6 accounted for 13%, 10% and 10% respectively. Only two records were assigned a research area of “Other”⁵ though both pieces of research were also assigned other research areas. In the case of the less well represented Areas, it is possible that the limitations of the data collection have not captured the full breadth of the research (particularly in the case of the UKRI results): if the research did not identify itself as linked/relevant to heritage, then it would not have been identified through the search. Furthermore, if research was funded by a Government Department, it may not have been captured due to the issues engaging/identifying research by/funded by Government Departments mentioned in the ‘Limitations and assumptions’ section; this may be particularly relevant for Area 4 and 5.

Distribution of research across the sector of lead organisations

Figure 3 shows how the research is distributed amongst lead organisation sectors. The Academic and Research sector was the most represented, representing 59% of the total. Religious organisations were the least well represented, only accounting for <1%. Regulatory and Arm’s-Lengths Bodies were the second most represented, with 20% of the total.

In the matrix, 97 of 249 records (39%) were from the UKRI database, most of which are led by Academic and Research organisations, meaning that Academic and Research organisations are heavily represented within the data. However, this represents a finding in itself: research funded through large funding organisations such as UKRI is much easier to identify than ad-hoc and/or unfunded research undertaken within other organisations. This is particularly relevant for Regulatory and Arm’s-Length Bodies and Charities and Member Organisations; organisations such as the National Trust, for example, undertake research

4 The entries from the Open University relate to work carried out by Freya Wise and collaborators; some of the work is the outcome of her PhD but it was not possible to identify which publications were as an outcome of the PhD work and which were part of other research – this may have skewed these results slightly.

5 An “Other” option was included within the options for main Research Area; this was assigned if a project was deemed to be relevant to climate change and heritage generally but was not clearly defined within the six Research Areas.

at a property level, outside formal funding or research programmes. This data is very difficult to capture, especially as the findings are often not publicly published or not widely shared.

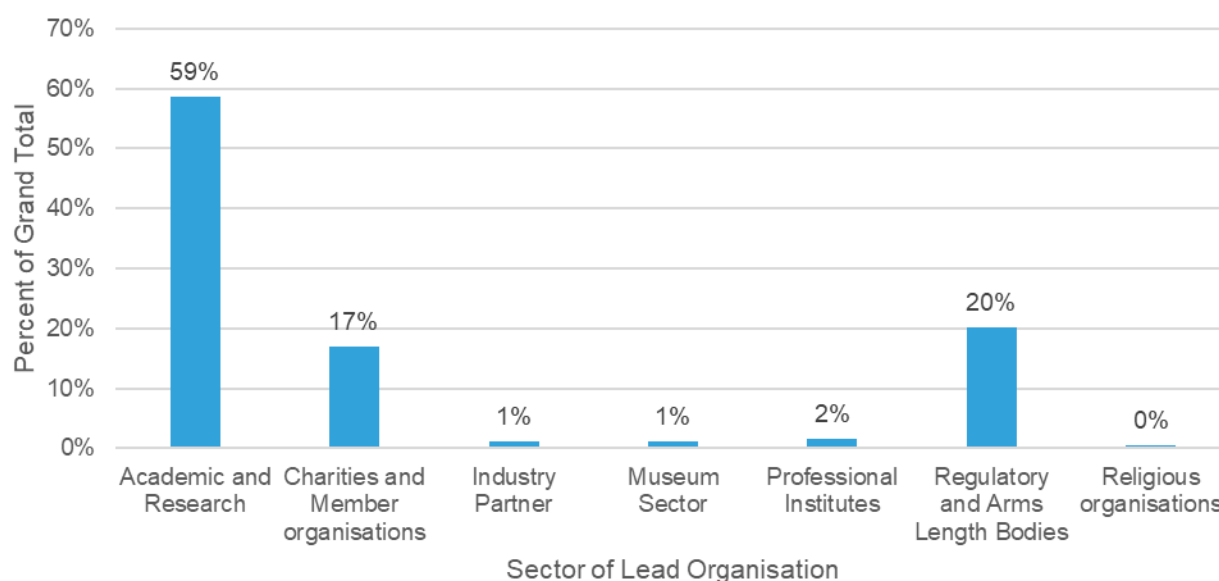


Figure 3. Percentage distribution of identified research across the sector of the lead organisation.

Research by Museums is under-represented in the matrix. It is possible that this is due to the data collection techniques used, rather than being an actual representation of the research ongoing in these organisations, especially as many museums included in this study are Independent Research Organisations (IROs). Response rate for the surveys from Museums was not high; additionally, as mentioned in the methodology, overarching organisations were approached rather than individual museums in most cases. Future work could look at techniques for capturing research from this sector.

Research led by Industry Partners only represents 1% of the total research identified. However, this is perhaps unsurprising as their work was only considered in scope when the research was carried out in partnership with in-scope organisations. Therefore, where Industry Partners are undertaking research under contract for other organisations, this project will appear in the matrix with the contracting organisation being the lead organisation. Industry Partners were not targeted for surveys as it was unrealistic within the timescales to identify which private organisations are collaborating with/working for in-scope organisations. Furthermore, when replies to the survey were received, the partner organisation was not able to provide any information about the research they were undertaking because they were under contract.

Professional Institutes are not highly represented, likely because the response-rate from these organisations was low, and their research often lies behind paywalls, so could not be accessed through the desk-based review or through the rapid review of published sources (academic papers). Additionally, they are unlikely to fund their research through Research Council funding or other funding bodies, so would not appear in our searches of these sources.

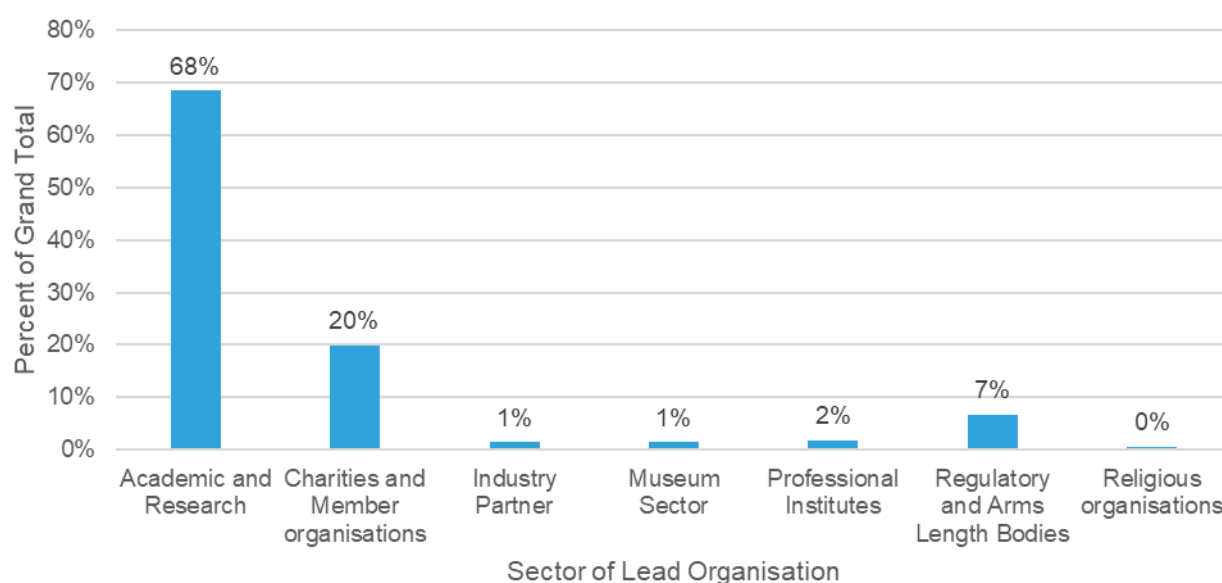


Figure 4. Distribution of sector research of the lead organisation (Historic England data excluded).

To test a potential bias in the results arising from multiple projects received from Historic England at project outset, a second analysis was undertaken in which any project where Historic England were identified as the lead were removed from the dataset (Figure 4). This resulted in the percentage of Regulatory and Arms Lengths bodies dropping from 20% (50 entries) of the overall total to 7% (14 entries).

Key Organisations

Figure 5 shows Lead Organisations that had five or more entries within the Excel matrix. Those organisations without five or more entries are recorded within the 'Other' category, which represents 146 entries. Historic England has the most entries in the matrix at 37, followed by the National Trust with 17 entries. There were some universities who appear to be undertaking more work in this area than others, particularly the University of Exeter who had 11 entries in the matrix.

Overall, there was a wide range of lead organisations within the matrix, the majority only undertaking one or two research projects in the area of climate change and heritage.

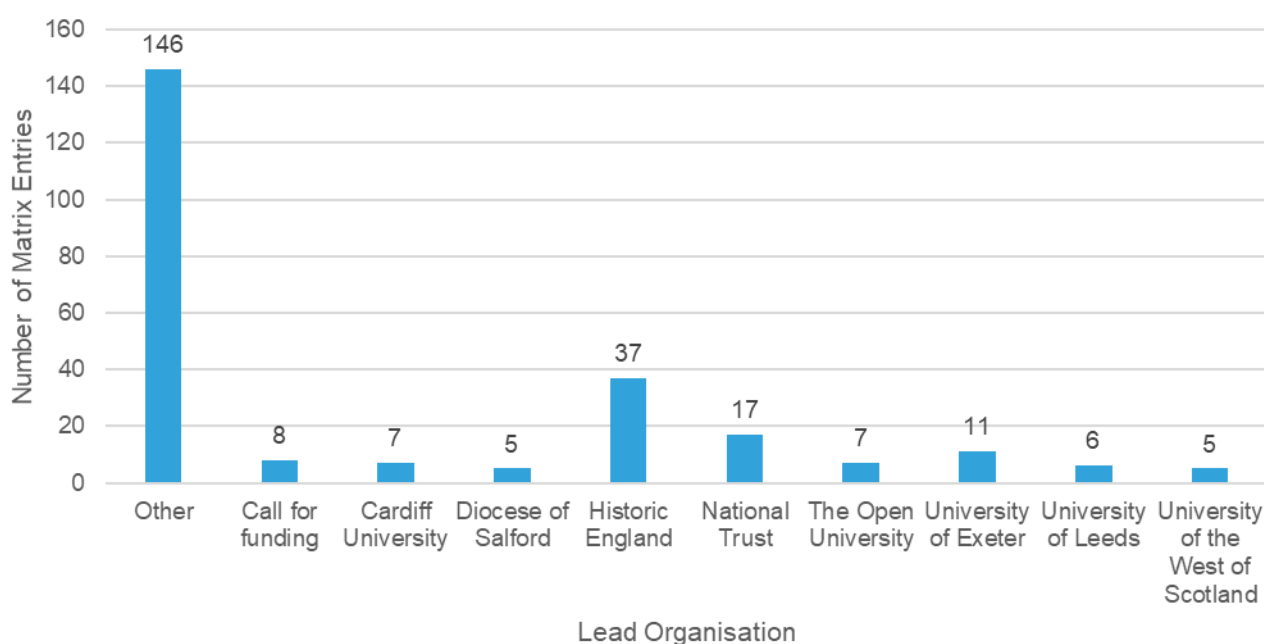


Figure 5. Organisations or Universities with five or more entries listed in the matrix.

Key Lead Organisations within each Area

Figure 6 shows which sectors are conducting the most research in each Research Area. In all Research Areas, Academic and Research Bodies are most prolific, although this may also partially reflect the relative ease of collecting and collating data from the UKRI database compared to collecting data from disparate sources for other organisations. Charities and Member Organisations carry out research across all areas, with a concentration on Area 1. Unlike Charities and Member Organisations, Regulatory and Arm's-Length Bodies seem to be concentrating more specifically on Areas 1, 2, 4, and 5; however, this only represents projects where Regulatory and Arm's-Length Bodies are lead organisations; these organisations might be involved as partner organisations in a range of Research Areas. A discussion of key lead organisations within each Research Area is included within the Discussion section.

Historic England were removed from the dataset so that any potential biases within the Regulatory and Arm's Length Bodies sector could be explored (Figure 7). Within Area 1, research funded by Regulatory and Arm's Length Bodies fell from 4% (22 entries) to 2% (8 entries) and in Area 4 fell from 5% (27 entries) to 1% (4 entries). The significant decrease in Area 4 demonstrates that the project has struggled to identify retrofit research ongoing in other organisations. This is likely because much of the research in this Area does not explicitly link to heritage.

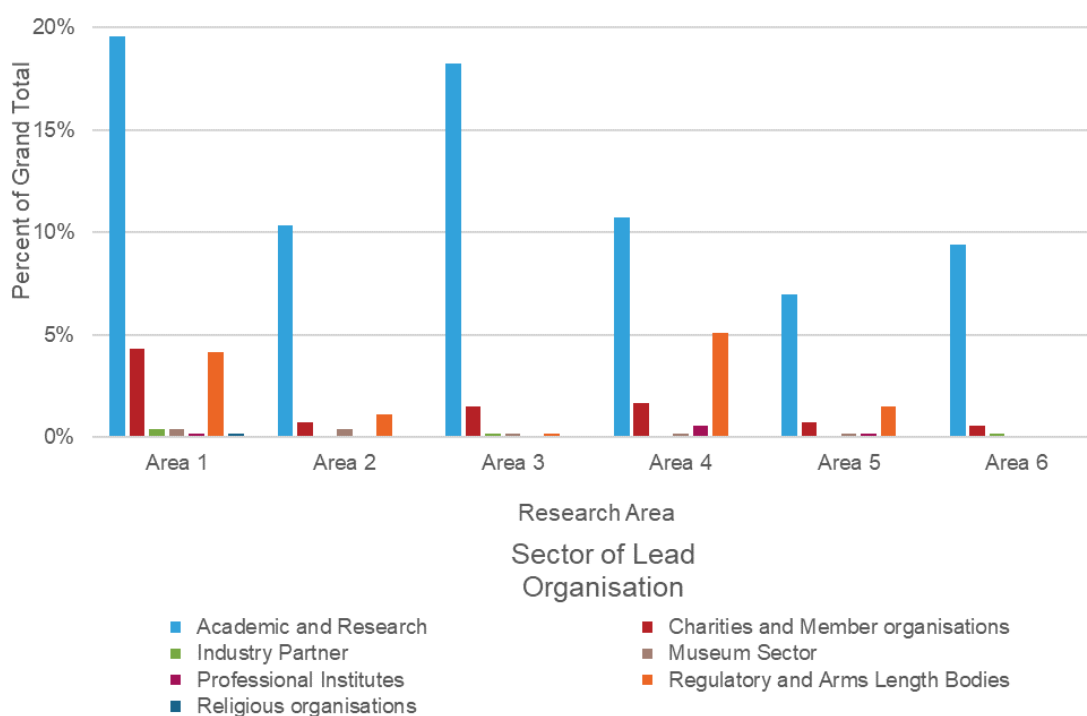


Figure 6. Research Area focus of each sector (based on sector of lead organisation).



Figure 7: Research Area focus of each sector (based on lead organisation; Historic England excluded)

Research location focus

Most projects fell under the UK-Wide category, representing 49% of the total (Figure 8). Of the four nations, England was the most represented at 22% of the total. This is partially due to the large amount of research captured within the matrix attributed to Historic England, which operates in England only, although it is worth noting that in many cases, the research will likely be relevant to UK-wide contexts. Scotland represented 7% of the total whilst Wales and Northern Ireland only 2% of the total each. This is not necessarily indicative of a lack of research being undertaken in these nations, but it may be that the research being undertaken considers a UK-wide context.

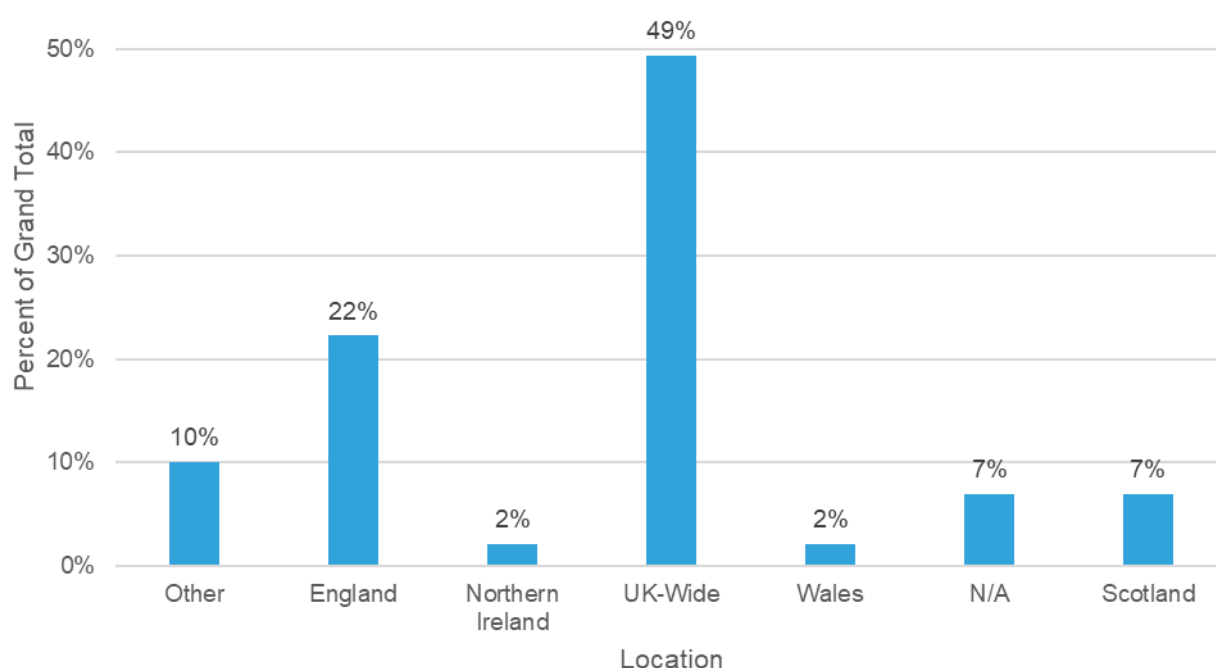


Figure 8. Distribution of research across the region of focus

Research was assigned as 'other' if the research was location specific or if the research included case studies both from UK and non-UK countries, this accounted for 10% of the total. Not applicable (N/A) research, which did not fall under any specific geographical location or where location was not specified, accounted for 7% of the total.

Key funders and funding patterns

Figure 9 shows how the research is distributed amongst funding body sectors. Research Councils were the most represented funding body type, accounting for 48% of the total. This category is comprised entirely of UKRI umbrella organisations (the projects identified come both from the UKRI database and from other aspects of the desk-based research). Entries identified from the UKRI data (included in this graph under 'Research Councils') represent 39% of the matrix; however, this does not entirely account for the high representation of Research Councils. Therefore, the findings do suggest that most research is funded either through Research Councils or through Regulatory and Arm's-Length Bodies.

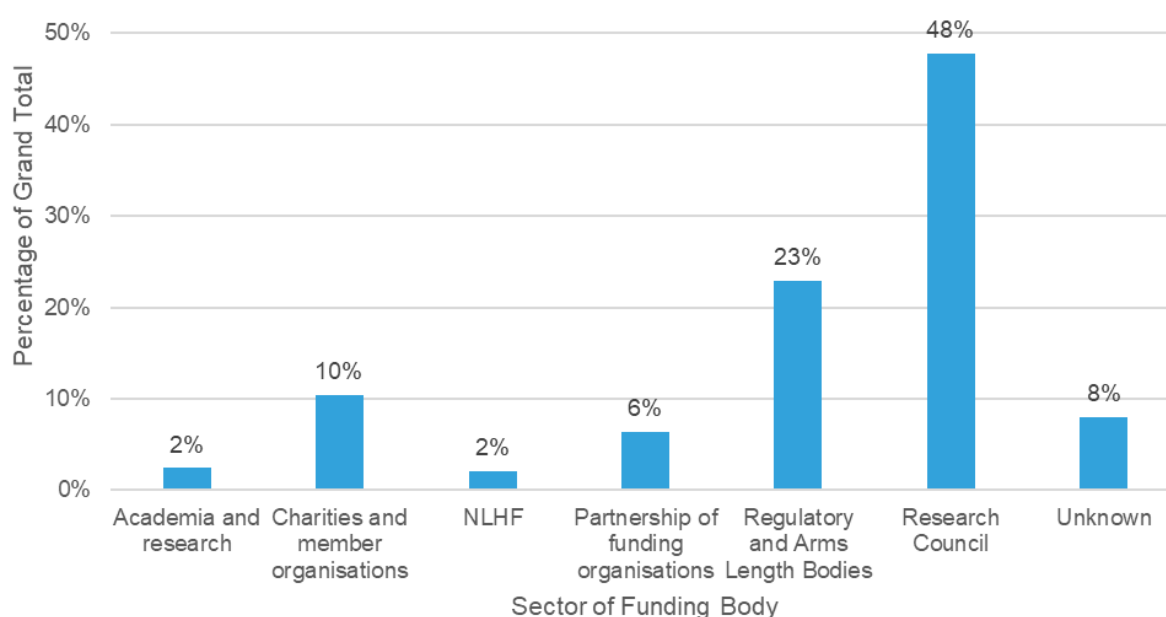


Figure 9. Percentage distribution of research across the sector of the funding body organisation.

Regulatory and Arm's-Lengths Bodies were the second most represented within the matrix (23%) (Figure 9). Historic England funding contributes a large portion of this category, and when split from the rest of this sector (Figure 10), represents 15% of the total (when Historic England projects and their Requests for Quotation (RFQs) are grouped). Also represented are BEIS, Historic Environment Scotland, Welsh Government, UK Government, City of London Corporation, Forestry Commission, DEFRA, FloodRe, DESNZ, European Commission (HORIZON.2.2), DCMS, Historic Environment Division – Department for Communities Northern Ireland (NI), and the British Council.

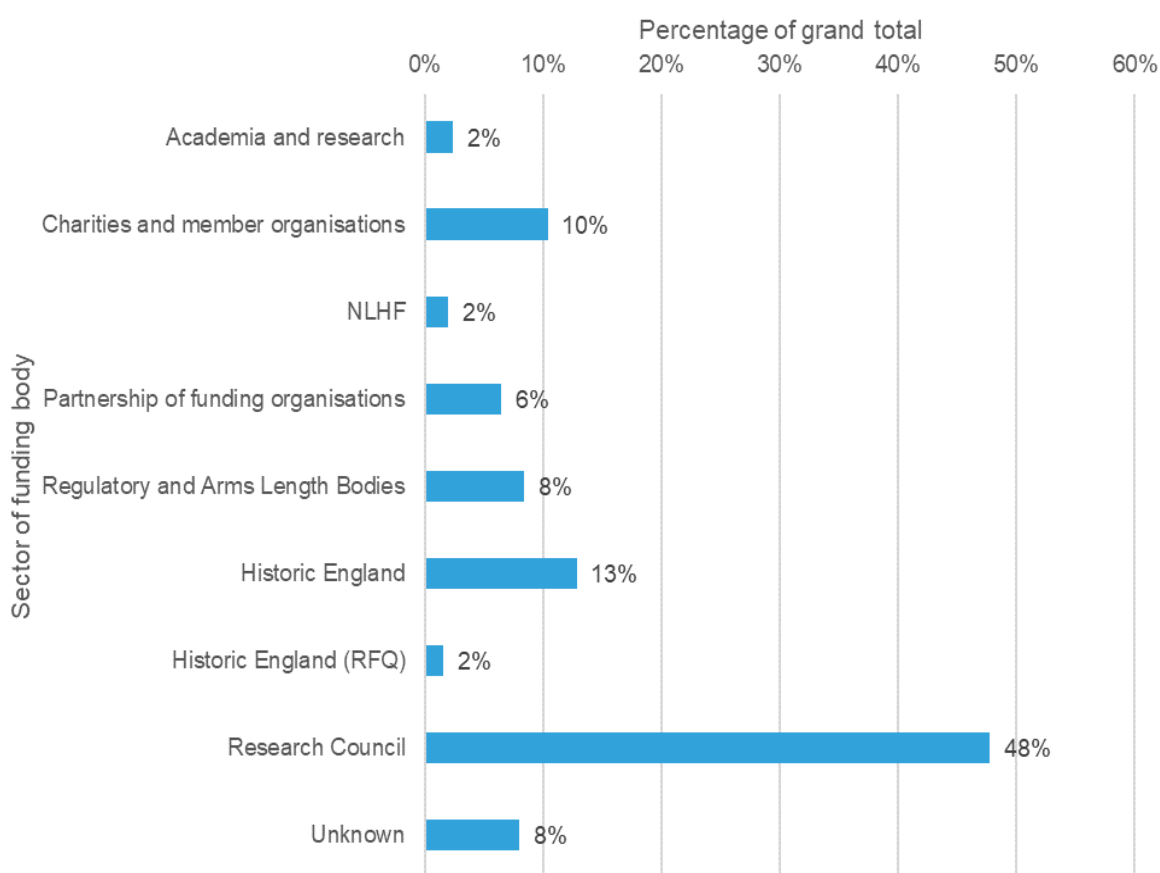


Figure 10: Distribution for sector of funding body.
Historic England data excluded from Arms-Length Bodies. RFQ stands for Requests for Quotation.

Research funded by Charities and Member Organisations (8% of the total) is comprised mainly of National Trust research, although other organisations were identified, such as the Vindolanda Trust. The National Lottery Heritage Fund was the least well represented, accounting for 2% of the total.

Figure 11 compares the sector of the lead research organisation with the funding body type. It demonstrates that Academic and Research organisations were primarily funded through the research councils. Regulatory and Arm's Length Bodies, along with charities and member organisations, mainly received funding from within their respective sectors, likely due to a predominance of self-funded research projects in these areas. There was insufficient data under the other sectors to draw any meaningful conclusions.

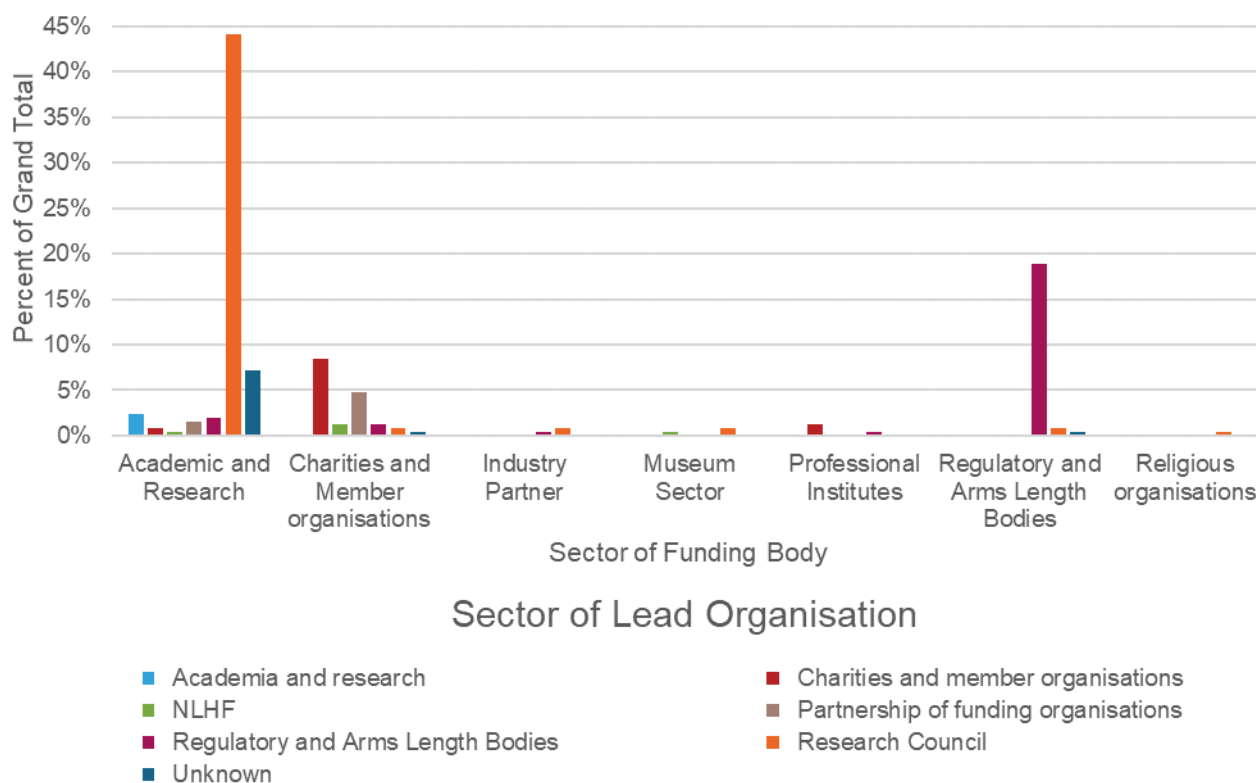


Figure 11. Sector of the lead research organisation compared with the funding body type.

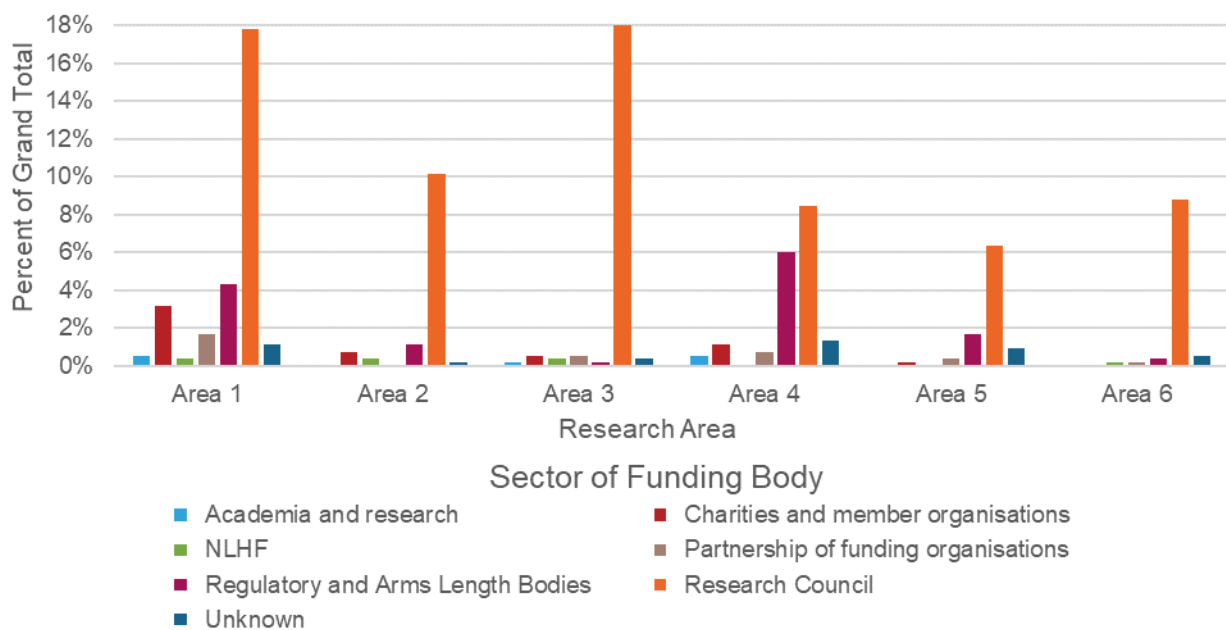


Figure 12. The distribution of funding body type across the Research Areas.

Figure 12 shows the distribution of funding body types across the Research Areas. Research Councils were the most common funding body type within each research area, likely due to the UKRI dataset. When assessing funding bodies broken down by their count within each Research Areas, Research Councils appeared much more frequently in multiple research areas than Regulatory and Arm's-Length Bodies or Charities, potentially suggesting that these organisations are more focused in their research objectives and funding. Within Area 1, Area 2, Area 4, and Area 5, Regulatory and Arm's-Length Bodies were the second most numerous funding body type. However, in Areas 1, 2 and 5 there was a significant difference between the amount of research funded by Research Council's compared to Regulatory and Arm's-Length Bodies. Within Area 1, Charities and Member Organisations were more common compared to the other research areas, though these organisations were still funding less than Research Councils and Regulatory and Arm's-Length Bodies.

Most prolific funders

A discussion of key funders within each Research Area is included within the Discussion section.

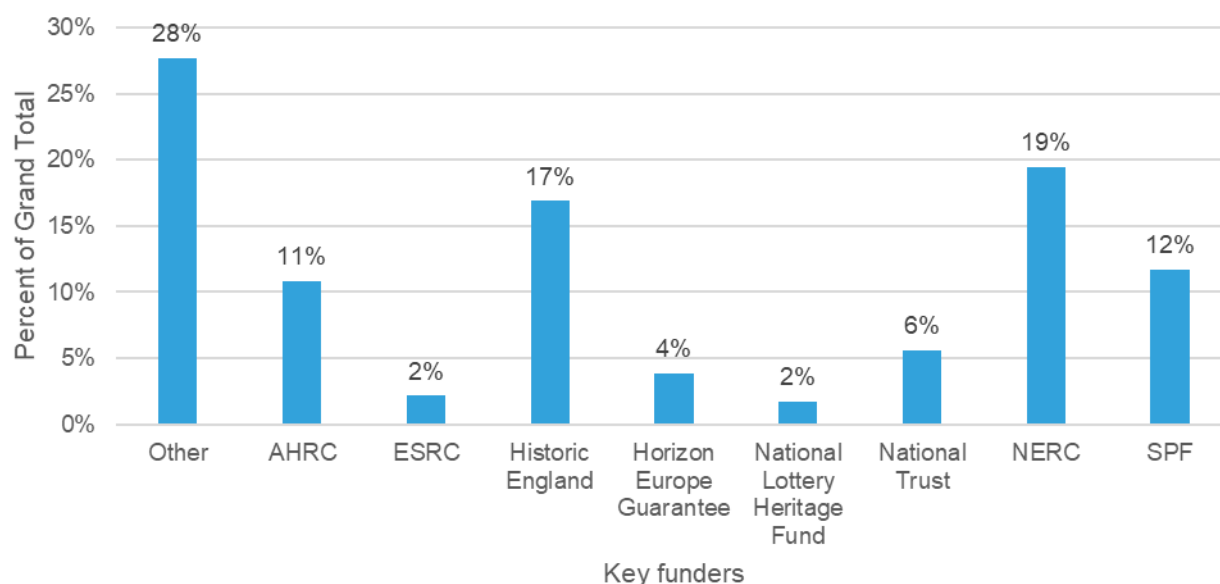


Figure 13. Organisations funding the most climate change and heritage projects. Measured as a count of projects funded, not as the amount of money awarded.

NERC were the most prolific funding body within the matrix, representing 19% of the total (Figure 13). Historic England represented 17% of the total. Other notable funders in the area were the AHRC, Strategic Priorities Fund (SPF), Horizon Europe Guarantee, National Trust, the National Lottery Heritage Fund and the ESRC. Other funding bodies represented 28% of the total number, showing that approximately 73% of projects were funded by one of the bodies shown on the graph above. Within the 'Other' category,

funding is usually awarded by sources external to the lead organisation, rather than self-funded projects. Within this category, self-funded projects are mainly those led by Regulatory and Arm's-Length Bodies (BEIS, DCMS, Historic Environment Division, Forestry Commission, DEFRA, FloodRe, and the British Council) or Professional Institutes/Charitable Organisations (International Council on Monuments and Sites (ICOMOS), the Institute of Historic Building Conservation (IHBC), Chartered Institute of Building (CIOB), the 20th Century Society (C20), Vindolanda Charitable Trust, the Woodland Trust, the National Trust).

Several projects within the matrix had no assigned funder – this mainly reflects projects where the funder was not known. However, in some cases, it reflects where organisations were undertaking research that is 'self-funded' within the organisation as part of routine work.

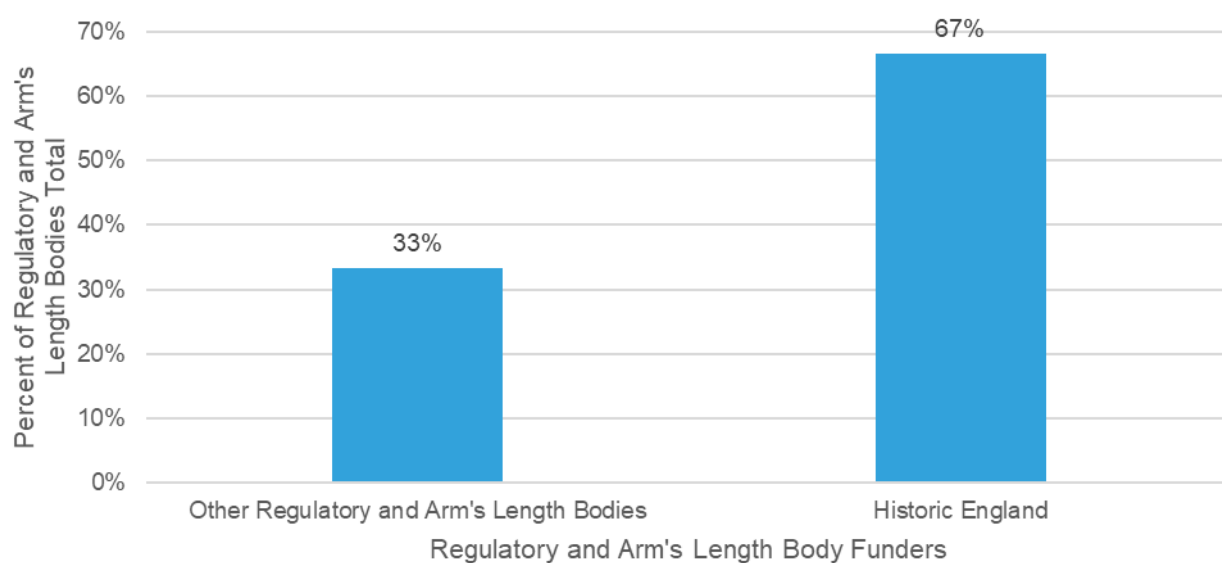


Figure 14. Research funded by Historic England compared to other Regulatory and Arm's-Length Bodies.

Figure 14 compares the amount of research being funded by Historic England compared to other Regulatory and Arm's-Length Bodies, with two thirds of the research being funded by Historic England. This is potentially due to the ease with which the list of research projects was obtained from Historic England, and that many of these were self-funded. As noted in the limitations section, there was difficulty accessing information and gaining responses from other Regulatory and Arm's-Length Bodies such as Natural England, the Environment Agency, and central Government Departments; this will have a significant impact on the distribution seen here.

Funding amount

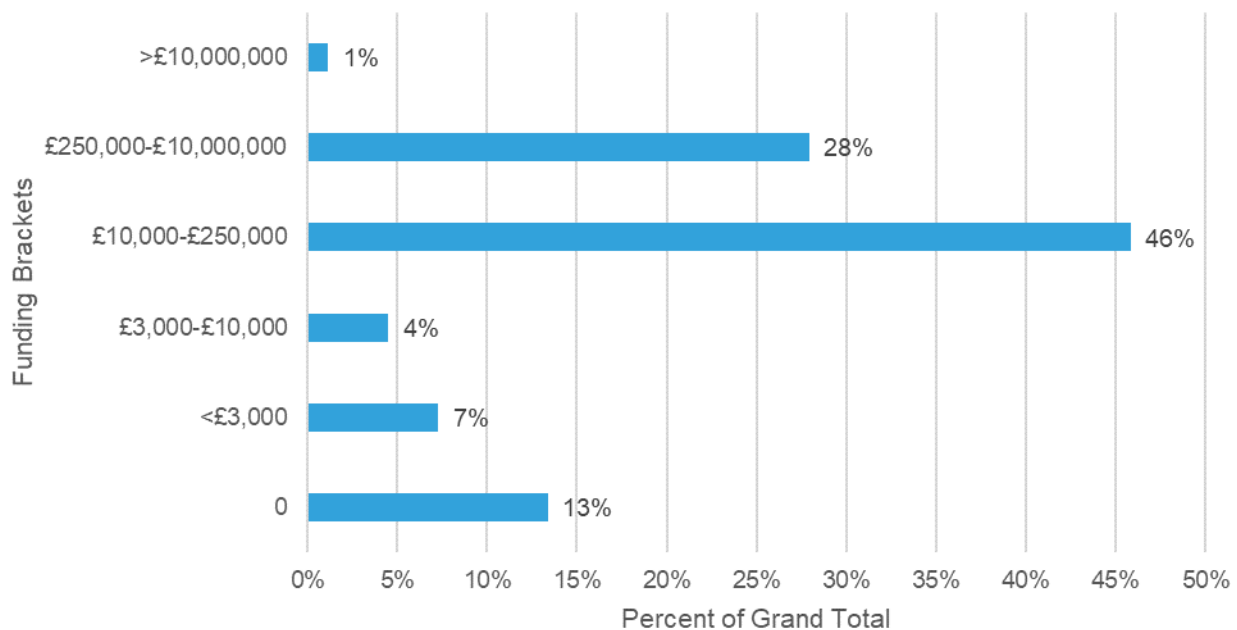


Figure 15. Distribution of research within each funding bracket.

The £10,000-£25,000 bracket represented 46% of the total, whilst £250,000-£10,000,000 bracket represented 28% (Figure 15). Research with no funding represented 13% of the total, whilst the smaller funding brackets of less than £3,000 and £3,000-£10,000 represented 7% and 4% of the total respectively. Within the UKRI dataset several results have erroneously assigned a funding value of 0 in their public database, however this does not represent the actual funding amount, which in these cases is unknown.

The £3,000-£10,000 bracket was represented almost entirely by Historic England projects (apart from a single piece of research undertaken by the Lancaster Institute for the Contemporary Arts (CCH77)).

A significant number of entries fell within the £250,000-£10,000,000 bracket, although a review of the average amount of funding within this bracket was £540,000, demonstrating that most of the entries were towards the lower end of the scale. This average was, however, only informed by UKRI entries where the actual funding amounts were available.

Broken down by the funding body type (Figure 16), most research projects funded by Research Councils fell within the £10,000-£250,000 bracket and the £250,000-£10,000,000 bracket. Regulatory and Arm's-Length bodies also predominantly fund in the £10,000-£250,000 bracket and, in comparison to Research Councils, provide little funding in the higher £250,000-£10,000,000 bracket. As mentioned previously, projects in the £3,000-£10,000 bracket were almost entirely undertaken by Historic England.

No key trends were immediately identified when breaking down the funding amounts into each Research Area (Figure 17). Generally, the relative spread of funding within each Area was similar, with the majority falling within the £10,000-£250,000 and £250,000-£10,000,000 range.

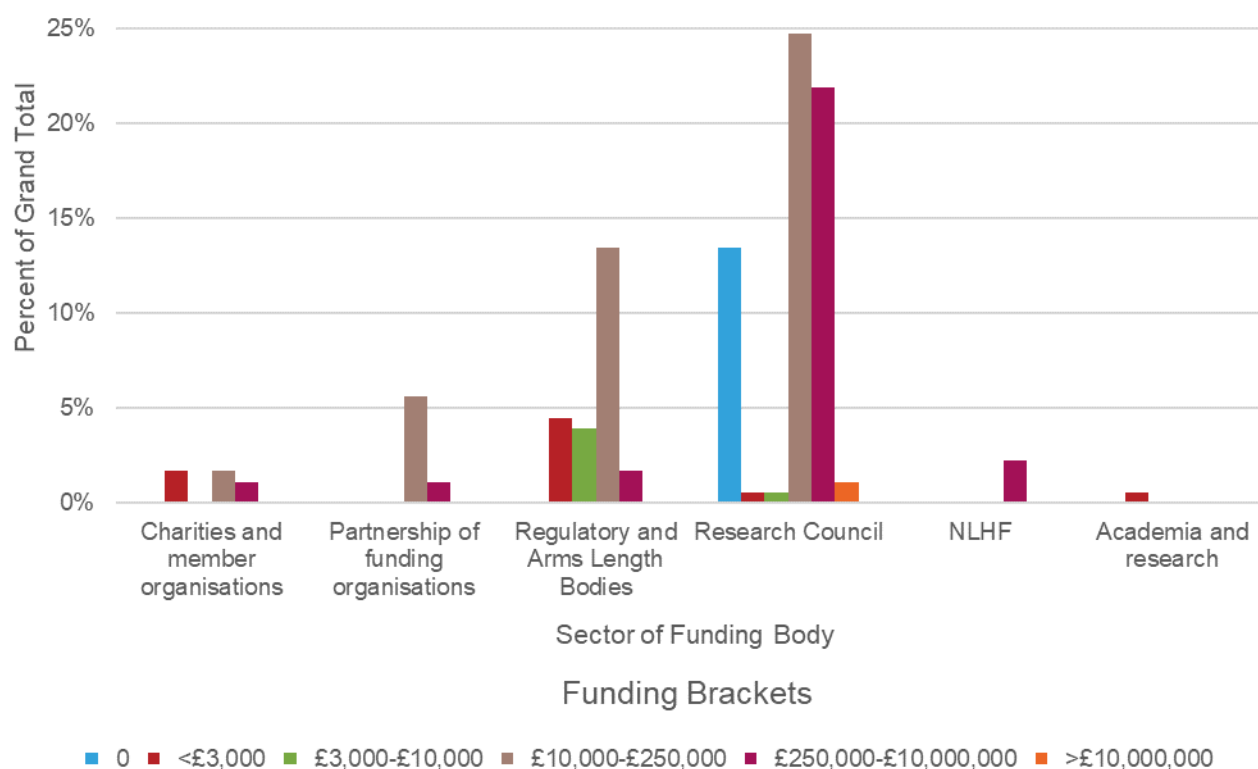


Figure 16. Amount of funding awarded by each funding body type.

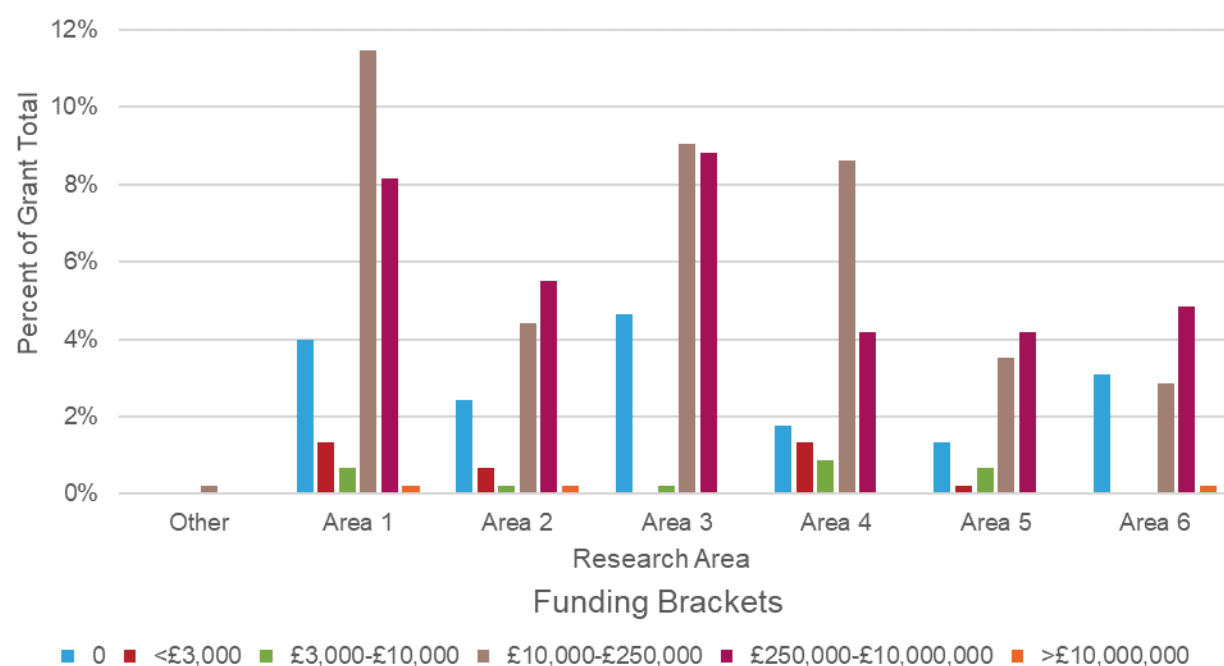


Figure 17. Amount of funding awarded to each Research Area, broken down by funding bracket.

Engagement outcomes and findings

The response-rate for the survey can be seen in Figure 18. Of the 173 organisations contacted, 32 organisations replied to the survey (34 responses were received in total, where multiple individuals from the same organisation replied separately). A further 14 organisations did not reply to the survey but were approached for telephone interviews bringing the total number contacted for engagement to 46. The percentage uptake on engagement was therefore 19% from the surveys and 27% total. A full list of contacts can be found in [Appendix 6](#).

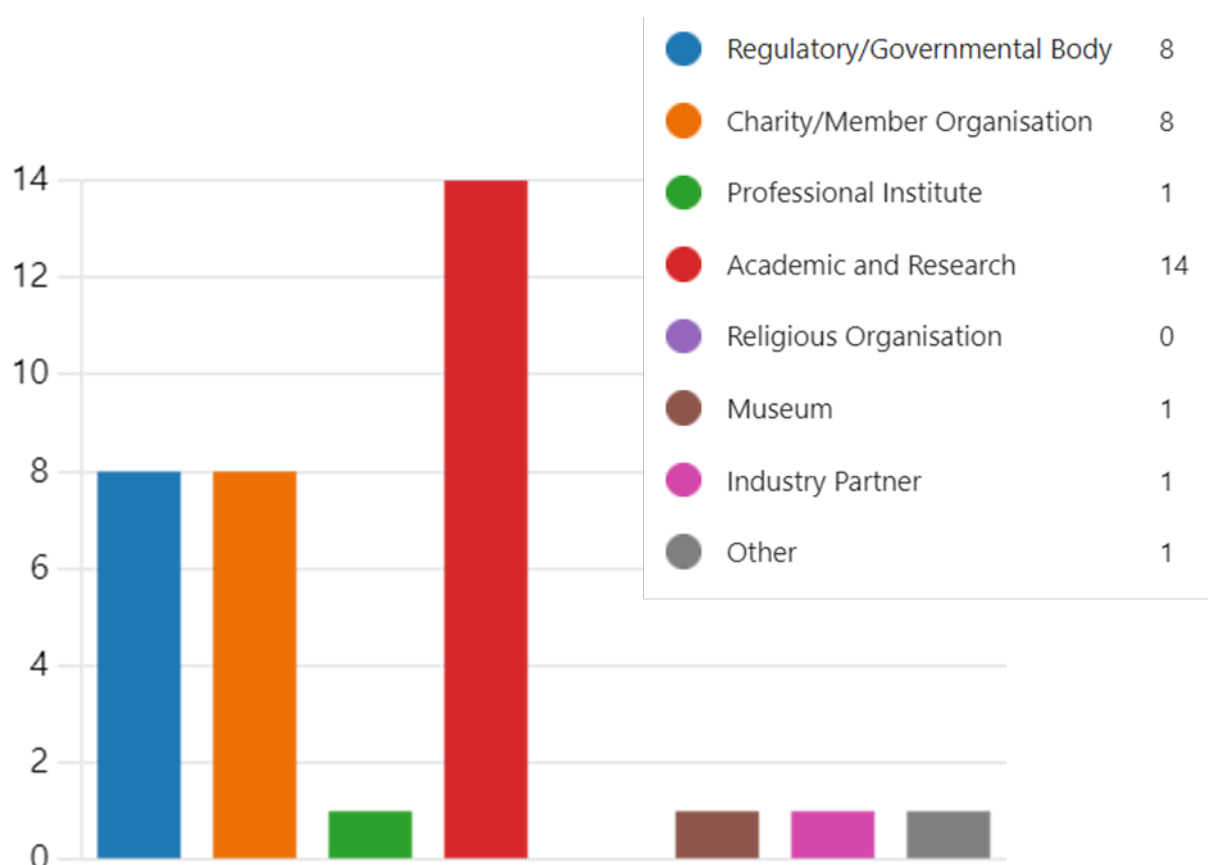


Figure 18. Survey respondents and their sectors.

Table 2: Organisations that make up the sectors of survey respondents graph above (Figure 18).

Sector type	Organisations
Regulatory/ Governmental Body	Cadw Surrey County Council Forestry Commission ALGAO Environment Agency RCAHMW Historic Environment Division (NI) Natural England
Charity/ Member Organisation	C20 Society UKGBC The Vindolanda Trust Architectural Heritage Fund Diocese of Salford Edinburgh World Heritage Trust The British Council MOLA
Professional Institute	Chartered Institute of Building
Academic & Research	Welsh School of Architecture, University of Cardiff University of Cardiff University of Liverpool Aberystwyth University University College Cork University College London St Mary's University, Twickenham Cardiff Metropolitan University University of Birmingham University of Cambridge University of St Andrews University of Glasgow The Open University Leeds Beckett University
Religious Organisation	None
Museum	Horniman Museum and Gardens
Industry Partner	Pvotal Consultancy Ltd
Other	None

The response rate from Government Departments and Arm's-Length Bodies was low, particularly from non-heritage/natural environment associated bodies. Whilst a response was received from the Environment Agency, they did not identify any relevant research where they were the lead organisation. Furthermore, the response from Professional Institutes, Religious Organisations, Museums, and Industry Partners was low.

A total of 31 organisations were identified for follow-up telephone interviews. 20 interviews were undertaken, and 12 interviews were taken forward to use as case studies. Details for each case study are provided in [Appendix 1](#). It should be noted that those who were contacted for telephone interviews, and the subsequent choice of case studies, were heavily influenced by which organisations were responsive to engagement through the survey, although 14 organisations that did not reply to the survey were also contacted.

As well as collecting information for case studies, additional questions were posed to interviewees to understand their views on the research landscape for climate change and heritage. The key themes discussed in the interviews are summarised in the next section.

Key themes identified through conversations

Research agendas

Interviewees were asked whether climate change is a priority area for their organisation or department. The answer was overwhelmingly yes, reflecting active engagement and prioritisation of climate change within the group. Whilst this group may not be representative of the sector as a whole, a significant number of interviewees were responding on behalf of national organisations and bodies or addressing work funded by them. This underscores a broader recognition of the importance of climate change in strategic planning and direction.

They were also asked whether their research agenda considers the impacts of climate change upon heritage, or the impacts of our reaction to climate change upon heritage. Approximately 75% of people who answered this question said yes and 30% said either no or that they do not have a research agenda.

When asked how they prioritise their research focus, a variety of answers were provided, including:

- Organisational/departmental strategy
- Policy
- Funding availability
- Geographic location

- To fill data gaps
- Personal interest.

Research and industry networks

Interviewees were a part of a range of research and industry networks depending on their specialisms and areas of work:

- Archaeological Research Frameworks relating to locations and/or disciplines/specialist topics
- Management and Partnership Boards for World Heritage Sites
- National Retrofit Hub
- Low Energy Transformation Initiative (LETI)
- Net Zero Carbon Buildings Standard
- UK Centre for Moisture in Buildings
- Scottish Blue Carbon Forum
- UK Blue Carbon Forum
- UN Ocean Decade Programme
- Heritage adaptation group
- Academic groups including international networks.

Research strengths

Interviewees perceived research to be strong when:

- Useable outputs were produced, such as a centralised information source (*Climate Change Risk Assessment for the Old and New Towns of Edinburgh World Heritage Site*, CCH88).
- Outputs empowered communities and connected to local people (*Guardians of Creation* (CCH196).
- Research was multidisciplinary and established collaboration networks/partnerships (*C-SIDE*, CCH152).
- Research used innovative and holistic approaches (*Running out of time? Peatland rehabilitation, archaeology and ecosystem services*, CCH112).
- Research worked to fill known data gaps within the sector (*Low Energy Retrofit of Historic Timber-Framed Buildings in the UK*, CCH193).

Strengths are discussed in further detail in [Appendix 1 – Case Studies](#).

Barriers and drivers

The main barriers and the main drivers to research around climate change and heritage were explored with interviewees. Several factors were mentioned in both categories, indicating the complexities of undertaking research in this area. For example, policy and funding were mentioned as both barriers and drivers, often by the same interviewee. This illustrates how policy and funding can significantly drive research in certain areas, while their absence can impede progress in others.

Another barrier mentioned by interviewees was public perceptions of heritage. This included lack of public interest in heritage in some cases, but also in cases where heritage was valued by the public, they often did not want to see change or adaptation relating to climate change, such as with *Reconstructing the Wildscape* (CCH44). Additionally, the variability of heritage assets was said to be a barrier; designing generic mitigation and adaptation measures can be difficult when each asset is so different, such as with the *Guardians of Creation* (CCH196) project. Other barriers comprise lack of collaboration across the sector (sometimes resulting in duplication of work), data gaps, lack of resources within organisations and departments, and a lack of guidance.

Drivers to research around climate change and heritage identified included changes in public perception, improved valuation of heritage assets, individual interests of researchers, increased industry interest, and tourism.

Collaboration

Nearly all interviewees said that collaboration could be improved across research in climate change and heritage. Some acknowledged that this has improved over time and continues to do so but recognised that collaboration is not consistent enough. One person mentioned that networks often “arise and then get abandoned”.

When asked how easy or difficult it is to find out what others are doing in the sector, it was frequently mentioned that it is easier in academic circles than it is across the sector in general. It has been observed that difficulties in discovering projects within the sector have sometimes led to duplicated efforts.

Actions to support climate change and heritage research

Interviewees were questioned about the support they or their organisation would deem most beneficial for addressing the impacts of climate change on heritage and the historic environment. Factors mentioned in responses included:

- Centralised, national database of ongoing/completed research in this area
- Standardisation in data collection, format, management, and terminology
- Creation of a simple toolkit to aid consideration of climate change impacts on heritage
- National research framework
- Specific remit for this area in government
- Improved collaboration
- Consideration of non-designated assets
- Training and capacity building
- Improved guidance for homeowners – interviewees suggested that guidance can sometimes lead to decision paralysis through fear of negatively affecting heritage values⁶.

6 The recently published 'Adapting Historic Buildings for Energy and Carbon Efficiency' Historic England Advice Note 18 (HEAN) guidance may help address this gap. <https://historicengland.org.uk/images-books/publications/adapting-historic-buildings-energy-carbon-efficiency-advice-note-18/>

Discussion of research areas

1: Research developing models and assessing long-term impacts of climate change on heritage

Key trends and general scale of research and funding

It appears that the majority of current research into the impacts of climate change on heritage, or our responses to it, primarily focusses on assessing the long-term impacts of climate change (Area 1). It was also seen that Area 1 is often a secondary interest of many projects, hence its high representation in the matrix analysis.

The three most prolific sectors within Research Area 1 are Academic and Research, Charities and Member Organisations and Regulatory and Arm's-Length Bodies. Within Area 1, there are no specific academic institutions doing more work than others, with a wide range of organisations involved in this Area. Within the Charities and Member organisation category, the National Trust represent the majority of the projects (12 of 20). Historic England is a key contributor in the Regulatory and Arm's-Length Bodies sector.

The National Trust and Historic England are undertaking a large proportion of the identified research in this area, particularly at a strategic level. Other organisations in this category undertaking strategic-level work include the Woodland Trust and UK Green Building Council (UKGBC). Work by other Regulatory and Arm's-Length Bodies is also strongly represented within this category; this research is usually UK-wide, strategic-level research to inform policy and practice, guidance and resources. Key research leads, aside from Historic England, include Forestry Commission, BEIS, Cadw, the Royal Commission on Ancient and Historical Monuments of Wales, City of London Corporation, the Climate Change Committee, the British Council, Historic Environment Division (NI), and Historic Environment Scotland. Most of this work is strategic-level research, developing guidance and resources.

It is likely that Natural England is undertaking research or accumulating unpublished expert knowledge relevant to this Area that has not been captured. During interviews with Natural England, it was highlighted that at an individual and team level, best practice and knowledge was being accumulated, but not published or synthesised because the team was working in implementation and delivery, rather than at a strategic level. Furthermore, Natural England highlighted that much of the research they are involved with that is published is made public via partner websites and outputs, rather than a central Natural England repository. For this reason, there is also likely to be work by Natural England in other Areas, particularly Area 6, which has not been captured.

Organisations such as the Vindolanda Charitable Trust, Edinburgh World Heritage Site, and the Diocese of Salford are conducting location-specific work. Despite its localised nature, this work is likely to yield findings with broader applicability.

Notable project partners working with the lead organisations within this Area include Natural Resources Wales, the Met Office, the Climate Heritage Network and ICOMOS.

Of the 159 projects within this area, 33 projects have been identified to be part of wider funding/research programmes and are identified as such within the matrix. Significant wider funding/research programmes include:

- National Trust Climate Change Programme
- UK Climate Resilience Programme
- International Co-Sponsored Meeting on Culture, Heritage and Climate Change (ICSM CHC)
- Third round Adaptation Reporting Power call
- Climate Change Risk Assessment (CCRA) Programme
- Embedded Researcher Scheme - UK Climate Resilience Programme
- Isle of Axholme & Hatfield Chase Partnership
- Horizon Europe
- Horizon Europe Guarantee
- Future of UK Treescapes
- Culture and Heritage Capital Programme
- Landscape Decisions
- GW4 Building Communities Programme
- International Energy Agency (IEA) Energy in Buildings and Communities (EBC) programme – Annex 89 – Ways to Implement Net-zero Whole Life Carbon Buildings
- Climate for Nature
- Heritage on the Edge
- Guardians of Creation Project
- Cultural Protection Fund
- Natural Capital and Ecosystem Assessment Programme (DEFRA)
- Historic Environment Scotland's Climate Vulnerability Index (CVI) methodology – applied across several projects.

No specific trends were seen in the amount of funding awarded to any one Area. However, within Area 1, Research Councils, followed by Regulatory and Arm's-Length Bodies fund the most projects. 159 entries in the matrix were attributed to Research Area 1. NERC is a

key funder within this Area, with 37 entries attributed to them, with SPF being the second most prolific funder (23 entries). As NERC and SPF are not explicitly linked with heritage, their high representation within the matrix, both within Area 1 and across all themes, illustrates the importance of engaging with research that may not appear at first to be relevant to heritage. A further 23 projects were funded through the AHRC and 14 through Historic England. Horizon Europe Guarantee were the only other notable funder under this research area, with 7 entries.

Table 3 shows an analysis of central Government Department involvement in research Area 1 projects. Within Area 1:

- 3 of 159 projects are **led** by Government Departments.
- 4 of 159 projects are **funded** by Government Departments.
- 11 of 159 projects are **partnered** with Government Departments.

Table 3: Government Department involvement in Research Area 1, highlighted in green.

Project	Code	Lead	Funder	Partners	Wider programme
Future of wind driven rain mapping	CCH1	DESNZ (previously BEIS)	DESNZ (previously BEIS)	Historic England	Unknown
UK Fourth Climate Change Risk Assessment	CCH33	Climate Change Committee	UK Government	N/A	The CCRA programme
mNCEA: Marine natural capital and ecosystem assessment programme	CCH245	DEFRA	DEFRA	Natural England, Historic England, Centre for Environment Fisheries & Aquaculture Science, Environment Agency, Joint Nature Conservation Committee, Marine Management Organisation	Natural Capital and Ecosystem Assessment Programme
Forests Fit for the Future	CCH252	DEFRA	DEFRA	Forest Research, Forestry Commission	Forest Research Trees and Forestry evidence programme (DEFRA)

Project	Code	Lead	Funder	Partners	Wider programme
Communicating Material Cultures of Energy: Five Challenges for Energy Communication	CCH43	Science Museum Group, Science Museum Research	AHRC	Includes BEIS	Not provided
Greenhouse Gas Removal Plus (GGR+): Sustainable Treescape Demonstrator & Decision Tools	CCH71	University of Exeter, Economics	SPF	Includes DEFRA and HM Treasury	Not provided
Mobilising Adaptation: Governance of Infrastructure through Coproduction (Topic B)	CCH76	University of Sheffield, Urban Studies and Planning	SPF	Includes DEFRA	Not provided
Sustainable development and resilience of UK coastal communities	CCH83	University of Exeter, Geography	SPF	Includes DEFRA	Not provided
School Buildings Adaptation, Resilience and Impacts on Decarbonisation in a Changing Climate (ARID)	CCH87	University College London, Bartlett School of Environment, Energy & Resources	SPF	Department for Education (DfE)	Not provided
DEFRA Embedding Economics into the Fourth UK Climate Change Risk Assessment	CCH108	School of Oriental and African Studies, Politics and International Studies	ESRC	DEFRA	Not provided

Project	Code	Lead	Funder	Partners	Wider programme
Changing Treescapes: Making visible the cultural values at risk from tree pests and diseases through arts approaches	CCH115	University of Gloucestershire, Countryside and Community Research Institute	SPF	DEFRA	Not provided
Understanding ecosystem stocks and tipping points in UK blanket peatlands (short form: Peatland Tipping Points)	CCH119	University of Newcastle, School of Natural & Environmental Sciences	NERC	Includes DEFRA	Not provided
Understanding the Value of Outdoor Culture and Heritage Capital for Decision Makers	CCH120	University of Exeter, Economics	AHRC	Includes DCMS	Culture and Heritage Capital Programme
Learning to adapt to an uncertain future: linking genes, trees, people and processes for more resilient treescapes (newLEAF)	CCH122	UK Centre for Ecology & Hydrology, Biodiversity (Penicuik)	NERC	Includes DEFRA	
Programme Coordination Team, Landscape Decisions - Towards a new framework for using land assets	CCH127	University of Leicester, School of Geography, Geology & the Environment	SPF	Includes the Crown Estate, HM Government, Ministry of Defence, DLUHC, DEFRA, Cabinet Office	Landscape Decisions

Nature of the research and potential gaps

The below case studies illustrate the nature of research in Area 1, with more detail provided in [Appendix 1](#) (where noted). Much of the research in this Area focusses on identifying climate hazards and impacts and using this information to develop adaptation and climate-resilient approaches. While some research is specifically designed to address heritage-focused questions, other studies, though not initially aimed at the historic environment, remain relevant to heritage managers and policymakers. An example of the former type is *CLIMA-Lev* (CCH129), which sought to understand the impact of weathering on historic buildings and to use this knowledge to develop self-healing mortars for heritage buildings. Another example is UCL's *Data-driven climate change risk assessment for heritage in England* (CCH10). Examples of the latter are *MEDiate* (CCH99) and *Sentinel treescapes for bio-security and risk management* (CCH168); these projects are less immediately relevant for heritage, but the findings may have relevance for heritage policymakers.

CLIMA-Lev (Climate Change – Leverhulme project) – CCH129

Lead: Cardiff University.

Funding: GW4 Building Communities Programme.

Timescale: 2023.

Aims and outcomes:

- To understand past and future impacts of weathering on built heritage.
- To use accelerated aging experiments to understand material degradation patterns.
- To design solutions tailored to challenges.
- To develop self-healing mortars for conservation to increase the resilience of historic buildings.
- Support future funding bids.
- Bring together academics and key stakeholders, including CADW and Historic England.

Partners: University of Bath, University of Bristol, University of Exeter.

MEDiate: Multi-hazard and risk informed system for Enhanced local and regional Disaster risk management – CCH99

Lead: NORSAR.

Funding: Horizon Europe.

Timescale: September 2022 – September 2025.

Aims:

- To develop a Decision Support System (DSS) for disaster risk management by considering multiple interacting natural hazards and cascading impacts using a novel resilient-informed and service-oriented approach.

Outcomes:

- The outcome will be a decision support framework in the form of a service-oriented web tool and accompanying disaster risk management framework providing end users with the ability to build accurate scenarios to model the potential impact of their mitigation and adaptation risk management actions.
- Scenarios can be customised to reflect local conditions and needs and will be based on a combination of the historical record and future climate change projections to predict impacts.

Partners: University College London, University of Strathclyde; Essex County Council; Anglia Ruskin University.

Sentinel treescapes for bio-security and risk management – CCH168

Lead: Fera Science.

Funding: £250,000 through SPF.

Timescale: August 2020 – March 2023.

Aims:

- To develop a monitoring system in locations likely to provide an early warning of pest and disease spread or in locations of importance for conservation, cultural reasons or public safety.
- Combine observations from sensors attached to individual trees with visual observations to estimate tree health and detect changes.
- Develop a web-based interface and models to explore the efficiency and cost-effectiveness of different designs of sensor networks.

Outcomes:

- Demonstrated a sentinel treescape digital environment of in-situ sensors, drone and satellite observations to monitor tree health and stability, allowing early-stage detection of stress.
- Integrated data layers across multiple spatial and temporal scales to determine sensitivity to tree health status.
- Used agent-based and network modelling approaches to assess the cost effectiveness of different sensor combinations and configurations.

Partners: University of Newcastle, University of Strathclyde, UK Centre for Ecology & Hydrology, DEFRA.

Of the 159 projects in this Research area, the split between the sub-Areas is:

- 63 relate to climate risk/hazard mapping (Area 1.1), of which only 11 identify 1.1 as their only sub-category.
- 19 relate to climate risk/hazard monitoring (Area 1.2), of which only 7 identify 1.2 as their only sub-category.
- 99 relate to developing adaptation & mitigation resources (Area 1.3), of which only 11 identify 1.3 as their only sub-category.
- 82 relate to developing policy and guidance (Area 1.4), of which only 3 identify 1.4 as their only sub-category.

The high number of projects within Areas 1.3 and 1.4 reflect many organisations identifying and ‘mapping’ climate change hazards and risk and using their research to develop policy, guidance, or resources for adaptation, resilience and mitigation. This includes projects such as Edinburgh World Heritage Site’s CCRA (see *below* for detail).

Much of the research is focussed on climate risk more generally, rather than mapping or monitoring a specific climate hazard. Exceptions to this include projects such as BEIS’ (now DESNZ) *Future wind driven rain mapping* project (CCH1). The research appears to have good coverage over both the general spatial risks of climate change (such as the National Trust’s *Climate Change Hazard Map*’ (CCH9)), which can identify historic landscapes and areas at risk, and over asset specific risks, such as:

- Ancient woodlands: Woodland Trust, Highest climate change risks for ancient woodlands project (CCH8).
- Archaeology: Historic England, Archaeological Sensitivity Pilots (CCH4) or the Vindolanda Trust Monitoring the buried archaeology of Vindolanda and Magna projects (CCH7 and CCH15).
- Coastal heritage: Historic England, Coastal monitoring for heritage (CCH45) and .Level of threat and time estimates of loss of coastal heritage (CCH146).
- Historic buildings: University of Manchester, Developing an urban heat resilience plan for Bristol (CCH135).

The projects at Vindolanda (CCH7) and the Edinburgh World Heritage Site (WHS) (CCH88) are two examples of site-specific research that will generate findings and approaches applicable to other sites and more widely. The Edinburgh WHS CCRA (CCH88), for example, was community-based, engaging a wide range of people on their experiences of the World Heritage Site, allowing a place-based assessment of risk.

Such approaches demonstrate the significance of local knowledge and values in informing CCRAs of assets and places that hold importance for many communities for diverse reasons.

Climate Change Risk Assessment for the Old and New Towns of Edinburgh World Heritage Site – CCH88

Lead: Edinburgh World Heritage Site (WHS).

Funding: £10k-£250k - Place-Based Climate Action Network (P-CAN) and EU funded Atlas.WH project.

Timescale: August 2020 - November 2021.

Aims:

- Understand the impacts of climate change on WHS and their communities.

Outcomes:

- Identified the impacts of climate change on WHS and their communities
- Undertook extensive community engagement and raised awareness
- Generated a robust dataset to inform long-term strategy and climate actions
- Created a versatile climate change risk assessment methodology that could be applied to 'urban' World Heritage properties.

Partners: City of Edinburgh Council, Historic Environment Scotland, Sniffer, the Edinburgh Climate Change Institute, the University of Edinburgh, and Edinburgh Adapts.



Photo credit: Dorothy Graves McEwan, JBA Consulting.

A more detailed case study is available in [Appendix 1](#).

Monitoring the buried archaeology of Vindolanda – CCH7**Lead:** Vindolanda Trust.**Funding:** Vindolanda Trust.**Timescale:** Ongoing.**Aims:**

- Information from weather stations at the site is being combined with information from buried probes which are monitoring water level, oxygen, soil moisture, and pH. This will allow an assessment of how much climate change can impact buried archaeology.

Outcomes:

- Ongoing project so final results are not yet available. However, early trends show a direct link between the condition of buried deposits and the weather pattern above the ground.
- Collecting novel data: sustained hydrological monitoring at a waterlogged site will increase understanding of the impact of climate change on buried archaeological remains and deposits.

Partners: None identified.

A more detailed case study is available in [Appendix 1](#).

2: Research on the impact on heritage of flooding and coastal erosion and our responses to these

Key trends and general scale of research and funding

Area 2 was not highly represented amongst the research collated. 65 entries in the matrix were attributed to Research Area 2. This may be because it is less broad than Area 1, so has captured a more focussed selection of research. As with all Areas, Academic and Research organisations are the most prolific within this area. Charities and Member Organisations, and Regulatory and Arm's-Length Bodies, are also represented, but much less so than Academic and Research organisations. The National Trust represent all the work by the Charity and Member Organisation sector for this Area.

Regulatory and Arm's-Length Bodies are represented by Historic England, RCAHMW, Historic Environment Scotland, DEFRA, and FloodRe. The Environment Agency is absent as a lead organisation. As mentioned in the limitations section, this absence may be because ongoing research in this area, it is not heritage-driven. Consequently, it was not recognised as relevant during the survey phase and therefore is not included in the matrix.

The Environment Agency were engaged through the telephone interviews but only two pieces of research were identified as having specific relevance. One was *Adaptive Release: Guidance Framework for Sites Affected by Coastal Erosion and Flood Management* (CCH141); the Environment Agency is a partner on this project, with Historic England as lead organisation. The Environment Agency were also identified as a partner in the Museum of London Archaeology (MOLA) *Coasts in Mind* project (CCH138).

The under representation from Regulatory and Arm's-Length Bodies in this Area may be due to the difficulty engaging them. It may also reflect a more wide-scale pattern of researchers and practitioners outside of the heritage sector failing to explicitly link flooding and coastal erosion impacts with the risks they pose to heritage.

A notable project partner to lead organisations within this Area is the Environment Agency; most other partner organisations are universities.

Of the 65 projects within this area, 6 projects have been identified to be part of wider funding/research programmes. Notable amongst these are:

- UK Climate Resilience Programme
- Isle of Axholme & Hatfield Chase Partnership
- Horizon Europe
- CITiZAN (Coastal and Intertidal Zone Archaeological Network)
- Thames Discovery Programme
- Heritage on the Edge
- UK Blue Carbon Evidence Partnership (UKBCEP) – UK Government.

Within Area 2, Research Councils, followed by Regulatory and Arm's-Length Bodies fund the most projects. NERC was again the most prolific funder in Area 2, with 19 entries. SPF had 15 entries, whilst the AHRC had 10. Also prominent under this Research Area were the National Trust, who had 4 entries, and Horizon Europe Guarantee who had 5. Historic England funded 3 projects within this Area; they were projects led internally rather than being projects led by other organisations and funded by Historic England.

Table 4 shows an analysis of central Government Department involvement in Research Area 2 projects. Within Area 2:

- 1 of 65 projects is **led** by a Government Department.
- 1 of 65 projects is **funded** by a Government Department.
- 5 of 65 projects are **partnered** with a Government Department.

Table 4: Government Department involvement in Research Area 2 highlighted in green.

Project	Code	Lead	Funder	Partners	Wider programme
DEFRA Flood Asset Review	CCH139	DEFRA	DEFRA	Historic England	No
Greenhouse Gas Removal Plus (GGR+): Sustainable Treescapes Demonstrator & Decision Tools	CCH71	University of Exeter, Economics	SPF	Includes DEFRA and HM Treasury	Not provided
Mobilising Adaptation: Governance of Infrastructure through Coproduction (Topic B)	CCH76	University of Sheffield, Urban Studies and Planning	SPF	Includes DEFRA	Not provided
Sustainable development and resilience of UK coastal communities	CCH83	University of Exeter, Geography	SPF	Includes DEFRA	Not provided
School Buildings Adaptation, Resilience and Impacts on Decarbonisation in a Changing Climate (ARID)	CCH87	University College London, Bartlett School of Environment, Energy & Resources	SPF	DfE	Not provided
Carbon Storage in Intertidal Environments (C-SIDE)	CCH152	University of St Andrews, Geography and Sustainable Development	NERC	Includes DEFRA	UKBCEP work for the UK Government

Nature of the research and potential gaps

The below case studies illustrate the nature of research in Area 2, more detail is provided in [Appendix 1](#). Of the 65 projects in this Research area, the split between the sub-Areas is:

- 31 relate to flooding and extreme events (Area 2.1).
- 26 relate to coastal change and sea level rise (Area 2.2).
- 28 relate to change in marine environment (Area 2.3).
- 8 relate to managed realignment and coastal retreat (Area 2.4).
- None relate to no further intervention (Area 2.5).
- 1 relates to hard engineering (rock armour and similar) (Area 2.6).

A large portion of research in this Area relates to projects developing policy and guidance for creating more resilient solutions to flood and coastal erosion management, although many of these are related to wider policy and guidance rather than focusing specifically on the impact on heritage. An example of a policy driven project is English Heritage's *Coastal Connections* (CCH246), although in this case, the project is specifically thinking about the risk to heritage. The project will develop management principles that could be applied elsewhere, particularly as the project will engage with adaptive release approaches.

Approximately 25 projects are related specifically to heritage and of these the majority are related to coastal erosion, such as the *CHERISH* project (CCH48), which aims to increase awareness and understanding of the impacts of climate change on Irish and Welsh heritage assets of the sea and coast. The local level 'toolkit' approach is likely to be applicable more widely.

Several projects are looking to understand the spatial risks of climate change in terms of flooding and coastal erosion. An example of this is a project by the Historic Environment Division (NI), who are using the National Trust climate hazard maps to develop a prioritisation and risk assessment framework for assets in State Care (CCH31). Whilst the first pilot concentrated on an inland priory, the next pilot is planned for the coastal Dunluce Castle to compare the differences between a sheltered priory and an exposed coastal site. As the project progresses, the aim is to develop a framework that can be tailored to the historic asset and the climate drivers specific to that asset and area; the framework could be used across the sector.

Coastal Connections – CCH246

Lead: English Heritage.

Funding: English Heritage and World Monuments Fund.

Timescale: Unknown.

Aims:

- Safeguard the world's most treasured places.
- Form a global network of coastal heritage sites by bringing together communities and organisations to share their knowledge and expertise.

Outcomes:

- Will develop tools and principles for guiding future management decisions.
- Will engage with approaches such as 'adaptive release' that become necessary when protection becomes unsustainable in the face of climate change.

Partners: None identified.



Hurst Castle. Photo credit: Stuart Noon, JBA Consulting.

CHERISH Project – CCH48

Lead: RCAHMMW.

Funding: €4.9 million through the Ireland-Wales Programme 2014-2020, part of the European Regional Development Fund.

Timescale: January 2017 to July 2023.

Aims:

- Raise awareness and understanding of the past, present and near-future impacts of climate change on the cultural heritage of seas and coasts in Ireland and Wales.

Outcomes:

- Guidance document produced to share the CHERISH 'toolkit' approach, exploring different survey techniques alongside case studies.

Partners: Aberystwyth University, Discovery Programme, Geological Survey Ireland.

A more detailed case study is available in [Appendix 1](#).

State Care Climate Change Vulnerability Pilot – CCH31**Lead:** Historic Environment Division in Northern Ireland.**Funding:** Initially <£3,000, funded by the Department for Communities Northern Ireland. Now, in-house with no dedicated funding stream.**Timescale:** Ongoing.**Aims:**

- Provide an overview of climate change threats to, and vulnerability of, the State Care monument portfolio.
- Develop a framework through pilot studies that can be tailored to monuments at risk of climate driver impacts.

Outcomes:

- Ongoing project so outcomes are currently limited.

Partners: National Trust (scoping stage only) and Friends of Grey Abbey.**A more detailed case study is available in [Appendix 1](#).**

Of the research identified, the impact of coastal change appears to be the focus; flooding is not as well represented. This may again be due to research into the impacts of flooding not specifically considering relevance to heritage. It is possible that work, particularly on the impact of flooding on built assets, is ongoing but is not considering the specific risks relating to historic buildings and structures as part of the built environment. An exception to this is the research on adaptive release for assets impacted by flood management and coastal erosion (CCH141). This is significant as it is an emerging approach, with Historic England, the National Trust, and the Environment Agency involved in similar projects (CCH21 and CCH141).

3: Research on climate change and its potential impact on intangible heritage

Key trends and general scale of research and funding

When viewed simply (for example, Figure 3), Area 3 was the second most highly represented amongst the research collated. 104 entries in the matrix were attributed to Research Area 3.

When broken down by lead organisation sector (Figure 6), most research in Area 3 is being carried out by Academic and Research Bodies, with only a small amount by Charities and Member organisations and even less by other sectors. After Academic and Research who have 93 projects within the matrix, Charities and Member organisations are the most prolific sector with 6 projects.

No notable project partners within this Area have been identified. Similarly, few specific wider funding / research programmes have been pinpointed that are specific to intangible heritage. However, the Cultural Protection Fund, managed by the British Council in partnership with DCMS has been recognised.

Within Area 3, Research Councils fund the most projects, followed by a small number funded by Regulatory and Arm's-Length Bodies and Charities and Member Organisations. The key funders within this Area were similar to the previous two, with 37 projects funded through NERC, 24 projects funded through SPF, 19 projects funded through the AHRC and 9 through Horizon Europe Guarantee. Notably there were no projects funded in this Research Area by Historic England.

Table 5 shows an analysis of central Government Department involvement in Research Area 3 projects. Within Area 3:

- 0 of 104 projects are **led** by Government Departments.
- 0 of 104 projects are **funded** by Government Departments.
- 11 of 104 projects are **partnered** with Government Departments.

Table 5. Government Department involvement in Research Area 3, highlighted in green.

Project	Code	Lead	Funder	Partners	Wider programme
Greenhouse Gas Removal Plus (GGR+): Sustainable Treespaces Demonstrator & Decision Tools	CCH71	University of Exeter, Economics	SPF	Includes DEFRA and HM Treasury	Not provided
Mobilising Adaptation: Governance of Infrastructure through Coproduction (Topic B)	CCH76	University of Sheffield, Urban Studies and Planning	SPF	Includes DEFRA	Not provided
Sustainable development and resilience of UK coastal communities	CCH83	University of Exeter, Geography	SPF	Includes DEFRA	Not provided
DEFRA Embedding Economics into the Fourth UK Climate Change Risk Assessment	CCH108	School of Oriental and African Studies, Politics and International Studies	ESRC	DEFRA	Not provided
Changing Treespaces: Making visible the cultural values at risk from tree pests and diseases through arts approaches	CCH115	University of Gloucestershire, Countryside and Community Research Institute	SPF	DEFRA	Not provided

Project	Code	Lead	Funder	Partners	Wider programme
Understanding ecosystem stocks and tipping points in UK blanket peatlands (short form: Peatland Tipping Points)	CCH119	University of Newcastle, School of Natural & Environmental Sciences	NERC	Includes DEFRA	Not provided
Understanding the Value of Outdoor Culture and Heritage Capital for Decision Makers	CCH120	University of Exeter, Economics	AHRC	Includes DCMS	Culture and Heritage Capital Programme
Learning to adapt to an uncertain future: linking genes, trees, people and processes for more resilient treescapes (newLEAF)	CCH122	UK Centre for Ecology & Hydrology, Biodiversity (Penicuik)	NERC	Includes DEFRA	Future of UK Treescapes
Programme Coordination Team, Landscape Decisions - Towards a new framework for using land assets	CCH127	University of Leicester, School of Geography, Geology & the Environment	SPF	Includes the Crown Estate, HM Government, Ministry of Defence, DLUHC, DEFRA, Cabinet Office	Landscape Decisions
Carbon Storage in Intertidal Environments (C-SIDE)	CCH152	University of St Andrews, Geography and Sustainable Development	NERC	Includes DEFRA	UKBCEP work for the UK Government
Sentinel Treescapes for Plant Biosecurity and Risk Management - Multiple Threats	CCH168	Fera Science (United Kingdom), Plant Pest & Disease	SPF	Includes DEFRA	Not provided

Nature of the research and potential gaps

Of the 104 projects identified relating to Area 3, only 7 are attributed solely to Area 3.

Much of the work in this area has intangible heritage as a secondary focus after tangible heritage. The other main theme of the research is community voices and memory to inform project aims and outcomes (such as *The Historic Environment as an agent of change in the climate emergency: a community-centred approach* – CCH61) or using heritage to engage communities in discussions around climate change (such as *Once upon a time in a Heatwave* – CCH91). Less research focussed on the specific risk to/impact on intangible heritage from climate change.

A project by the British Council, *The British Council Strategic Literature Review: Climate Change Impacts on Cultural Heritage* (CCH243), is one of the few projects explicitly undertaking research on the risks to / impacts on intangible heritage. *Harbourview* (CCH147) and *Preserving Legacies* (CCH160) (outlined below and detailed in [Appendix 1](#)) are examples of projects that are considering the impacts/risk of climate change on cultural heritage through innovative methods. *Harbourview* and *Preserving Legacies* (CCH147 and CCH160) both illustrate that research of this type, when identified, is likely to be based at the local-level. This may explain the difficulty locating this type of research: if it is local-level and community led, it may not be undertaken by the national-scale organisations engaged through this project. Despite their local focus, projects like these may provide methodologies applicable elsewhere or on a national scale. Both projects illustrate the importance of engaging local communities in projects concerning intangible heritage.

There is potential that some projects in Research Area 4 (historic buildings) may include aspects affecting intangible heritage in the form of traditional craft skills relating to building practices and techniques; similarly, aspects of traditional land management may have been captured in several Research Areas. The relevance of this research may not have been explicitly recognised by survey respondents, interviewees or identified within project summaries.

Preserving Legacies: A Future for our Past – CCH160

Lead: The International Council on Monuments and Sites (ICOMOS).

Funding: Amount unknown, funded by The National Geographic Society with support from Manulife.

Timescale: Ongoing.

Aims:

- Increase access to heritage adaptation and transform heritage conservation to meet the challenges of the climate crisis.
- Empower every community with the scientific knowledge and technical training to achieve appropriate climate adaptation plans.
- Deliver an interactive training program to equip communities with the tools to minimise climate change impacts and maximise opportunities.

Outcomes:

- Ongoing project so outcomes are currently limited. Project will be taking place over the next decade.
- Results from Year One include partner led climate risk assessments from Jordan and the Philippines and a growing community of practice, with eight further sites actively involved.

Partners: Climate Heritage Network, the National Geographic Society, and Manulife Financial Corporation.

A more detailed case study is available in [Appendix 1](#).

Harbourview – CCH147

Lead: Centre for Sustainable Building Conservation, University of Cardiff.

Funding: £10,000 from the ESRC-IRC UK/Ireland Networking Grant.

Timescale: March 2021 to October 2022.

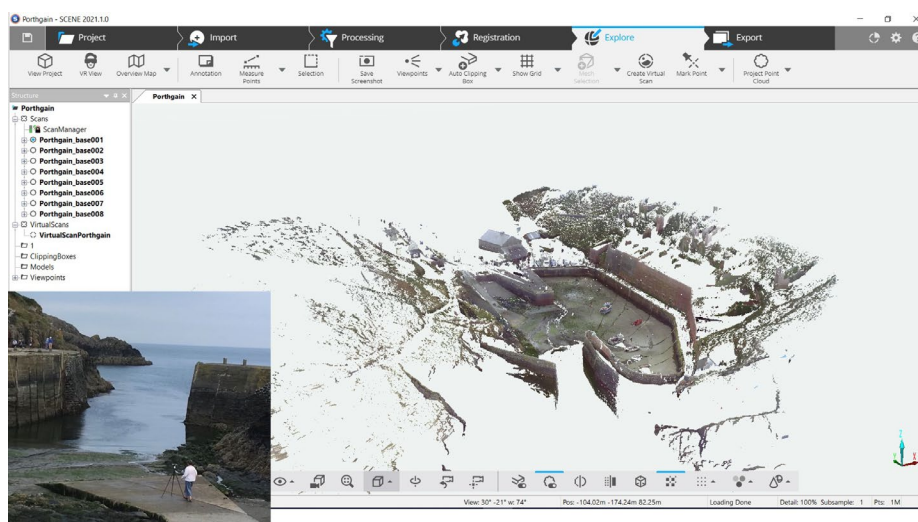
Aims:

- Document the historic harbours and generate a network across the coasts of Wales and Ireland that can build awareness of the importance of harbours as coastal heritage.

Outcomes:

- Photographed the historic harbours of Ireland and Wales to provide a description and generate a trilingual map which incorporated historic photographs and maps. Users could contribute material via an online form to share narratives.
- Various 3D models of four harbours created to support the project engagement. Models are available through the project website.
- Four workshops with a diverse range of stakeholders were held to raise awareness of the importance of harbours as coastal heritage.

Partners: University College Dublin.



Porthgain Laser scan: Low tide 8th September 2021. Photo credit: Oriel Prizeman and Stella Rhode.

A more detailed case study is available in [Appendix 1](#).

4: Research to inform best practice methods of maintenance, repair and adaptation (and maladaptation) of the historic building stock, including retrofit and energy performance, to meet challenges of climate change

Key trends and general scale of research and funding

Area 4 represented 18% of the total research collated, making it the third most researched topic after Area 1 and 3 respectively. 96 entries in the matrix were attributed to Research Area 4. As with all Areas, Academic and Research organisations are the most prolific within this Area, followed by Regulatory and Arm's-Length Bodies.

Research Area 4 is the Area in which Regulatory and Arm's-Length Bodies are most highly represented. Approximately two thirds of the projects by these bodies are from Historic England. This is likely due to the detailed data collected directly from Historic England through the project and may not represent the true breadth of research ongoing in this Area by other bodies. However, as mentioned above, collecting data on work done by other Regulatory and Arm's-Length Bodies was challenging, as engagement was low, and information is not easily accessible online. The other active organisations in this sector were Historic Environment Scotland, Cadw, the Climate Change Committee and the City of London Corporation.

It is also anticipated that wider studies into retrofit, building adaptation and energy efficiency which are not specifically targeted at heritage assets will include data and case studies relevant to the sector. However, it has been challenging to identify and capture these within the research matrix. These are also likely to include projects and programmes which are funded by, or partnered with, Government Departments.

The Open University, University of Cardiff and Leeds Sustainability Institute are key Academic and Research organisations researching in this Area. Charities and Member organisations are also undertaking a relatively high number of projects, with Edinburgh World Heritage Trust undertaking 3 of the 9 research projects

Notable strategic-level project partners within this Area include English Heritage, BEIS, Historic Environment Scotland, and the Institute of Historic Building Conservation (IHBC). English Heritage is undertaking research with Historic England into the suitability of Nanolimes for the consolidation of limestone (CCH177). BEIS was a partner in a National Trust early career fellowship looking at heritage sensitive carbon reduction and soft retrofit (CCH198). Historic Environment Scotland are a key partner in the work undertaken by Edinburgh World Heritage (CCH209, CCH210, and CCH211). IHBC is undertaking research into the pressures placed on historic buildings and landscapes to provide energy savings and energy generation (CCH197).

Of the 96 projects within this area, 15 projects have been identified to be part of wider funding/research programmes. Notable amongst these programmes are:

- Future of UK Treescapes
- Horizon Europe Guarantee
- GW4 Building Communities Program
- International Energy Agency (IEA) Energy in Buildings and Communities (EBC) programme – Annex 89 – Ways to Implement Net-zero Whole Life Carbon Buildings
- Embedded Researcher Scheme for the UK Climate Resilience Programme
- Landscape Decisions
- Guardians of Creations Project
- The UK Carbon Budgets (CCC)
- Edinburgh World Heritage conservation funding programme
- UK Government's plan for Net Zero.

Within Area 4, Research Councils fund the most projects. In this Area, Regulatory and Arm's-Length Bodies come much closer than in other Areas to matching the Research Councils in terms of numbers of projects funded. Historic England were the most prolific funder with 26 entries under this Area. NERC had 16 entries, SPF had 12 entries, the AHRC had 9 entries, and the Horizon Europe Guarantee had 5.

Table 5 shows an analysis of central Government Department involvement in Research Area 4 projects. Within Area 4:

- 1 of 96 projects is **led** by a Government Department.
- 3 of 96 projects are **funded** by a Government Department.
- 5 of 96 projects are **partnered** with Government Departments.

Table 6. Government Department involvement in Research Area 4, highlighted in green.

Project	Code	Lead	Funder	Partners	Wider programme
Adapting historic homes for energy efficiency: a review of the barriers	CCH251	DEZNS, DCMS, and DLHUC	DEZNS, DCMS, and DLHUC	Unknown	Part of UK Government's plan for Net Zero
The Demonstration of Energy Efficiency Potential (DEEP) project	CCH191	Leeds Sustainability Institute at Leeds Beckett University	DESNZ	Unknown	Unknown
UK Carbon Budget Progress Reports to Parliament	CCH206	Climate Change Committee	UK Government	Unknown	UK Carbon Budgets
Greenhouse Gas Removal Plus (GGR+): Sustainable Treescapes Demonstrator & Decision Tools	CCH71	University of Exeter, Economics	SPF	Includes DEFRA and HM Treasury	Not provided
Mobilising Adaptation: Governance of Infrastructure through Coproduction (Topic B)	CCH76	University of Sheffield, Urban Studies and Planning	SPF	Includes DEFRA	Not provided
School Buildings Adaptation, Resilience and Impacts on Decarbonisation in a Changing Climate (ARID)	CCH87	University College London, Bartlett School of Environment, Energy & Resources	SPF	DfE	Not provided
DEFRA Embedding Economics into the Fourth UK Climate Change Risk Assessment	CCH108	School of Oriental and African Studies, Politics and International Studies	ESRC	Includes DEFRA	Not provided
Learning from history: heritage sensitive carbon reduction	CCH198	National Trust	AHRC	Includes BEIS	No

Nature of the research and potential gaps

Of the 96 projects in this Research Area, the split between the sub-Areas is:

- 3 relate to flood proofing (Area 4.1).
- 31 relate to energy efficiency measures including insulation and retrofit of new technology, services and micro generation (Area 4.2).
- 8 relate to measures to prevent overheating (Area 4.3).
- 17 relate to material usage including low carbon materials and those which promote a circular economy, whilst also being appropriate to the heritage asset (Area 4.4).
- 14 relate to carbon reduction during maintenance and repair regimes of historic buildings (Area 4.5).
- 35 relate to low carbon and sustainable solutions for building services to respond to heating, cooling, water usage and drainage (Area 4.6).
- 11 relate to the effect of changing biota and their growth rates on material degradation (Area 4.7).
- 19 relate to how all of the measures identified in the other sub-Areas interact with historic building fabric and the unique challenges that historic buildings present (Area 4.8).

Unlike other Areas, much of the research in this area does relate specifically to historic buildings. A good example of the type of work ongoing into energy efficiency and retrofit measures is the work at the Open University (CCH202) described below. Edinburgh World Heritage is undertaking a project that exemplifies the type of work ongoing in the area, which will produce case studies on building adaptation to inform future guidance (CCH209). Both CCH202 and CCH209 will provide case study findings and approaches that can be applied across the sector.

Reducing Carbon while Retaining Heritage: retrofitting approaches for vernacular buildings and their residents – CCH202*

Lead: Open University.

Funding: £10,000-£250,000, funded by AHRC through the Design Star Centre for Doctoral Training.

Timescale: Published 2022.

Aims:

- Examined the potential for realistic carbon reduction through retrofit in vernacular buildings whilst retaining their heritage value.
- Assessed lifecycle modelling of retrofit options, including embodied carbon.

Outcomes:

- Positive synergies between measures with low embodied carbon and those acceptable to residents' heritage values
- Many buildings with heritage value have positive aspects relating to climate change impacts.
- Standard modelling tools poorly reflect vernacular buildings' performance and residents' behaviours.
- Embodied carbon of retrofits should be considered alongside operational savings.

Partners: None identified.



Cumbrian heritage building. Photo credit: Freya Wise, Open University.

A more detailed case study is available in [Appendix 1](#).

*PhD Thesis published at the Open University (CCH202). This thesis also produced other outputs, including a book chapter 'Embodied Carbon and building retrofit: A heritage example' (CCH218) in Area 5.

Practical Research as part of the Climate Emergency Grant (practical research as part of the conservation funding programme) – **CCH209**

Lead: Edinburgh World Heritage Trust.

Funding: £10,000-£250,000 through Historic Environment Scotland.

Timescale: December 2022 - September 2023.

Aims:

- The grant provides funding to private, public, and third sector organisations for targeted, small-scale energy efficiency improvements to historic windows/doors and climate change adaptation interventions to rainwater drainage systems.
- Conservation repairs will be at the core of the proposed interventions.
- To produce retrofit and climate change adaptation guidance that is place-based and relevant to historic buildings.

Outcomes:

- Creation of case studies that can inform future place-based guidance that is sensitive to Edinburgh's heritage.

Partners: Historic Environment Scotland

Manchester University are working with Bristol City Council to develop a Heat Vulnerability Index and Heat Resilience Plan (CCH135); this project is not specifically looking at heritage, but it may provide insights helpful for adapting and increasing the resilience of historic buildings

The low number of projects related to flood-proofing historic buildings reflects the gap noted in Area 2: that the impact of flooding on historic buildings appears to be less well researched or considered. Notably, in Area 4, all three projects relating to flood-proofing are led by Historic England. This may reflect that this kind of practice-level measure is being carried out at a local level or within individual Property Flood Resilience programmes, without any strategic level research or recent (post-2018) guidance specific to heritage buildings.

Developing an urban heat resilience plan for Bristol – CCH135**Lead:** University of Manchester.**Funding:** £10,000-£250,000 through NERC.**Timescale:** September 2021 – September 2022.**Aims:**

- Co-develop a Heat Vulnerability Index and a Heat Resilience Plan for the city of Bristol that will support the city council in developing strategies to reduce heat risk, adapt buildings and increase resilience.

Outcomes:

- Developed the Keep Bristol Cool mapping tool for policy makers and practitioners to explore how current heat vulnerability varies across different neighbourhoods and how climate change may increase temperatures in the future.
- Provided an insight into how urban heat risks vary across the city and within communities.
- Identified the areas where high temperatures and heatwaves could have the biggest impact on people's health and wellbeing.

Partners: Bristol City Council, Met Office.

5: Research on heritage, embodied carbon comparative carbon accounting in relation to historic assets

Key trends and general scale of research and funding

Area 5 was not highly represented amongst the research collated. 49 entries in the matrix were attributed to Research Area 5. As with all Areas, Academic and Research organisations are the most prolific. Regulatory and Arm's-Length Bodies and Charities and Member Organisations are also represented, but much less so than Academic and Research organisations.

Research in this Area is mainly carried out by Academic and Research Bodies and Regulatory and Arm's-Length Bodies. Regulatory and Arm's-Length Bodies are mainly represented by Historic England, although the City of London Corporation, the CCC, Association of Local Government Archaeological Officers, DCMS and DEFRA are also represented. Edinburgh World Heritage and the Diocese of Salford are the only charities represented. Across all research in this Area, a similar pattern is seen in the partner organisations, with most partners coming from academic and research organisations.

Of the 49 projects within this area, 14 projects have been identified to be part of wider funding/research programmes. Notable amongst these are:

- Horizon Europe Guarantee
- Future of UK Treescapes
- Culture and Heritage Capital Programme
- UK Blue Carbon Evidence Partnership (UKBCEP) - UK Government
- Landscape Decisions
- The UK Carbon Budgets (CCC)
- Edinburgh World Heritage conservation funding programme
- Guardians of Creation project
- Carbon Working Group for Heritage Organisations
- Natural Capital and Ecosystem Assessment Programme.

No specific trends were seen in the amount of funding awarded to any one Area. However, within Area 5, Research Councils, followed by Regulatory and Arm's-Length Bodies fund the most projects. NERC were the most prolific funder with 17 entries, 8 entries were funded through SPF.

Table 7 shows an analysis of central Government Department involvement in Research Area 5 projects. Within Area 5:

- 2 of 49 projects are **led** by Government Departments.
- 3 of 49 projects are **funded** by Government Departments.
- 4 of 49 projects are **partnered** within Government Departments.

Table 7: Government Department involvement in Research Area 5, highlighted in green.

Project	Code	Lead	Funder	Partners	Wider programme
Valuing culture and heritage capital: a framework towards informing decision making	CCH219	DCMS	DCMS	Historic England, Arts Council England, Macquarie University, Department of Economics	No
Marine natural capital and ecosystem assessment programme	CCH245	DEFRA	DEFRA	Natural England, Historic England, Centre for Environment Fisheries & Aquaculture Science, Environment Agency, Joint Nature Conservation Committee, Marine Management Organisation	Natural Capital and Ecosystem Assessment Programme
UK Carbon Budget Progress Reports to Parliament	CCH206	Climate Change Committee	UK Government	N/A	UK Carbon Budgets
Changing Treespaces: Making visible the cultural values at risk from tree pests and diseases through arts approaches	CCH115	University of Gloucestershire, Countryside and Community Research Institute	SPF	DEFRA	Not provided
Understanding ecosystem stocks and tipping points in UK blanket peatlands (short form: Peatland Tipping Points)	CCH119	Newcastle University, School of Natural & Environmental Sciences	NERC	Includes DEFRA	Not provided
Understanding the Value of Outdoor Culture and Heritage Capital for Decision Makers	CCH120	University of Exeter, Economics	AHRC	Includes DCMS	Culture and Heritage Capital Programme
Carbon Storage in Intertidal Environments (C-SIDE)	CCH152	University of St Andrews, Geography and Sustainable Development	NERC	Includes DEFRA	UKBCEP work for the UK Government

Nature of the research and potential gaps

Of the 49 projects in this Research Area, the split between the sub-Areas is:

- 8 relate to quantifying embodied carbon of heritage assets, including the historic building stock (Area 5.1).
- 3 relate to identifying and quantifying carbon sequestration opportunities associated with heritage assets (Area 5.2).
- 18 relate to comparative assessments of carbon footprints of materials used in the maintenance and restoration of heritage assets (Area 5.3).
- 5 relate to carbon emissions associated with archaeological techniques (Area 5.4).
- 22 relate to natural capital and ecosystems services approaches to valuing the landscapes and heritage (Area 5.5).

Much of the research in this area is around carbon accounting (CCH215 for example), for historic buildings. However, one project is looking to develop a carbon calculator for archaeological fieldwork (CCH227), the findings of which provide an approach that can be applied across the archaeological sector. Additional research on assessing carbon emissions associated with archaeological techniques (Area 5.4) is ongoing, however much of this is being done by private sector archaeological contracting organisations which are out of scope of this research review.

Guidance on Catholic diocesan carbon accounting – CCH215

Lead: Diocese of Salford.

Funding: Sits within a wider project which received £150,000. Funding for this element estimated at one third to one half of initial grant, although more funding has been attracted.

Timescale: Published in July 2023.

Aims:

- Provide understanding of carbon accounting.
- Create guidance for carbon accounting for any diocese's assets and actions.

Outcomes:

- The first interpretation of the Greenhouse Gas Protocol within the Catholic Church.
- Particularly applicable in the UK but used globally as a framework.

Partners: St Mary's University, Laudato Si' Research Institute and the Tyndall Centre for Climate Change Research.

A more detailed case study is available in [Appendix 1](#).

Carbon Calculator for Archaeological Fieldwork – CCH227

Lead: Federation of Archaeological Managers and Employers (FAME).

Funding: FAME and ClfA; other funding sources being sought.

Timescale: 2023 – ongoing.

Aims:

- The Carbon Working Group for Heritage Organisations is to develop a working, simple, standardised carbon calculator for archaeological investigation and fieldwork activities.
- Standardisation will allow comparability in assessment of carbon during procurement.
- Calculator to be relevant to all activities, projects, locations and contractors.
- Calculator to address activities which are common to archaeological investigation.

Outcomes:

- Published carbon calculator.

Partners: Association of Local Government Archaeological Officers (ALGAO), Chartered Institute for Archaeologists (ClfA), Historic England, facilitated and chaired by Costain.

Another significant theme of the research within this Area looks at embodied carbon of historic buildings (CCH218). Research by Historic England and the Open University (note this is published research generated from a single PhD – CCH202) makes up the majority of this work. Research such as this could be used alongside non-heritage research (not identified within this review) to develop approaches for historic buildings more widely.

Several projects are looking at valuing historic assets, including historic landscapes. For example, the University of Exeter is developing a tool that can undertake a better social cost benefit analysis of cultural and heritage capital to improve sustainable management of these assets (CCH120). This will be an important tool for valuing heritage capital more widely, therefore improving management decisions. Whilst there is not much research in sub-Area 5.2, much research ongoing under sub-Area 5.5 would be applicable to both.

Embodied carbon and building retrofit: A heritage example – CCH218*

Lead: Open University.

Funding: AHRC through the Design Star Centre for Doctoral Training

Timescale: Published in 2023.

Aims:

- Assess the embodied carbon of 40 measures chosen to retrofit 13 residential buildings in Northern England.
- Life cycle analysis of measures, with a range of options considered for each retrofit type where possible.

Outcomes:

- Embodied carbon costs varied significantly across different measures and material options.
- Identified a lack of Life Cycle Analysis (LCA) data for some measures and noted several areas where the international standard for LCA was challenging to apply to retrofitting historic buildings.

Partners: None.



Shutters can have similar lifecycle carbon to window replacements.

Photo credit: Freya Wise, Open University.

A more detailed case study is available in [Appendix 1](#).

*This project is a book chapter published under the PhD at the Open University (CCH202) that was used as a case study in Area 4.

Understanding the Value of Outdoor Culture and Heritage Capital for Decision Makers – CCH120

Lead: University of Exeter.

Funding: £500,000 through AHRC.

Timescale: September 2023 – March 2026.

Aims:

- To explore the relationship between the natural and historic environments.
- To find ways to identify the value that historic environment brings, allowing better decision-making about management and investment into cultural heritage assets in the outdoors.

Outcomes:

- Will support the development of a Culture and Heritage framework for decision making, contributing to a robust evidence base and best practice guidelines for incorporating culture and heritage into national accounts and management decisions.
- The findings will be reported to policy makers such as DCMS and DEFRA and their public bodies to have an immediate impact on practice.

Partners: National Trust, Forestry England, and the Land, Environment, Economics and Policy Institute (LEEP).

6: Research on the role of historic land and seascapes in carbon sequestration and offsetting

Key trends and general scale of research and funding

Area 6 was not highly represented amongst the research collated. 58 entries in the matrix were attributed to Research Area 6. As with all Areas, Academic and Research organisations are the most prolific. Charities and Member Organisations are also represented, but much less so than Academic and Research organisations. Regulatory and Arm's-Length Bodies are absent from this analysis. However, although after data collection ceased, information was received from Natural England which arrived too late to be included in the graphical analysis (CCH244 and CCH245). It is also anticipated that research undertaken by the Environment Agency, but not identified through this project, could be applied to historic land- and seascapes.

The charities represented are the Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire, the Woodland Trust, and the National Trust. It is worth noting that DEFRA, BEIS, and DCMS are partner organisations for the National Trust project, *Nature Based Solutions for Climate Change at the Landscape Scale* (CCH222). DEFRA and DESNZ also issued the research call for the *Transforming land use for net zero, nature and people (LUNZ) programme* (CCH221), funded by UKRI.

Of the 58 projects within this area, 17 projects have been identified to be part of wider funding/research programmes:

- UK Climate Resilience Programme
- Isle of Axholme & Hatfield Chase Partnership
- Future of UK Treescapes
- Culture and Heritage Capital Programme (AHRC/DCMS)
- Landscape Decisions
- Transforming land use for net zero, nature and people (LUNZ) funding call
- Natural Capital and Ecosystem Assessment Programme – Marine natural capital and ecosystem assessment (DEFRA – Natural England involvement)
- UK Blue Carbon Evidence Partnership (UKBCEP) – UK Government
- Action Oak Initiative.

Within Area 6, Research Councils fund the most projects. Of these 22 were funded by NERC and 17 were funded by the Strategic Priorities Fund. The only other notable funder in this Area was the AHRC who had 7 entries. Within Research Area 6 it is noteworthy there are very low numbers of projects funded by other funding body types.

Table 7 shows an analysis of central Government Department involvement in Research Area 6 projects. Within Area 6:

- 1 of 58 projects is **led** by a Government Department.
- 3 of 58 projects are **funded** by Government Departments.
- 11 of 58 projects are **partnered** within Government Departments.

Table 8. Government Department involvement in Research Area 6, highlighted in green.

Project	Code	Lead	Funder	Partners	Wider programme
Marine natural capital and ecosystem assessment programme	CCH245	DEFRA	DEFRA	Natural England, Historic England, Centre for Environment Fisheries & Aquaculture Science, Environment Agency, Joint Nature Conservation Committee, Marine Management Organisation	Natural Capital and Ecosystem Assessment Programme
Nature Based Solutions for Climate Change at the Landscape Scale (Wild Exmoor Carbon Sequestration Project)	CCH222	National Trust	UK Government	DEFRA, BEIS (no longer exists), DCMS	Unknown
England Peat Map	CCH248	Natural England	DEFRA	DEFRA, Natural England, Environment Agency, Forestry Commission, Welsh Assembly Government, Countryside Council for Wales, Northern Ireland Environment Agency, Cadw	Natural Capital and Ecosystem Assessment Programme (NCEA).
Greenhouse Gas Removal Plus (GGR+): Sustainable Treescapes Demonstrator & Decision Tools	CCH71	University of Exeter, Economics	SPF	Includes DEFRA and HM Treasury	Not provided
Mobilising Adaptation: Governance of Infrastructure through Coproduction (Topic B)	CCH76	University of Sheffield, Urban Studies and Planning	SPF	Includes DEFRA	Not provided

Project	Code	Lead	Funder	Partners	Wider programme
Changing Treescapes: Making visible the cultural values at risk from tree pests and diseases through arts approaches	CCH115	University of Gloucestershire, Countryside and Community Research Institute	SPF	DEFRA	Not provided
Understanding the Value of Outdoor Culture and Heritage Capital for Decision Makers	CCH120	University of Exeter, Economics	AHRC	Includes DCMS	Culture and Heritage Capital Programme
Learning to adapt to an uncertain future: linking genes, trees, people and processes for more resilient treescapes (newLEAF)	CCH122	UK Centre for Ecology & Hydrology, Biodiversity (Penicuik)	NERC	Includes DEFRA	Future of UK Treescapes
Programme Coordination Team, Landscape Decisions – Towards a new framework for using land assets	CCH127	University of Leicester, School of Geography, Geology & the Environment	SPF	Includes the Crown Estate, HM Government, Ministry of Defence, DLUHC, DEFRA, Cabinet Office	Landscape Decisions
Carbon Storage in Intertidal Environments (C-SIDE)	CCH152	University of St Andrews, Geography and Sustainable Development	NERC	Includes DEFRA	Yes - UKBCEP work for the UK Government
Sentinel Treescapes for Plant Biosecurity and Risk Management – Multiple Threats	CCH168	Fera Science (United Kingdom), Plant Pest & Disease	SPF	Includes DEFRA	Not provided
Land use for net zero – research (LUNZ-Research)	CCH221	Call for funding	BBSRC, UKRI, NERC, ESRC, AHRC, ESRC, MRC, STFC	DEFRA and DESNZ	Transforming land use for net zero, nature and people' programme

Nature of the research and potential gaps

Of the 58 projects in this Research Area, the split between the sub-Areas is:

- 16 relate to the carbon sequestration potential of upland and/or lowland peat (Area 6.1).
- 9 relate to the carbon sequestration potential of non-peat wetlands (Area 6.2).
- 17 relate to the carbon sequestration potential of ancient woodlands (Area 6.3).
- 48 relate to general carbon sequestration research (Area 6.4, usually incorporating projects from Area 6.1-6.3).
- No projects were identified relating to carbon offsetting for green finance (Area 6.5).

As mentioned at the beginning of this section, Area 6 was under-represented amongst the research collated. This may be because general research on carbon sequestering landscapes is not typically considered relevant to heritage. For example, while there is extensive work on restoration schemes and research into functioning peatlands, this work is often not driven by heritage and archaeology and does not acknowledge the significance of healthy peatlands for preserving peatland heritage. Consequently, it has not been captured within this project. The definition and linkage of research to heritage is likely to account for the absence of projects under Area 6.5, despite the potential relevance of some projects.

This Area includes both research around active carbon sequestration in functioning habitats (Area 6.2 and 6.3) and research around the preservation of carbon-rich deposits (stores) that are not part of active ecosystems (Area 6.1). The research is relatively balanced between Areas 6.1 to 6.3 in this respect. There is a lack of research identified around the monitoring of wetland (including peatland) sites to gain an understanding site conditions and their impact on buried archaeological and paleo-archaeological remains and their preservation. Furthermore, there is also little research around monitoring the condition of these remains. This may again be due to how research in this Area is categorised.

C-SIDE (CCH152) and the *Role of recent climate change on carbon sequestration in peatland systems* (CCH223) are examples of research into carbon storage which highlight the benefits of accretion on sequestration and the risks of carbon release if carbon-storing habitats are not protected.

Carbon Storage in Intertidal Environments (C-SIDE) – CCH152

Lead: School of Geography and Sustainable Development at the University of St Andrews.

Funding: ~£900,000 through NERC.

Timescale: May 2018 to May 2023.

Aims:

- Improve the understanding of intertidal saltmarsh habitat through a large-scale study of saltmarsh carbon storage, accretion (burial) rates, and factors impacting habitat resilience.

Outcomes:

- An understanding of UK-wide saltmarsh carbon stores and accretion rates.
- Average accretion rates are low year on year but overall carbon stocks across UK saltmarshes are very large; if not protected, this could release stored carbon and have further climate change impacts.

Partners: University of York, Bangor University, University of Leeds, and the UK Centre for Ecology & Hydrology (UKCEH).

A more detailed case study is available in [Appendix 1](#).

Role of recent climate change on carbon sequestration in peatland systems – CCH223

Lead: School of Geography, University of Plymouth.

Funding: Unknown.

Timescale: Published 2019.

Aims:

- To understand the impact of recent climate change on carbon sequestration in peatland systems (valley mire and blanket bog) in South-West England.

Outcomes:

- Similar mean rates of carbon accumulation since 1850 in both valley mire and blanket bog, suggesting that recent changes in the climate have had limited impact on the strength of carbon sinks in South-West England.
- Past and contemporary rates of CO₂ sequestration were found to be at the maxima of those reported for temperate peatlands.
- Sequestration rates are stable and may possibly be increasing due to climate change.

Partners: None identified.

Projects such as *C-SIDE* (CCH152) and the *Role of recent climate change on carbon sequestration in peatland systems* (CCH223) are rare and much of the research into the role of historic landscapes in carbon sequestration and climate adaptation is studied as a secondary theme to a wider project; the *Reconstructing the Wildscape* project is an example of this (CCH44). This project also gave rise to a follow-up project that plans to study the potential impacts of managed re-wetting and restoration of peatlands on heritage (CCH224), which may be applicable more widely.

Research identified by Natural England that was not captured in the analysis included work ongoing at a practice-level providing heritage/archaeological expertise to peatland restoration projects on a grant scheme (CCH244). The strength of this work lies with its new approach: previously, peatland restoration would avoid areas containing historic assets. However, with the involvement of heritage professionals a deeper appreciation of heritage significance and capacity for change is now integrated into these projects, allowing for the restoration of more areas. This, in turn, expands the potential available area for carbon sequestration via peatland restoration. A limitation of this work is that knowledge generated in this implementation focused work is not published because it is outside the remit of this practice-level team. Natural England has also developed the *England Peat Map* (CCH248), which seeks to understand the peatland resource – this was identified via engagement with other specialists rather than during engagement with Natural England. The project aims to map the condition and extent of England's peatlands to support mitigation action through sequestration.

Reconstructing the Wildscape – CCH44

Lead: University of Glasgow.

Funding: Unknown, funded through the Heritage Lottery Fund.

Timescale: 2018-2023.

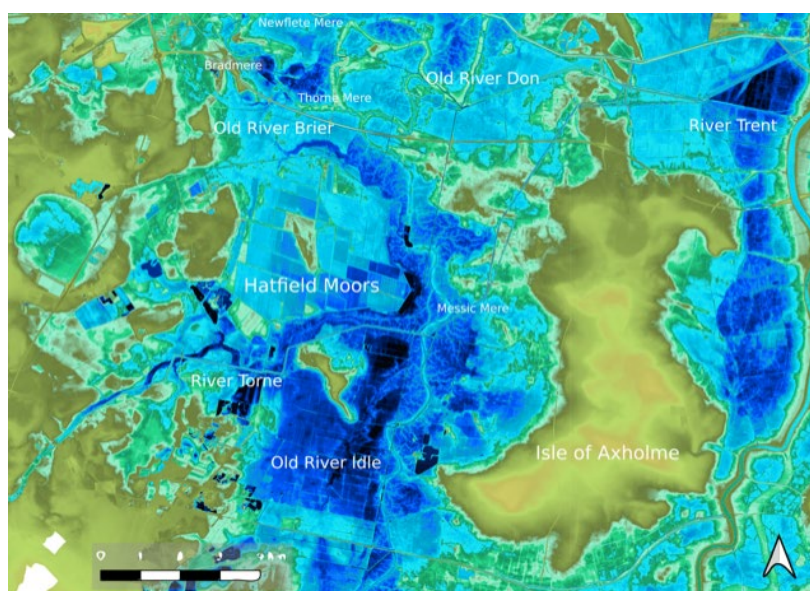
Aims:

- To synthesise and reanalyse existing environmental records and create new records with known archaeological records for the wider Humber Levels region.
- To use a whole catchment-scale approach to explore the historic landscape and understand its long-term evolution.

Outcomes:

- Elucidated the pathways of wetland development over the last 10,000 years and their associated archaeology.
- Unravelling the roles of sea, climate change and human beings in shaping the distinctive landscape, ecosystems, hydrology and economic, social and land use practices.
- The pre-drainage landscape offers valuable lessons around water and land management that are relevant for nature restoration and managing changing hydrological regimes in 'blue-green' landscapes.

Partners: University of Plymouth, University College Cork, University of Birmingham, University of Hull, University of Coventry, University of Bournemouth, Thorne and Hatfield Moors Conservation Forum, North Lincolnshire Council, Humberhead Levels Partnership, and Isle of Axholme & Hatfield Chase Landscape Partnership.



Hatfield Moors flood risk map: Blue colour ramp indicates risk level: darker blue is higher risk; green for low risk/elevated areas. Photo credit: Nicki Whitehouse, University of Glasgow.

A more detailed case study is available in [Appendix 1](#).

Further work and future research opportunities

Several stakeholders, interviewed during the study, expressed their appreciation and anticipation of this research as a resource to collate all ongoing research into climate change and heritage, including studies beyond just published materials. Notably, Cadw and the AHRC showed keen interest in seeing the outcomes of this project and the accompanying matrix.

Opportunities for future work include:

- As identified throughout the report, engaging with Government Departments and Arm's-Length Bodies was challenging. Future work could look to engage further with these organisations. This could involve a working group to maintain contact with these agencies, sharing knowledge that has not been or will not be published, and capturing broad cross cutting themes, approaches, methodologies and grey literature.
- There would appear to be numerous projects and partners with whom Historic England could productively engage in collaborative research to avoid duplication of effort and maximise effective use of resources. This would need to be considered and addressed within the wider strategic plan for climate change research within Historic England.
- A methodology could be developed to identify work by central Government Departments and Arm's-Length Bodies, particularly work not identified as heritage and climate change focused but that is relevant. This could include a deeper review of Government funding and grants, mapping to identify relevant Departments and Arm's-Length Bodies, and further engagement that draws on Historic England's professional contacts and networks.
- Using tender portals to identify commissions by Government Departments and Arm's-Length Bodies and other organisations could be explored (both for existing work 2018-2023 and future work), although this would require ongoing resources.
- A review of research undertaken/ongoing/planned by the scoped out non-UK organisations doing UK relevant research/case studies.
- A full review of published papers identified as containing the search keyword terms within topic, rather than just author keywords, could be undertaken and included in the matrix. Attribution to research themes this may require coding similar to the UKRI analysis, which could modify the R code used for the UKRI results.

- Expansion of the search terms for Areas 4, 5 and 6 around retrofit, embodied carbon, natural capital, and carbon sequestration (rather than restricting it to just heritage) so that a full complement of relevant research can be captured.
- Further consideration of whether there is a real absence of research around the risk to intangible heritage, or if it has not identified through this methodology. This would involve a more in-depth analysis of the projects captured, to identify those projects from the UKRI analysis that may have been included erroneously, and an extensive literature review (which was out of the scope of this project).
- The response rate from Museums and overarching organisations for Museums was not high. Further work could look at techniques for capturing research from this sector. For example, further engagement with museums and museum networks to identify strategic-level research, or local/collections research which would be applicable in a wider sector context.
- Consider whether there is merit in maintaining the research matrix, or periodically reviewing and updating it to capture the results of ongoing work and new studies. Appropriate mechanisms to undertake this would need to be identified.

Appendix 1

Case Studies

Case studies have been used to illustrate key points from the review, either to indicate there is significant engagement or where there is a paucity of research. The aim was to feature two case studies per theme however this was dependent on the information available. The detail of the case studies was drawn from the survey results and interviews with researchers. As a result, any assessment of the strengths, limitations, data and future research opportunities are therefore the interpretation of those that completed the surveys or the interviewees. Thus, we have not sought to reappraise the results of the research.

i. Research developing models and assessing long-term impacts of climate change on heritage.

Case Study 1 – Climate Change Risk Assessment for the Old and New Towns of Edinburgh World Heritage Site

Organisation: Edinburgh World Heritage

Partners included the City of Edinburgh Council, Historic Environment Scotland, Sniffer, the Edinburgh Climate Change Institute, the University of Edinburgh, and Edinburgh Adapts Supported and contributed to the organisation of the Climate Vulnerability Index (CVI) series of workshops led by James Cook University Australia with Historic Environment Scotland

Funding: £10,000 - £250,000 through the Place-Based Climate Action Network (P-CAN) and EU funded AtlaS.WH project. The project formed part of a wider research or funding project from both the P-CAN and AtlaS. WH projects.

Contact: Yann Grandgirard, Head of Climate Change at the Edinburgh World Heritage Trust

Description: Climate change is a major threat to World Heritage Sites across the world and its impacts can seriously compromise their integrity and future generation's ability to benefit from them. In 'urban' sites such as the Old and New Towns of Edinburgh World Heritage Site, challenges posed by climate change are much more complex as they encompass problems that cities are already facing on top of those relating specifically to heritage and conservation. This project aims to look at the impacts of climate change on World Heritage Sites and their communities by directly engaging with them at a large scale. The project informed and tested a replicable approach to 'Climate Change Vulnerability and Impact Assessment' based on extensive community engagement, using an innovative methodology focussed on value-based assessment.

Results:

- Identified the impacts of climate change on the World Heritage Site and its communities, as well as their vulnerabilities and current gaps in knowledge/themes for future research.
- Generated a robust dataset that will help inform a long-term strategy and initiate place-based climate actions in Edinburgh's World Heritage Site.

- Increased awareness of local climate change impacts. This has built momentum and capacity locally through the influencing of strategic policies involving the World Heritage Site, and the provision of research opportunities.
- Increased awareness around the need to take a specific approach to adapt the World Heritage Site, compared to the rest of the city, due to its cultural significance - reflected in the new draft Climate Ready Edinburgh Plan (2023, currently under public consultation).
- Provided an impactful case study of a Climate Change Risk Assessment (CCRA) of a World Heritage Site, which can be built upon for other heritage assets.
- Created a versatile CCRA methodology based on values and involving extensive community engagement that could be applied to 'urban' World Heritage properties and more generally to heritage assets or geographical areas
- Project report to be publicly available in 2024.

Research Strengths and Limitations:

- Research findings have been used to inform Edinburgh World Heritage's 'Climate Emergency Programme' for the World Heritage Site, incorporated into the review of the 'Old and New Towns of Edinburgh World Heritage Site Management Plan 2023+' and is influencing the city of Edinburgh's policies and current/future projects.
- Partnership project that had a wide variety of stakeholders on the steering group, including the City of Edinburgh Council, Historic Environment Scotland, Sniffer, the Edinburgh Chamber of Commerce, tourism industry partners, the University of Edinburgh, the World Heritage Site coordinator, and Edinburgh World Heritage Site staff.
- Community-based, but not community-led; a wide range of people and organisations were consulted on their experiences of the Site which meant that the understanding was place-based and rooted in local knowledge. There was a focus on 'under-represented' groups in both heritage and climate change, so the project specifically targeted young people, ethnic minorities and low socioeconomic groups.
- Deeply rooted in bottom-up evidence gathering, combined with top-down expertise from specialists that could identify risks that local people may not notice, so as many risks were identified as possible within the bounds of the funding and scope.

- Assessing true level of risk was challenging, due to the inherent limitations of scale and detail (as with all CCRAs). In CCRAs, a decision needs to be made over the level of detail that risk should be assessed at, for example, whether to assess individual or categories of buildings, specific locations or wider asset groups.
- Limitations were identified over which risks were assessed, as climate change poses many and time available for the engagement process was limited. These limitations were acknowledged at the beginning of the project and were dealt with through taking a value-based approach. For example, some assets were considered at higher risk and/or held higher value to the World Heritage Site's communities, so were considered in greater detail. Complex values of intangible heritage were not well documented for this reason. The project was regarded to be a high-level risk assessment.

Data Limitations:

- A series of stakeholder events including a survey and workshop sessions were conducted for this project. The survey was successful; however, the organisation of the workshop engagement was hindered as it took place during the Covid-19 pandemic. This meant that it was conducted exclusively via video call. Despite this, 593 individuals were engaged through 20 online workshops.
- Difficult at first to gather participants for the workshops, and this was more significant in some participant groups than others. For example, some often underrepresented communities were difficult to reach out to, which became a methodological limitation as these were likely to bring new information to the project. An example is groups from low socio-economic backgrounds who were more likely to lack internet access.

Potential future research:

- Identify and collect data on specific climatic hazards in different areas of the World Heritage Site, and the impacts of in-combination hazards.
- Investigate the effects of in-combination climatic hazards, such as increased heat alongside rainfall. There is a particular need to understand the continuous effects of these on different materials.

Case Study 2 – Monitoring the buried archaeology of Vindolanda and Magna

Organisation: Vindolanda Charitable Trust

Funding: £10,000 to £250,000, funded by the Vindolanda Charitable Trust. Does not form part of a wider research or funding project.

Contact: Dr Andrew Birley, Director of Excavations at Vindolanda Charitable Trust.

Description: The Vindolanda Charitable Trust has undertaken a major research project at the Magna Roman Fort. This research looked at mapping climate data taken from weather stations at the site which monitor daily rainfall, wind direction, barometric pressure and temperature with information matched to oxygen, soil moisture and pH from probes buried below the ground.

Based on the work that has taken place at Magna, the Vindolanda Charitable Trust has replicated the monitoring at the site of Vindolanda and across all parts of their archaeological and land management operations. This will allow them to look at the impact of climate change on two sites seven miles apart.

These probes constantly monitor pH, oxygen reduction potential (ORP), soil moisture and electrical conductivity, all of which are vital indicators of changing conditions in the preservation of landscapes. Every 15 minutes some 160 readings are taken which are showing the link between the changing climate and deeper impacts on the assumed 'sealed environments' below.

The Trust has put a long term (10 to 20 years) commitment to continue monitoring very closely what is going on under the ground at its archaeological sites. The intention is that the data gained from this monitoring will be shared open source with the archaeological community. The result will be to see what the key trends are in the data, and from that develop models and artificial intelligence that can help predict what may happen in those buried environments based on different factors.

Data will be shared through an online portal, so that anyone interested will be able to access it. The details of the projects will also be communicated to visitors to Vindolanda, and live data from the probes will be projected onto a wall with an explanation of what they mean and why they are undertaking the monitoring.

Results:

- Work is still ongoing and so at this stage there are no final results. However, early trends in the data do show a direct link between the condition of buried deposits and the weather pattern above the ground.
- From data collected to date, it is extremes that appear to be causing the most harm. This includes very wet, hot, or dry conditions.
- The amount of rain is not significantly increasing on sites compared to previously, but the pattern of rainfall events has.
- The understanding of the relationship between intense drought and rainfall and greater penetration of oxygen under the ground has been refined.
- A direct link has also been made between the amount of oxygen under the ground and the pH of the soil, which has a significant impact on the preservation of certain archaeological materials.

Research Strengths and Limitations:

- The probes are providing constant monitoring, which is much more reliable than in the past when monitoring used to only be undertaken at regular intervals.
- The data received is very consistent and stored securely.

Data Limitations

- No known data limitations.
- The probes are solar powered, so batteries need to be charged and replaced manually.

Potential future research:

- Research into the properties of certain archaeological layers that may offer greater resilience to climate change impacts.
- Further research into the certain properties of these materials that offer greater protection than some of the other materials that you commonly find on archaeological sites.
- Forward modelling of impact and degradation based on the probe data and the refinement of future research and managements strategies for the sites under the Trusts care.

ii. Research on the impact on heritage of flooding and coastal erosion and our responses.

Case Study 1 – State Care Climate Change Vulnerability Pilot

Organisation: Historic Environment Division in Northern Ireland (NI).

Partner organisations included the National Trust (at scoping stage) and Friends of Grey Abbey, a local community group.

Funding: Initially <£3,000, funded by the Department for Communities Northern Ireland. Now being developed in-house with no dedicated funding stream. Does not form part of a wider research or funding project.

Contact: Rebecca Enlander, Curatorial Archaeologist in the Climate Change Working Group at the Historic Environment Division (NI).

Description: HED work with the State Care heritage team to care for a portfolio of 188 heritage monuments. They are looking across the estate to assess key vulnerabilities of the State Care monuments, drawing on 3Keel projected climate hazard data and National Coastal Erosion Risk Mapping (NCERM) for asset type prioritisation. So far, it is largely coastal sites that are most at risk from the state care portfolio.

HED are in the early stages of a pilot study of Grey Abbey priory (using a framework developed in conjunction with colleagues at National Trust – Mount Stewart) to develop a data-based, evidence-based and place-based monitoring and action framework for site management. This work will lay the foundations for other frameworks to be developed at other sites. This pilot study focusses on specific climate change impacts encountered at the priory, including erosion of sandstone carved doorways, ground movement, storm damage (including trees coming down in close proximity to the priory), and increased growing seasons affecting vegetation on the masonry. Additional case studies are planned to compare and contrast the relatively sheltered priory with an exposed coastal site (Dunluce Castle).

The project aims are to provide an overview of the climate change threats to and vulnerability of the State Care monument portfolio, and to develop a framework through pilot studies that can be tailored to monuments at most risk to climate driver impacts. The framework will allow site-specific thresholds to be set, and resultant actions to be developed including preventative activities, investment cases and in extreme scenarios, adaptive release.

Results:

- Ongoing project so official outputs are currently limited. Dissemination methods likely to include internal and external written outputs.

Research Strengths and Limitations:

- A pioneering research piece into asset prioritisation, meaning that limited resources and funding can be allocated effectively. The Grey Priory framework will also lay the foundations for future monitoring, which has not been done before.
- Lack of specific focus on climate change across the organisation. Any climate change-specific analysis is therefore additional to statutory roles and responsibilities held by the research team. This results in limited resources and has led to inconsistent data collection in some instances.
- Lack of centralised data, leading to issues with increased workload and issues with collaboration.

Data Limitations:

- Data gaps identified in 3Keel for Northern Ireland, with no landslide or soil heave data. Gaps filled with proxy data.
- Internal data gaps within the Historic Environment Division as land use recording has been poor historically.
- Data accessibility was challenging. Obtaining Ordnance Survey data was difficult due to sublicensing issues.

Potential future research:

- Filling data gaps that currently exist within 3Keel and within the Historic Environment Division. This would build the evidence base available for Northern Ireland.
- Climate hazards need to be considered more in general in Northern Ireland, including monitoring of climate impacts and the scale and rate of loss for certain asset types.
- More focus on rock art and less visible heritage.

Case Study 2 – CHERISH Project

Organisation: Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMMW).

Partners included the Discovery programme: Centre for Archaeology and Innovation Ireland; Aberystwyth University: Department of Geography and Earth Sciences; and Geological Survey Ireland.

Funding: €4.9 million through the Ireland-Wales Programme 2014-2020, part of the European Regional Development Fund. Does not form part of a wider research or funding project.

Contact: Louise Barker, Senior Investigator at RCAHMMW.

Description: CHERISH is a cross-disciplinary project aimed at raising awareness and understanding of the past, present and near-future impacts of climate change on the cultural heritage of our seas and coasts. The project employed a wide variety of approaches including terrestrial and aerial laser scanning, geophysical survey, palaeoenvironmental sampling, excavation, and shipwreck monitoring.

The project focused on several iconic coastal locations in Ireland and Wales including Castell Bach and Glascarrig. The study areas were chosen with the help of agencies, landowners and local groups, based on current and future climate change risks. The study areas extended from coast edge, onto the intertidal zone, to inshore waters under 40m depth and out to offshore islands. A wide range of heritage sites were chosen including remains of promontory forts, castles, timber and iron shipwrecks, submerged forests and island landscapes (CHERISH Project 2023, 12).

Phase 1 of CHERISH focused on data gathering and the survey and investigation of the study areas, which ended in June 2022. The output of this work was a guidance document that reflected on the survey and analysis. Phase 2 of CHERISH focuses on sharing and discussing the results of the work (CHERISH Project 2023, 11).

Results:

- Guidance document, published in July 2023, produced to share the CHERISH 'toolkit' approach, which integrated the disciplines of archaeology, geomatics, geography, palaeoecology, history, geomorphology and maritime geophysics. The guidance explored the different survey techniques used in the CHERISH project alongside case studies of how it was used.

- Overall purpose was to raise knowledge and awareness of how climate change was impacting on coastal heritage. This greater understanding can allow better understanding what the triggers are for impacts on coastal heritage, such as increased rainfall resulting in more erosion on a site due to saturated surfaces. This can then be used to help decide on mitigation strategies for a site, and to understand where similar sites may also be under threat.

Research Strengths and Limitations:

- Interdisciplinary working; it was necessary for archaeologists to work with other disciplines to gain a full understanding of the site and the threats it was under to create the toolkit approach. This included geologists, geographers, marine geophysicists, and climate scientists.
- Completed a lot of work with the resources given and techniques are now embedded in daily working practices.
- Kickstarted other projects that hadn't been able to progress for many years. For example, CHERISH investment at the National Trust owned Dinas Dinlle hillfort expanded into a larger collaboration and partnership project, which has been able to deliver additional work.
- Undertaking of real analysis and data comparisons were more limited than initially expected (but sufficient).

Data Limitations:

- For many sites there was no significant existing data, however the project collected data, so this reduced the limitation.

Potential future research:

- Use the toolkit at other coastal sites and at inland sites.

iii. Research on climate change and its potential impact on intangible heritage.

Case Study 1 – Harbourview

Organisation: Centre for Sustainable Building Conservation at University of Cardiff and University College Dublin

Funding: £10,000 from the ESRC-IRC UK/Ireland Networking Grant.

Contact: Professor Oriel Prizeman, Director of the Centre for Sustainable Building Conservation, Welsh School of Architecture, University of Cardiff, and Dr Elizabeth Shotton, Associate Professor at the School of Architecture, Planning and Environmental Policy at University College Dublin. Does not form part of a wider research or funding project.

Description: The ambition of the project was to document the historic harbours and generate a network across the coasts of Wales and Ireland in order to build awareness of the importance of harbours as coastal heritage. Historic harbours fall between different heritage designations as they are neither monuments nor buildings. Thus, their importance is overlooked, even though they are integral to the understanding of the human occupation of islands. Harbours are at risk of climate change as a result of rising sea levels and increases in the number and frequency of storms. This could result in their disappearance, due to their unique position of vulnerability on the coast.

The Harbourview project aimed to connect lost associations across the Welsh and Irish coasts, bringing hidden parallels to the fore using digital methods, including 3D recording and visualisation. The output of this was four digital models of harbours in Ireland and Wales, a trilingual website and an edited book. These were used in a public engagement stage to stimulate conversations around the harbours in terms of their pathways for goods, but also as ports for knowledge and beliefs.

Results:

- The initial main output was to photograph every historic harbour along the east coast of Ireland and the Welsh coastline to provide a description and generate a trilingual GIS map which also incorporated historic photographs and maps. A “Storymap” allowed users to contribute material via an online form to share narratives.

- Various 3D models of four harbours were created using both Terrestrial Laser Scanning and Photogrammetry to support the project engagement which are accessible on the trilingual project website. The models are available and accessible through the project website and on the University data service for a period of 10 years.
- Four public engagement workshops were held to bring together local historic knowledge and to experiment with the creation of photogrammetric models. Two were held in Wales, and two in Ireland, followed by a symposium to conclude the project at the Museum of Modern Literature in Dublin. This drew together community representatives, public and private stakeholders, professionals, and academic experts from a range of disciplines to discuss and reflect upon the future challenges and opportunities for the preservation and documentation of historic harbours in Ireland and Wales.
- The Royal Commission of Ancient and Historic Monuments in Wales has noted that the project's approach to documentation has impacted their approach to the recording and classification of harbour structures.

Research Strengths and Limitations:

- The research accessed people with a range of connections to the coast, statutory heritage bodies in Ireland and Wales, engineers, landowners, local communities, people interested specifically in harbours and technical methods, as well as people who held strong interests in local history. This meant that the connections formed because of the project were from a diverse group united by their anxieties around coastal erosion, allowing a range of intangible histories to be uncovered.
- The project was funded by a networking grant and as such no staff time was funded. This limited the scope and extent to which the researchers could commit themselves to the project.
- There were issues in accessing permission to scan the harbours for the 3D models as this work took place during the Covid-19 pandemic, although these were worked around eventually. This also meant that the public engagement element of the project was significantly delayed and one of the workshops recruited far fewer people than anticipated.

Data Limitations:

- The data collection process was stalled by the Covid-19 pandemic.

Potential future research:

- Extend the project to encompass the role of Ireland as a historical pathway to Europe for knowledge and culture.
- Engage further with the risks of coastal erosion as a diminishment of intangible as well as tangible heritage
- More widely, there is a need to find a way to fully correlate the intangible value of places (such as harbours) into a benefit for communities. This was felt to be important as these areas hold 'high intangible value almost without exception' but tend to be underprivileged as a result of industrial decline and in need of support.

Case Study 2 – Preserving Legacies: A Future for our Past

Organisation: The International Council on Monuments and Sites (ICOMOS)

Partners included the Climate Heritage Network, the National Geographic Society, and Manulife Financial Corporation.

Funding: Funded by The National Geographic Society with support from Manulife

Contact: Dr Victoria Herrman, Project Director; Dr William Megarry, the ICOMOS Focal Point for Climate Change and Heritage and Workshop Director for the Preserving Legacies project.

Description: Preserving Legacies is increasing access to heritage adaptation and transforming conservation as a field to meet the challenges of the climate crisis. Climate change will impact inherited traditions, livelihoods, and identities as well as the physical fabric of heritage sites. Therefore, the project aims to empower every community with the scientific knowledge and technical training to achieve appropriate place and people-based climate adaptation plans.

Through an interactive training program, Preserving Legacies equips communities with the capability to understand and visualise climate change impacts on a local scale, map the vulnerability of their sites and the community values they hold to those impacts, and act to minimise the adverse consequences of climate change and maximise the opportunities it presents.

The approach integrates scientific, local, and indigenous knowledge to find sustainable and culturally appropriate solutions to the long-term preservation of cultural heritage sites. This integration of different knowledge systems supports developing better approaches to adaptation and learning from ancestral practices to safeguard values for the next generations.

The project initially involved ten heritage sites in the first cohort in 2023, with the vision to build a global community of practice that reaches thousands of sites in the decade to come.

Results:

This project will be taking place over the next decade, working to democratise the capacity building model for climate change and cultural heritage and scale this model to thousands of sites – results are currently not known. Results from Year one include partner led climate risk assessments from Jordan and the Philippines and a growing community of practice, with eight further sites actively involved.

Research Strengths and Limitations: Unknown

Data Limitations: Unknown

Potential future research:

- Potential future research will become clearer as the project unfolds.
- Research over the next ten years will focus on scaling the capacity building model to thousands of sites across the world.

iv. Research to inform best practice methods of maintenance, repair and adaptation (and maladaptation) of the historic building stock, including retrofit and energy performance, to meet challenges of climate change

Case Study 1 – Reducing Carbon while Retaining Heritage: retrofitting approaches for vernacular buildings and their residents

Organisation: Open University

Funding: £10,000-£250,000, funded by UKRI, the Arts and Humanities Research Council (AHRC) through the Design Star Centre for Doctoral Training. Does not form part of a wider research or funding project.

Contact: Dr Freya Wise, visiting fellow at the Open University

Description: Published under a PhD at the Open University, along with *Embodied Carbon and building retrofit: A heritage example in Area 5*.

Although retrofitting is key to reduce global carbon emissions, standard retrofitting approaches are often not appropriate for the 20-30% of UK homes with heritage value. This project examined the potential for realistic carbon reduction from these buildings while retaining heritage value. The county of Cumbria was the location focus for this research which involved a resident survey, 16 individual building-resident case studies with both quantitative and qualitative data, and lifecycle modelling of retrofit options, including embodied carbon.

A range of buildings were included as case studies, varying in age, materials, and designated status. An individual approach was taken to ensure that the heritage value that people invest in their homes was recognised. It was also important to consider the positive aspects of heritage as well as the negative, such as increased summer comfort for occupiers: retrofit should not damage these benefits.

Results:

- Outputs published in 2022.
- Most residents of vernacular buildings, whether with official heritage designation or not, invest heritage values in their buildings and these values affect the retrofits they consider acceptable and will therefore enact.

- Most residents already engage in energy conscious behaviour. In contrast to common assumptions, most residents find their buildings comfortable, emphasising excellent summer performance, although previous maladaptation can present challenges.
- Showed that standard modelling tools poorly reflect both vernacular buildings' energy performance and residents' behaviours and preferences, thus frequently recommending inappropriate alterations that fail to make predicted savings.
- When the embodied carbon of the retrofits was calculated alongside the operational savings it frequently influenced which measures had the lowest lifecycle carbon.
- Positive synergies between measures with low embodied carbon and those acceptable to residents' heritage values; these measures tend to be non-invasive and less technical but are harder to model and quantify and therefore often overlooked.

Research Strengths and Limitations:

- In-depth, detailed and interdisciplinary, addressing a number of important research gaps.
- Limited by the funding that was available. Only high-level visual surveys could be completed rather than detailed in-situ measurements, meaning that when data was inputted into models, assumptions were often required. Models could have been calibrated better if more refined technical data was available.
- Engagement with organisations was challenging. Organisations such as the National Trust and SPAB were approached to assist with the research due to the properties under their care, however replies were limited. Thus, some properties that could have been well suited to this research were not included in the participant pool.
- Fieldwork was also limited due to the outbreak of the Covid-19 pandemic; technical visits and surveys could only be undertaken for 13 of the 16 case study buildings, and the additional three had to be surveyed using online methods.

Data Limitations:

- Some gaps in technical data from the fieldwork meant that researchers used the literature to find data around some performance parameters for heritage buildings, such as air tightness. However, only small amounts of data were available. This led to challenges calculating averages to use in models.
- Well-used energy modelling tools were not set up for certain types of retrofit measures specific to heritage buildings. For example, some tools did not have options to model wood burning stoves. Lack of data explaining how to navigate this issue resulted in having to develop proxies for certain aspects.

Potential future research:

- Thermal comfort in heritage buildings and the performance of heritage buildings in general.
- Apply findings in other areas with strong cultural identity, as well as areas with weaker cultural identity. This would see if the findings were consistent across geographic locations and whether heritage is valued in the same way in different areas.
- Guidance for homeowners could be improved to result in empowerment rather than emphasising heritage concern and potentially resulting in decision paralysis through fear of negatively affecting heritage values.

v. Research on heritage, embodied carbon comparative accounting in relation to historic assets.

Case Study 1 – Guidance on Catholic diocesan carbon accounting (from the Guardians of Creation programme)

Organisation: Diocese of Salford.

Partners included St Mary's University, Laudato Si' Research Institute and the Tyndall Centre for Climate Change Research.

Funding: The project sits within the wider 'Guardians of Creation' project, which was initially awarded £157,895. The funding for this element of the project could be inferred to be around one third to one half of the initial grant award. The project has since attracted additional funding.

Contact: Dr Roland Daw, Senior Lecturer at St Mary's University, and Dr Emma Gardner, Head of Environment for the Diocese of Salford.

Description: This project sits within the *Guardians of Creation* project which comprises five reports aiming to develop transformational responses to the ecological crises in Catholic dioceses:

- The first report, *Guidance on developing strategy for decarbonising Catholic diocesan building stocks*, provides advice on developing and implementing a strategy in the diocese for reducing the carbon footprint of the diocese's buildings.
- The second report (described here), *Guidance on Catholic diocesan carbon accounting*, gives advice on measuring, understanding, and reporting the diocese's carbon footprint.
- The third report, *Developing whole-school approaches to sustainability in Catholic education*, gives advice on implementing both school-level and diocese-level strategies for responding to the current ecological crisis via Catholic education.
- The fourth report, *Educating and empowering Laudato Si' Champions in Catholic Education*, outlines a template for delivering learning around Catholic responses to the ecological crisis in secondary schools.
- The final report, *Understanding Catholic parishioners' responses to the ecological crisis* discusses the experiences, beliefs and behaviours of Catholic parishioners in their own responses to the ecological crisis.

This research aimed to provide Catholic dioceses with an auxiliary understanding of carbon accounting, and to offer a comprehensive guide to creating a carbon account that can be used by any diocese. It was recognised that this is not a 'one-size-fits-all' approach, as each diocese will have unique assets and differences in specific aspects of the process, so each element of the process has explanations of how to approach the account in a diocese-specific way.

This piece of research supports the resolution from the Bishops' Conference asking that all Catholic dioceses in England and Wales establish a methodology for carbon accounting and declare their targets for decarbonisation. The bishops invited all dioceses to look to the work of the wider Guardians of Creation project as they began to decarbonise.

Results:

- Published in July 2023.
- The research is an interpretation of the Greenhouse Gas Protocol within the context of the Catholic Church. It deals first with the motivations behind carbon accounting, followed by guides to the six major elements in the diocesan carbon accounting process.
- The guidance applies mainly for churches and other diocesan in England and Wales due to their unique data gathering methods, and the method has been trialled successfully for the Diocese of Salford.
- Globally it has been used as a framework, as the research was advised for use as a starting point for carbon accounting, rather than a complete methodology for every scenario. The guidance has been used across the world since its publication and has been received very well by dioceses.

Research Strengths and Limitations:

- The team were very satisfied with the research, particularly the carbon accounting guidance as this was adopted immediately by two dioceses, and there has been a surge in investment in building surveys with the intention of decarbonising them in future.
- No example of a 'demonstration church' or complete case study that would illustrate the information in the Guardians of Creation series. Minimal information based on physical primary data on buildings.

Data Limitations:

- Lack of test cases and demonstration sites across the research series, although this piece specifically was piloted in the Diocese of Salford.
- Generally, no difficulty accessing data for this guidance piece.

Potential future research:

- Examples of 'demonstration churches' where the research findings and recommendations made across the Guardians of Creation project have been implemented successfully.
- Expected that this will result in positive change across the Church, as this document provides a manageable and uncomplicated approach to carbon accounting, and the wider research series will provide a framework for all dioceses to work from, making the ultimate goal of climate action seem achievable and accessible.

Case Study 2 – Embodied carbon and building retrofit: A heritage example

Organisation: Open University

Funding: Amount unknown; partially funded by UKRI and AHRC through the Design Star Centre for Doctoral Training, linking to the PhD undertaken for *Reducing Carbon while Retaining Heritage: retrofitting approaches for vernacular buildings and their residents* discussed above. However, it was partially self-funded. Does not form part of a wider research or funding project.

Contact: Dr Freya Wise, visiting fellow at the Open University

Description: Published under a PhD at the Open University, along with *Reducing Carbon while Retaining Heritage: retrofitting approaches for vernacular buildings and their residents* in Area 4.

This project assessed the embodied carbon of 40 retrofit measures chosen to retrofit 13 residential buildings in Northern England. It centred on using the international Lifecycle Assessment (LCA) standard EN 15978 methodology and discussing the suitability of this for heritage retrofit. For example, these standards assume (and calculate the carbon emissions of) the demolition of the building at the end of the assessment, however with heritage buildings this is rarely the case. This introduces the consideration of biogenic carbon delay within the assessment when calculating embodied carbon.

The project assessed the impact of retrofit measures with respect to their embodied carbon at different stages of the lifecycle to calculate the total embodied carbon of each measure. In total, 40 measures were assessed, including insulation, window additions and replacements, system improvements, LED lights, and wall hangings. A range of options were considered for each retrofit type where possible, such as three different materials for floor insulation. This allowed a detailed comparison of embodied carbon across different measures and materials.

Results:

- Embodied carbon costs varied significantly across the different measures and material options, while in many cases offering similar operational carbon savings.
- In some cases, lifecycle stages which are often deemed insignificant were found to have a substantial impact on total embodied carbon.
- Identified a lack of available LCA data for some measures and noted a number of areas where EN 15978 was challenging to apply for retrofit projects specifically in heritage buildings.

- By breaking down the embodied carbon costs by lifecycle stage, this research illustrates the importance of assessing embodied carbon for retrofitting and including as many lifecycle stages in assessments as possible to ensure a holistic approach.
- Published in 2023.

Research Strengths and Limitations:

- A range of materials were considered, so they were able to be compared in terms of embodied carbon. The research also considered materials from a heritage perspective.
- Difficulty in placing the assessment in different potential future scenarios. For example, grid decarbonisation needs to be considered for operational carbon, but to what extent should this be incorporated into the assessment? This introduced uncertainty into the assessment.
- Despite assessing 40 measures, this research is still relatively small-scale.

Data Limitations:

- Difficult to find data for some elements, such as the embodied carbon of wall hangings, secondary glazing, and window shutters. Resulted in proxies having to be used in the assessment. For example, data for wooden decking was adjusted to obtain a proxy for window shutters. Data was particularly hard to find for heritage elements.
- Also difficult to find data for certain lifecycle stages, with installation carbon and maintenance carbon proving especially difficult. Embodied carbon may change for these stages too, as changes are made to materials and legislation.

Potential future research:

- More measures need be assessed in many retrofits across the country, which would also result in more data being available for future projects.
- Clearer regulations needed to ensure that heritage buildings are considered and valued within these types of assessments, particularly building this into the international standards.

vi. Research on the role of historic land and seascapes in carbon sequestration and offsetting

Case Study 1 – Carbon Storage in Intertidal Environments (C-SIDE)

Organisation: School of Geography and Sustainable Development at the University of St Andrews.

Partners included the University of York, Bangor University, University of Leeds, and the UK Centre for Ecology & Hydrology (UKCEH).

Funding: ~£900,000 through the Natural Environment Research Council (NERC) through UKRI. Occasionally, other elements and parallel projects were funded by organisations such as WWF-UK. The project contributes evidence to a larger blue carbon initiative; the UK Blue Carbon Evidence Partnership (UKBCEP).

Contact: William Austin, Professor in the School of Geography and Sustainable Development at the University of St Andrews.

Description: The main aim of this project was to improve the understanding of intertidal saltmarsh habitat, undertaking a large-scale study of saltmarsh carbon storage, accretion (burial) rates, and factors impacting habitat resilience. The UK is particularly well-suited to assess saltmarsh carbon due to the regional differences in coastal environments on the north and south coasts.

The first stage of the project was to undertake a UK-wide carbon stock assessment, understanding present-day soil organic carbon stocks and then to assess how these have changed over time. Habitats were then assessed to understand the detailed accretion rates, providing a spatial and a temporal understanding of saltmarsh carbon stocks across the entire UK. The project also looked to understand how sea level change might impact saltmarsh carbon stocks and accretion rates. This research sought to understand whether stocks are being lost due to accelerating sea level rise (and erosion) or whether sea level rise is driving an increase in carbon stocks through enhanced accretion at some sites.

Results:

- Resulted in an understanding of UK-wide saltmarsh carbon stores and accretion rates. Multiple publications up to 2024.
- Found that the average accretion rates are low year on year but overall, the carbon stocks across UK saltmarshes are very large. Therefore, if saltmarsh carbon stocks are not protected, this could lead to the release of stored carbon and further climate change impacts.
- The next phase of work (and the end goal of the project) is to use this understanding to inform policy and habitat management. This will aim to provide practical guidance for coastal managers and inform shoreline policy to safeguard carbon storage in the intertidal zone.
- The outputs from this work have fed into further work and assessments, including data being used to undertake greenhouse gas accounting for the UK Greenhouse Gas Inventory and to further develop the saltmarsh carbon code.

Research Strengths and Limitations:

- Multidisciplinary, completed by a very diverse group of researchers across several technical areas and locations.
- Covid-19 pandemic impacted fieldwork. When specialist analysis laboratories reopened after the pandemic, there was a bottleneck in getting samples analysed.
- Limited by funding and resources; a range of sites were surveyed to allow findings to be up-scaled to the whole of the UK. More site-specific work could have been undertaken to get a detailed understanding of different sites.

Data Limitations:

- The study would have benefited from certain datasets being open access when looking to undertake the modelling aspect of the work. For example, improved access to UK-wide LiDAR data to model future sea level rise scenarios to the end of the century.

Potential future research:

- Further improve our understanding of the risks to saltmarsh carbon. Large carbon stores are present in vulnerable coastal settings and if climate change impacts these settings, carbon could be released, leading to further climate change impacts (GHG emissions) through a positive feedback loop.
- This research should be linked to future sea level rise scenarios to place the risk into regional context.

Case Study 2 – Reconstructing the Wildscape

Organisation: University of Glasgow

Partners included the University of Plymouth, University College Cork, University of Birmingham, University of Hull, University of Coventry, University of Bournemouth, Thorne and Hatfield Moors Conservation Forum, North Lincolnshire Council, Humberhead Levels Partnership, and Isle of Axholme & Hatfield Chase Landscape Partnership.

Funding: Funded through the Heritage Lottery Fund, University of Plymouth and University of Glasgow.

Contact: Professor Nicki Whitehouse, Professor of Archaeological Science, University of Glasgow.

Description: The project worked to synthesise and re-analyse existing palaeoenvironmental records and create new records, with known archaeological records for the wider Humber Levels region (which includes Thorne and Hatfield Moors, the largest lowland raised bog systems in eastern England) a designated SSSI site in the Humber region, and undertake a new investigation of the meres and palaeochannels of the Rivers Don, Torne and Idle. The investigation took a whole catchment-scale approach to understand the connections between fluvial, hydrological and ecological systems, lowlands and nearby uplands of the Isle of Axholme with their associated archaeology and chronology. It also mapped extensive areas of peatlands underneath ‘warped’ agricultural lands and created a large GIS model of landscape features mapped and their archaeology, alongside land cover maps derived from pollen data and MSA (Multiple Scenarios Approach) for the Humberhead Levels landscape. This landscape is intensely vulnerable to sea level and climate change, being at 4m OD and subject to regular extreme life-threatening flooding. At the same time, the area is key to England’s food production, as well as carbon capture in the form of agricultural peatlands.

By examining existing records and creating new records, the project explored the historic landscape to understand its long-term evolution, mapped and analysed the historic environment and considered conservation and management of its wetlands, alongside climate mitigation and land use change issues. This provided an important environmental context, demonstrating the landscape’s evolution and development and allowing the archaeological datasets to be investigated at a regional scale over time.

Results:

- Elucidated the pathways of wetland development over the last 10,000 years and their associated archaeology.
- Unravelling the roles of sea, climate change and human beings in shaping the distinctive landscape, ecosystems, hydrology and economic, social and land use practices.
- Focused on the connected nature of these systems, including understanding a fully integrated water catchment system that drove much of the landscape distinctiveness. This water catchment system led to great continuity of landscape and place usage through prehistory up to 17th century until drainage and Reclamation which started in the 17th century and continues to today. However, drainage has also transformed the sense of place for communities as connections to wetland landscapes and deep cultural connections have been lost, arguably set in motion the deep social and economic deprivation that characterises the region today.
- The pre-drainage landscape offers valuable lessons around water and land management that are relevant for nature restoration and managing changing hydrological regimes in 'blue-green' landscapes.
- The project is ongoing, and there are plans for an external written output and presentation.

Research Strengths and Limitations:**Strengths**

- The findings have informed English Nature's local management plans and fed into a net-zero report for the Yorkshire Wildlife Trust and Natural England.
- Findings also fed into Historic England's Peatlands Policy document to show how archaeology is relevant when developing sustainable approaches in the present day.
- The knowledge generated has also fed into the National Trust's peatlands and historic environment guidance document.
- Members of the project team have run a workshop and will publish a paper discussing the importance of archaeological science for nature conservation.
- Created strong links between the project team and local stakeholders.
- Created opportunities for volunteers.

Limitations

- None identified.

Data Limitations: Unknown

Potential future research:

- Plans to undertake targeted new fieldwork, data collection and analyses from the Moors and surrounding meres/floodplains to address periods and locations of limited knowledge, working within the project team and with local citizen science volunteers.
- Project information will be used in a variety of public engagement material (website, information boards for Natural England etc) and will update the Management Plan for the Moors.
- Plans to use peatland mapping generated from this project to feed into understanding of lowland peatland carbon capture and vulnerabilities of land use change in lowland areas with peat resources that go beyond the region and that can be applied to other areas of lowland peat resources in the UK.

Appendix 2

Feedback and actions following engagement with the Historic England Project Board

Date	Feedback point	Feedback/action
24/10/23	Inception meeting (Historic England Project Manager and Project Board)	Case studies to be used to illustrate key points from the review. For example, to indicate where there is significant engagement or where there is paucity of research.
25/10/23	List of organisations shared	The Historic England Project Board added organisations and provided contact details where possible. Directed to scope-in Industry Partners.
25/10/23	Matrix shared	Comments received and incorporated
07/11/23	Catch up meeting	JBA were directed to: - Scope-in Industry Partners. - Include active funding calls in the matrix to ensure a consolidated source of information. The Historic England Project Board confirmed that the scope of the review should encompass not only existing and completed research, but also forthcoming projects identified through Calls for Proposals and similar avenues. It was emphasised by the Project Board that the project is to be rapid review rather than exhaustive traditional literature review.
07/11/23	Matrix shared with additional fields following feedback	No comments received
07/11/23	Survey questions shared	Comments received and incorporated
23/11/23	Telephone interview questions shared	Feedback provided after mid-point meeting and comments incorporated.
28/11/23	Mid-point meeting (Historic England Project Manager and Project Board): Interim results shared, with graphs indicating the proposed methodology for matrix analysis. Initial list of interviewees and case studies shared.	No comment on the graphs/analysis method. The Historic England Project Board agreed to share organisations they thought should be contacted for case studies and interviews – incorporated into onward telephone interview plan.

Date	Feedback point	Feedback/action
28/11/23	Funding brackets to be used within the matrix shared with the Historic England Project Board for approval.	No comment received
06/12/23	The search terms used to categorise the UK Research and Innovation (UKRI) projects into sub-themes was shared.	Feedback was given by the Historic England Project Board on search terms and the sub-categories used – this was incorporated where possible.
17/01/24	Case study options shared – based on which organisations could be contacted through interviews.	Comments received and case studies changed as far as data from the engagement allowed.

Appendix 3

Excel matrix fields

Field Name	Description	Column format
Lead Organisation	The lead or primary organisation undertaking or coordinating the research.	Free text
Sector (organisation type)	The sector under which the research organisation falls, as defined within the list of organisations.	Dropdown list
Research Area (Historic England Area)	The research areas as defined by Historic England as being of particular interest. Research could also be marked as 'other' if it does not fall under one of the six Research Areas identified but was judged to be relevant.	Dropdown list
Research sub-category	A number of sub-categories within each research area were identified to facilitate more detailed analysis at a later date.	Dropdown list
Research Title	The title of the research either defined by the researcher or by JBA if no specific title has been assigned to the research.	Free text
Two Line Summary	A short summary providing detail on the nature of the research.	Free text
Expected outputs	The expected or actual outputs from the research: internal output, external written output, external presentation, external toolkit/guidance.	Dropdown list
Climate Hazard Type	The research is categorised into one or more categories based on the climate hazards it considers.	Dropdown list
Climate Change Measure	Categorised into the measures against climate change comprising adaptation, mitigation and resilience.	Dropdown list
Asset type	The type of asset that is the focus of the research including: archaeology, buildings, landscapes and intangible.	Dropdown list
Direct or Indirect impacts.	Categorised into direct or indirect impacts as defined by the Climate Change Committee.	Free text
Funding body	The body providing the funding for the research.	Free text
Funding body type	The type of funding body such as: Regulatory and Arm's-Length Bodies; Charities and Member organisations; Professional Institutes; Academic and Research; Religious organisations; Museum Sector; Industry Partner.	Free text
Funding amount	The amount of funding received. This was categorised into bands to allow data to be easily analysed at a later stage.	Dropdown list
Does this research feed into a wider funding project?	An indication as to whether the research is part of wider project that is being funded by a singular body.	Free text

Field Name	Description	Column format
Description (further detail)	A longer more detailed description of the research.	Free text
Timeframe or date of publication	The timeframe in which the research is likely to be completed by or the date of publication if the work has already been published.	Free text
Location of research	The location on which the research primarily focuses.	Dropdown list
Partner organisations	Partner organisations whom the lead organisation may be working with.	Free text
Names of researchers and/or authors	List of researchers or authors.	Free text
Primary Contact	The primary contact for the research.	Free text
Secondary Contact	Secondary contact for the research.	Free text

Appendix 4

Websites reviewed by sector and organisation

Sector	Organisation
Regulatory and Arm's-Length Bodies	Climate Change Committee (CCC)
Regulatory and Arm's-Length Bodies	Historic Environment Scotland (HES)
Regulatory and Arm's-Length Bodies	Historic Environment Division (Northern Ireland)
Regulatory and Arm's-Length Bodies	Cadw
Regulatory and Arm's-Length Bodies	Royal Commission on Ancient and Historical Monuments of Wales (RCAHMW)
Regulatory and Arm's-Length Bodies	Department for Digital, Culture, Media & Sport (DCMS)
Regulatory and Arm's-Length Bodies	Department for Levelling Up, Housing and Communities (DLUHC)
Regulatory and Arm's-Length Bodies	DEFRA (Department for Environment Food and Rural Affairs)
Regulatory and Arm's-Length Bodies	Environment Agency (EA)
Regulatory and Arm's-Length Bodies	Natural England
Regulatory and Arm's-Length Bodies	United Nations Educational, Scientific and Cultural Organisation UK (UNESCO)
Regulatory and Arm's-Length Bodies	Department for Energy Security and Net Zero (DESNZ)
Regulatory and Arm's-Length Bodies	Department for Science, Innovation and Technology (DSIT)
Regulatory and Arm's-Length Bodies	National Highways
Charities and Member organisations	National Trust for Scotland
Charities and Member organisations	English Heritage
Charities and Member organisations	Council for British Archaeology (CBA)
Charities and Member organisations	Heritage Alliance
Charities and Member organisations	Heritage Funding Directory
Charities and Member organisations	Historic Houses Foundation
Charities and Member organisations	Society for the Protection of Ancient Buildings (SPAB)
Charities and Member organisations	National Trust
Charities and Member organisations	Archaeology Scotland
Charities and Member organisations	The Ancient Monuments Society
Charities and Member organisations	The Georgian Group
Charities and Member organisations	The Victorian Society
Charities and Member organisations	The Twentieth Century Society (C20)
Charities and Member organisations	Sustainable Traditional Buildings Alliance (STBA)
Charities and Member organisations	Architectural Heritage Fund
Charities and Member organisations	Pilgrims Trust
Charities and Member organisations	Institute of Conservation (ICON)

Sector	Organisation
Charities and Member organisations	SAVE heritage
Charities and Member organisations	Forestry Commission
Charities and Member organisations	Woodland Trust
Charities and Member organisations	Forestry England
Charities and Member organisations	Canal and River Trust
Academic and Research	Global Climate Research Portal
Academic and Research	Heritage Research Hub
Other	National Lottery Heritage Fund (NLHF)

Appendix 5

Scoped in climate hazards

- Mean air temperature
- Extreme heat
- Cold spell
- Frost
- Mean rainfall
- River flooding
- Heavy rainfall and flooding due to rainfall
- Landslide
- Drought
- Weather increasing risk of wildfire
- Mean wind speed
- Severe wind storm
- Snow
- Relative sea level
- Coastal flood
- Coastal erosion
- Mean ocean temperature
- Marine heatwave
- Ocean acidity
- Ocean salinity
- Dissolved oxygen
- Air pollution weather
- Atmospheric CO₂ at surface
- Changes in biological growth (e.g. mould)
- Changes in species distribution (e.g. invasive species)
- Shrink-swell
- Storm surge

Appendix 6

Organisations engaged through surveys and interviews

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
360 Grant Nav	Y			
Aberystwyth University	Y	Y		
Archaeology Scotland	Y			
Archaeology, Architecture, Environment & Sustainability, and Geography university departments	Identified through funding bodies			
Architectural Heritage Fund	Y	Y		
Arts Council England	Identified through funding bodies			
Association of Independent Museums (AIM)	Y			
Association of Local Government Archaeological Officers (ALGAO) – LPA funded/driven work	Y	Y		
Bath University – Institute for Sustainability	Y			
Built Environment Forum Scotland (BEFS)	Y			
BEIS (Department for Business, Energy & Industrial Strategy)	Contact form			
Birmingham University	Y	Y		
British Academy	Y			
British Council	Contact form			
British Museum	Y			
Building Research Establishment (BRE)	Y			
Cadw	Y		Y	Y
Cambridge Archaeological Unit	Y			

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
Cambridge University – Cambridge Heritage Research Centre	Y			
Cambridge University	Y	Y	Y	
Canal and River Trust	Y			
Cardiff Metropolitan University	Y	Y		
Cardiff University	Y		Y	Y
Cardiff University – Welsh School of Architecture	Y	Y		
Catapult	Y			
Catholic Church Bishop's Conference of England and Wales	Y			
Chartered Institute for Archaeologists (CIfA) – climate change working group	Y			
Chartered Institute of Building (CIOB)	Y	Y		
Chartered Institution of Building Services Engineers (CIBSE)	Y			
Church of England (CoE)	Y			
Climate Change Committee (CCC)	Contact form			
Climate Heritage Network	Contact form		Y	Y
Council for British Archaeology (CBA)	Y			
Centre for Research into Energy Demand Solutions (CREDS)	Y			
Department for Environment, Food and Rural Affairs – Earth Observation Centre of Excellence (DEFRA)	Y			
Department for Environment, Food and Rural Affairs (DEFRA)	Y			
Department for Digital, Culture, Media & Sport (DCMS)	Y			

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
Department for Levelling Up, Housing and Communities (DLUHC)	Y			
Department of Energy Security and Net Zero (DESNZ)	Y			
Diocese of Salford	Y	Y	Y	Y
Durham University	Y			
East Anglian Archaeology Research Framework	Y			
Edinburgh Napier University	Y		Y	
Edinburgh World Heritage Site – Climate Emergency Grant (EWHS)	Y	Y	Y	Y
English Heritage Trust	Y		Y	
Environment Agency (EA)	Y	Y	Y	Y
Environmental Audit Committee	Y			
Engineering and Physical Sciences Research Council (EPSRC) Centre for Doctoral Training in Science and Engineering in Arts Heritage and Archaeology	Y			
EPSRC Grants on the Web database	Identified through funding bodies			
Esmée Fairbairn Foundation	Y			
Exeter University	Y		Y	Y
Federation of Archaeological Managers and Employers (FAME)	Y			
Forestry Commission	Y	Y		
Forestry England	Y		Y	Y
Garfield Weston Foundation	Y			
Glasgow University	Y	Y	Y	Y
Global Climate Research Portal	Y			
Great North Museum	Y			
Green Alliance	Y			

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
Heritage Alliance members (where applicable)	Y			
National Lottery Heritage Fund	Y			
Heritage Funding Directory	Y			
Heritage Research – Arts and Humanities Research Council Heritage Priority Area (AHRC)	Y			
Heritage Research Hub	Y			
Hindu Forum of Britain	Y			
Historic Buildings and Places	Y			
Historic England	N/A			
Historic Environment Division (Northern Ireland)	Y	Y	Y	Y
Historic Environment Scotland	Y		Y	
Historic Houses	Y			
Historic Houses Foundation	Y			
Historic Towns Forum	Unable to find contact			
Homes England	Y			
International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM)	Y			
International Council of Museums (ICOM)	Y			
International Council on Monuments and Sites UK (ICOMOS)	Y	Y	Y	
Industrial Decarbonisation Research & Innovation Centre at Heriot Watt University (IDRIC)	Y			
Institute of Civil Engineers (ICE)	Contact form			
Institute of Conservation (ICON)	Y			
Institute of Environmental Management & Assessment (IEMA)	Y			

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
Institute of Historic Building Conservation (IHBC)	Y			
Institution of Structural Engineers (IStructE)	Contact form			
International Science Partnerships Fund (ISPF)	Y			
International Union for Conservation of Nature UK Peatland Programme (IUCN)	Y			
Joint Committee of the National Amenity Societies	Y			
Kent County Council	Unable to find contact			
Landscape Institute	Y			
Laudes Foundation	Contact form			
Leeds Beckett University – Leeds Sustainability Institute	Y	Y	Y	
Leeds University	Y			
Liverpool University	Y	Y		
London Energy Transformation Initiative (LETI)	Y			
London-Loughborough Engineering and Physical Sciences Research Council (EPSRC) Centre for Doctoral Training in Energy Demand	Y			
London School of Economics (LSE) – Grantham Research Institute on Climate Change & the Environment	Y			
Manchester University	Y			
Met Office, Hadley Centre	Y			
Museum of London Archaeology (MOLA)	Y	Y	Y	
Museums Association	Y			
Muslim Council of Britain	Y			
National Grid	Contact form			

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
National Heritage Science Forum	Y			
National Maritime Museum	Y			
National Museum Scotland	Y			
National Museum Wales	Y			
National Museums Directors Council	Y			
National Museums Liverpool	Y			
National Parks England	Y			
National Trust for Scotland	Y			
National Trust	Y		Y	Y
National Highways	Y			
Natural England (NE)	Y	Y	Y	Y – two
Natural History Museum	Contact form			
Natural Resources Wales (NRW)	Y			
National Endowment for Science, Technology and the Arts (NESTA) Arts and Humanities Research Council (AHRC) Natural Environment Research Council (NERC) Economic and Social Research Council (ESRC) Engineering and Physical Sciences Research Council (EPSRC)	Identified through funding bodies			
Network of Buddhist Organisations	Y			
North East research framework for the Historic Environment	Y			
Northern Ireland Department for Communities	Y			
Open University (OU)	Y	Y	Y	Y
Oxford Archaeology	Y			
Oxford University – Environmental Change Institute	Y			

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
Oxford University – School of Geography & Environment	Y			
Peat Partnership	Y			
Pilgrims Trust	Y			
Pitt Rivers Museum	Y			
Plymouth University	Y		Y	
Preserving legacies	Y		Y	
Pvotal Consultancy	Y	Y		
Royal Botanic Gardens Kew	Y			
Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW)	Y	Y	Y	Y
Royal Geographical Society (RGS)	Y			
Royal Institute of British Architects (RIBA)	Y			
Royal Institution of Chartered Surveyors (RICS)	Y			
Royal Meteorological Society	Y			
Royal Town Planning Institute	Y			
Royal Society for the Protection of Birds) Northern Ireland (RSPB)	Y			
Royal Society for the Protection of Birds) Scotland (RSPB)	Y			
Royal Society for the Protection of Birds) United Kingdom (RSPB)	Y			
Royal Society for the Protection of Birds) Wales (RSPB)	Y			
Salford University	Y			
SAVE Britain's Heritage	Y			
Science Museum Group	Y			
Sikh Council UK	Y			

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
Society for Museum Archaeology	Contact form			
Society for the Protection of Ancient Buildings (SPAB)	Y			
South West Heritage Trust	Y			
St Mary's University	Y	Y		
Surrey County Council Archaeological Research Framework	Y	Y		
Sustainable Traditional Buildings Alliance (STBA)	Y			
Tate	Y			
The Ancient Monuments Society	Y			
The Ashmolean Museum	Y			
The Courtauld Institute of Art	Y			
The Energy Saving Trust	Contact form			
The Georgian Group	Y			
The Horniman Museum and Gardens	Y	Y		
The James Hutton Institute	Y			
The Jewish Leadership Council	Y			
The Manchester Museum	Y			
The Museum of London	Y			
The Twentieth Century Society (C20)	Y	Y	Y	
The Victorian Society	Y			
The Wolfson Foundation	Y			
The Oxford Research Centre in the Humanities (TORCH)	Y			
Tyndall Centre for climate change research, University of East Anglia (UEA)	Y			
University College London – Energy Institute (UCL)	Y	Y	Y	

Organisation	Survey issued	Replied?	Invited to interview?	Interviewed?
University College London – Institute for Sustainable Heritage (UCL)	Y		Y	Y
UK Centre for Ecology & Hydrology (UKCEH)	Y			
UK Green Building Council (UKGBC)	Y	Y		
UK Heritage Adaptation Partnership	Organisations with partnership already included			
UK Research and Innovation	Identified through funding bodies			
United National Educational, Scientific and Cultural Organisation – UK (UNESCO)	Y			
University College Cork	Y	Y	Y	Y
University of East London	Y			
University of St Andrews, Geography and Sustainable Development	Y	Y	Y	Y
University of the West of England (UWE)	Y		Y	Y
Victoria and Albert Museum (V&A)	Y			
Vindolanda Trust	Y	Y	Y	Y
Wildlife Trust	Y			
Woodland Trust	Y		Y	
Total:	173 organisations invited to complete survey	34 individual responses, 32 organisations responded	31 organisations asked to interview	19 organisations interviewed; 20 interviews conducted

Appendix 7

UKRI research councils scoped in and out

Acronym	Full name / description	Scope in / out
AHRC	Arts and Humanities Research Council	In
BBSRC	Biotechnology and Biological Sciences Research Council	Out
COVID	Covid-specific funding	Out
EPSRC	Engineering & Physical Sciences Research Council	Out
ESRC	Economic and Social Research Council	In
FIC	Fund for International Collaboration	In
FLF	Future Leaders Fellowships	In
GCRF	Global Challenges Research Fund	Out
Horizon Europe Guarantee	Funds interrupted from Brexit	In
Innovate UK	Innovate UK (innovation across all sectors)	Out
ISCF	The Industrial Strategy Challenge Fund	Out
MRC	Medical Research Council	Out
NC3RS	Replacement, Reduction and Refinement	Out
NERC	Natural Environment Research Council	In
Newton Fund	Partnerships in Africa, Asia and Latin America	Out
SPF	Shared Prosperity Fund (levelling up local places)	In
STFC	Science and Technology Facilities Council	Out
UKRI	UK Research and Innovation	In
UUI	UK Ukraine Initiative	Out

Appendix 8

Search terms used for first UKRI coding

Climate change term	Heritage	General
Acidity		
Adapt	Historic	Habitat
Adaptation	Historic land	Restoration
Air temperature	Listed	
Atmospheric		
Biodiversity	Fishing	
Biodiversity net gain	Water usage	
Biota	Theatre	
BNG	Cooling	
Carbon	Heating	
Carbon	Historical building	Maladaptation
Carbon capture	Glazing	
Circular economy	Ritual	
Climate	Buried	
Climate change	Heritage	Retrofit
Coastal		
Coastal retreat	Craft	
Cold	Estate	
Dissolved organic carbon		
Dissolved oxygen		
DO		
DOC		
Drought	Museum	
Ecological		
Ecology	Agriculture	
Ecology	Practice	
Ecosystem	Building fabric	
Embodied	Cultural	Degradation

Climate change term	Heritage	General
Emissions	Culture	Sustainability
Erosion		
Extreme	Garden	
Fauna	Ancient	
Fire		
Flood	Underwater	
Flora	Knowledge	
Foot printing	Repair	
Footprint	Maintenance	
Frost	UNESCO	
Green finance	Shading	
Heat	Park	
Heatwave		
Hydrological	Farm	
Land		
Landslide	Religious	
Managed realignment	Tradition	
Mitigate	Building	
Mitigation	Asset	
Moorland	Fabric	
Natural assets	Insulation	
Natural flood management	Festival	
Nature	Farming	
NFM	Expression	
Ocean		
Offsetting	Intangible	Sustainable
Peat	Drainage	
PFR	Skills	
PLP	Oral tradition	
Pluvial	Maritime	
Pollution		
Precipitation	Marine	

Climate change term	Heritage	General
Property flood resilience	Land management	
Property level protection	Language	
Rain	Religion	
Rainfall	Coast	
Resilience	Historic seascapes	Natural capital
Resilient	Historical	
River restoration	Energy	
Salinity		
Sea level	Historic buildings	Peatland
Sequestration	Archaeology	Economy
Severe		
Snow		
Soil		
Storm		
SUDs	Event	
Sustainable urban drainage systems	Performing arts	
Temperature	World heritage site	
Tree	Performance	
Weather		
Wind		
Woodland		

Appendix 9

Second UKRI coding approach and search terms

The coding will "read" the title and abstract for each research project, it will then look to assign one or more subcategory to each research project. The code will identify whether the title and/or abstract contains a term from Column A and a term from Column B, and then look to see if it contains any of the terms beneath each subcategory (Columns C to AH); if the title and/or abstract meets these criteria, it will assign the corresponding subcategory to the research project in a new column of the spreadsheet. The code will allow several subcategories to be assigned if the title and/or abstract contains a term in Column A and B, and then key terms from multiple columns C-AH.

If the code identifies a title/abstract with a term from column A and B but not from columns C-AH, then they will be assigned a general category for manual review & categorising.

The search terms have been chosen with the aim of relating only to its sub-category, which is why there is no duplication of terms.

All search terms that contain two words will be searched as a whole term e.g. "hazard mapping" rather than "hazard" and/or "mapping".

Column	Research area	Type of term	Search terms
A	-	Heritage terms	Heritage; Historic; Historical; Archaeology; Archaeological; Intangible; Culture; Cultural; Buried; Tradition; Traditional; Ecclesiastical; Ecclesiastic; Ancient; Vernacular; Listed Structure; Listed Building; Scheduled monument; Estate; Stately; Veteran tree; Conservation; Conserve; Museum; Worship; Religious; Registered battlefield; Registered landscape; Registered park; Registered garden; Designed landscape; Paleo*; Palaeo*; Designated asset; Protected wreck; Sense of place
B	-	Climate terms	Climate; Tipping point; Carbon; Global warming; Global heating; Environmental crisis

Column	Research area	Type of term	Search terms
C	1	Climate Risk/Hazard mapping	Risk map*; Hazard map*; Mapping risk; Mapping hazards; Mapping climate risk; Mapping climate hazards; Threat map*; Risk assess*; Resilien*; Vulner*
D	1	Climate Risk/Hazard monitoring	Risk monitoring; Hazard monitoring; Monitoring risk; Monitoring hazards; Monitoring climate risk; Monitoring climate hazards; Monitoring climate threats
E	1	Adaptation & Mitigation Resources	Adapt*; Mitigat*
F	1	Policy and guidance	Strategy; Policy; Plan; Agenda; Resource; Advice; Guidance
G	2	Flooding and extreme events	Flood; Flooding; Rain; Rainfall; Fluvial; Pluvial; Hydraulic; Hydro; Storm; Precipitation; Extreme weather; Extreme event; Overtopping; Over topping
H	2	Coastal change and sea level rise	Erosion; Coastal change; Sea level; Coastal squeeze; Coastal grazing marsh
I	2	Change in marine environment (potentially exposing remains previously preserved through submersion or extreme weather)	Submerged; Submerge; Oxygen; Anaerobic; Preserve; Preserved; Acidity; Salinity; Temperature; Marine; Ocean; Maritime; Intertidal
J	2	Managed realignment and coastal retreat	Managed realignment; Retreat; Soft defence; Saltmarsh; Sand dune; Dissipate; Soft engineering; Riparian
K	2	No further intervention	Breach; Do nothing; No further intervention; No intervention; Do minimum; No active intervention
L	2	Hard engineering (rock armour, concrete revetments)	Hold the line; Hard defence; Rock armour; Rock armor; Sea wall; Revetment; Hard engineering; Tetrapod; Riprap

Column	Research area	Type of term	Search terms
M	3	Social practices including approaches to livelihoods like farming and fishing	farming; fishing; social; livelihood; economy; economic; society; societal; pastoral
N	3	Knowledge and practice of nature, ecology, flora, fauna and land management	ecology; flora; fauna; land management; biology; species; nature; natural; habitat; biodivers*; hedgerow
O	3	Traditional craft and building skills	craft*; building skill; artisan*; construction skill; Indigenous knowledge; Local knowledge; Stone walls
P	3	Oral tradition, expression and language	oral; language; lore; folk; poetry; ballad; prose; chant; folktales; linguistics
Q	3	Festivals, rituals, events, performing arts and cultural expression	festival; ritual; art; expression; performance; perform; fair; holiday; festive
R	4	Flood proofing - property flood resilience	Property Flood Resilience; PFR; Property Level Protection; PLP; Flood proofing; Flood proof
S	4	Energy efficiency measures including insulation and retrofit of new technology, services and micro generation	retrofit; insulation; micro generation; utilities; renewable; energy generation; energy efficiency; Moisture risk; Maladaptation; Indoor air quality; IAQ; Thermal performance; Indoor environmental quality; IEQ; Hygrothermal; energy demand; u-value; heat loss; Building performance; operational energy; operational carbon; energy performance certificat*; EPC; Energy model*; Standard Assessment Procedure; SAP; PAS 2035; PAS 2038; Energy performance; building stock modelling; moisture accumulation; building performance simulation; Fabric first; whole house approach; refurbishment
T	4	Measures to prevent overheating including shading, glazing and building fabric enhancements;	overheating; glazing; shading; fabric; solar gain; passive; g-value

Column	Research area	Type of term	Search terms
U	4	Material usage including low carbon materials and those which promote a circular economy, whilst also being appropriate to the heritage asset	materials; sympathetic; circular economy; recycle; recycling; reuse; re-use; low carbon material
V	4	Carbon reduction within maintenance and repair regimes for historic buildings.	repair; maintenance; deterioration; deteriorate; Carbon reduction; decarbon*
W	4	Low carbon and sustainable solutions for building services to respond to heating, cooling, water usage and drainage, etc.	heating systems; cooling systems; emissions; electrification; heat network; heat pumps; biogas; hydrogen; energy use; water use; drainage; rainfall capture; Nature based solutions; SUDS; Sustainable Urban Drainage System; Stormwater management; district heating
X	4	The effect of changing biota and their growth rates on material degradation	Biota; Condensation; Mould; Damp; Bacteria; Spore; Fungus; Fungal; decay; wood rot; Biodeterioration
Y	5	Quantifying embodied carbon in heritage assets including building stock	embodied carbon; whole life carbon; embodied emissions; upfront emissions; in-use emissions; end of life emissions; demolition emissions
Z	5	Identifying and quantifying carbon sequestration opportunities associated with heritage assets	"carbon sequestration" and "asset"
AA	5	Comparative assessments of carbon footprints of materials used in the maintenance and restoration of heritage assets	Carbon footprint; restoration; Environmental product declaration; EPD
AB	5	Carbon emissions associated with archaeological techniques	geophysics; excavation; boreholes; coring; trenching; Dating; watching brief; sampling

Column	Research area	Type of term	Search terms
AC	5	Natural capital and ecosystems services approaches	Natural capital; Ecosystem services; Heritage capital; Historic capital
AD	6	Peat – upland and lowland	peat; mire; bog
AE	6	Wetlands (non-peat)	moorland; fenland; fen; moors; water meadow; RAMSAR; wetland; marsh
AF	6	Carbon capture and sequestration research	"carbon sequestration" and "landscape"; "carbon sequestration" and "seascape"; "carbon sequestration" and "peat"; Biogenic carbon; "carbon sequestration" and "woodland"; "carbon sequestration" and "wetlands"
AG	6	Carbon offsetting and green finance initiatives	offsetting; green finance; offset; Carbon credit
AH	6	Ancient woodlands	Ancient woodland; tree

Bibliography

Fatorić, S., and E. Seekamp. (2017) 'Are Cultural Heritage and Resources Threatened by Climate Change? A Systematic Literature Review', *Climatic Change* 142, no. 1-2, 227-254. <https://doi.org/10.1007/s10584-017-1929-9>

Historic England (2017) *Research Agenda*. <https://historicengland.org.uk/images-books/publications/he-research-agenda/research-agenda/> (acc. October 2023).

Historic England (2022) *Heritage and Climate Change. A strategy for Historic England's response to the climate, energy and biodiversity crisis*. <https://historicengland.org.uk/advice/climate-change/our-strategy/> (acc. October 2023).

Historic England (2023) *Historic England Corporate Plan 2023-26*. <https://historicengland.org.uk/images-books/publications/he-corp-plan-2023-26/> (acc. October 2023).

Orr, S.A., Richards, J., and Fatorić, S. (2021) 'Climate Change and Cultural Heritage: A systematic literature review (2016-2020)', *Historic Environment Policy and Practice*, 12:3-4, 434-477. <https://www.tandfonline.com/doi/full/10.1080/17567505.2021.1957264>

Warren, R., Watkiss, P., Wilby, R.L., Humphrey, K., Ranger, N., Betts, R., Lowe, J., and Watts, G. (2016) *UK Climate Change Risk Assessment Evidence Report: Chapter 2, Approach and Context. Report prepared for the Adaptation Sub-Committee of the Committee on Climate Change*. <https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017/ccra-chapters/> (acc. October 2023)



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