Historic England

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Identification of climate hazard and climate change adaptation resources

JBA Consulting

Climate Change / Policy & Evidence

Identification of climate hazard and climate change adaptation resources

JBA Consulting

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Summary

This report outlines findings related to identifying climate hazard resources relevant to safeguarding heritage sites against the impacts of climate change. It details the development of a data catalogue, identifies a wide range of tools and datasets that can support adaptation to climate change impacts on heritage sites, evaluates climate change risk assessment (CCRA) methodologies suitable for the heritage sector, and proposes ways to present this information effectively to both internal and external stakeholders. It highlights the datasets and tools available now, as well as key information gaps and the need for accessible tools that cater to different stakeholders within the heritage sector.

The work underscores the critical role of Historic England in leading the move towards a more resilient heritage sector, capable of facing the challenges posed by a changing climate by both informing others on suitable approaches and resources, and assessing risks at a strategic, national level. The report emphasises collaboration, knowledge sharing, and the use of tools and data sets to enhance resilience and inform decision-making processes regarding the protection of cultural heritage from climate risks.

Contributors

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Cover photo: Martello tower No. 66, 320m north east of Langley Point, Eastbourne, on the Sussex coast[1] © JBA Consulting

Archive location

Key report outputs are issued to HE and there are no project archive elements requiring retention in a public archive. Project specific business files are retained by JBA.

Date of survey/research/investigation

Research was carried out between December 2023 and March 2024. This report was written in March 2024.

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Abbreviations

Acronym	Definition
ALB	Arm's Length Body
ARP	Adaptation Reporting Power
CCC	Climate Change Committee
CCKP	Climate Change Knowledge Portal
CCRA	Climate Change Risk Assessment
CCRAO	Climate Change Risk and Opportunities Assessment
CDS	Climate Data Store
CEDA	Centre for Environmental Data Analysis
CID	Climatic Impact-Driver
CRA	Climate Risk Assessment
CVI	Climate Vulnerability Index
DCIoS	Devon, Cornwall and Isles of Scilly
Defra	Department for Environment, Food and Rural Affairs (Defra)
DEZNZ	Department for Energy Security and Net Zero
DLUHC	Department for Levelling Up, Housing and Communities
DSIT	Department for Science, Innovation and Technology (DSIT)
EA	Environment Agency
EHT	English Heritage Trust
EIA	Environment Impact Assessment
ESRI	Environmental Systems Research Institute, Inc
GIS	Geographic Information System
HES	Historic Environment Scotland
IPCC	Inter-Governmental Panel on Climate Change
ISO	International Organisation for Standardisation
IUCN	International Union for Conservation of Nature

Acronym	Definition
LCAT	Local Climate Adaptation Tool
NGO	Non-Governmental Organisation
NI	Northern Ireland
OUV	Outstanding Universal Value
ProFSea	Projecting Future Sea Level
RCAHMW	Royal Commission on the Ancient and Historical Monuments of Wales
RCP	Representative Concentration Pathway (a climate scenario)
TCFD	Task Force on Climate-Related Financial
UKCEH	UK Centre for Ecology and Hydrology
UKCIP	UK Climate Impact Programme
UKCP18	UK Climate Projections 2018
UKCRI	UK Climate Risk Indicators

Introduction

Project background

Historic England's Corporate Plan[2] is made up of six priorities, priority four of the plan is Climate Action. "Our leadership ensures that heritage plays an important role in the fight to limit climate change impacts." This priority is consequently broken down into six outcomes, one of which is, "People are better equipped to make historic buildings and places more resilient to our changing climate".

Historic England's Climate Change Strategy[3] describes the organisation's 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."

The aim of Strand 2 within the Strategy "Managing risks: understanding the threats of climate change" states:

> "We will identify, understand, and respond to threats to heritage from a changing climate. We will share our insights: listening, learning, and collaborating with partners to effect, enable and catalyse change and risk management."

This research report has been prepared by JBA Consulting on behalf of Historic England to support their response to these priorities, aims and outcomes by addressing Climate Action 2.3 "Map climate-related hazards" and by informing Climate Action 2.1 "Work with climate scientists on implications for heritage of future climate projections" and Climate Action 2.2 "Develop ways to quantify and monitor climate related risks" within the Climate Change Strategy.

[2] Historic England, (2023). Corporate Plan.
[3] Historic England, (2022). Climate Change Strategy.

This project contributes towards Historic England's research agenda[4], in particular the '#adapt' theme, which includes: local planning; national planning and infrastructure; land management; climate change; heritage crime; and societal change.

This research addresses these objectives through the development of a data catalogue, guidance and this final report - outlining the applicability of data, tools for assessing climate hazards and change, and approaches to climate change risk assessment suitable for Historic England and the broader heritage sector.

Aims and objectives

In accordance with Historic England's Corporate Plan[5], Climate Change Strategy[6] and Third National Adaptation Programme (NAP3)[7] commitments, three key aims were identified at the project's inception to meet the scope of the project:

1. To better understand what data, tools and methods exist.
2. To share information that allows those responsible for heritage to carry out risk assessment.
3. To understand (and get recommendations on) what Historic England could package up and share as useful data, methods and outputs for heritage managers, working at various spatial scales.

To meet these aims, this project addressed the following objectives:

- Provide a clear picture of the resources currently available and in development to understand and communicate information about climate change hazards and impacts.
- Develop a clear understanding about both available data and evidence gaps.
- Understand where opportunities for partnership working exist.
- Understand where information is available in a format that can be publicly sign-posted.
- Understand where data can be used for Historic England's own modelling of climate change impacts in England.

Scope

To meet these objectives a desk-based review was undertaken to collate as many relevant tools and sources of data as possible; a review of climate change risk assessment (CCRA)

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[4] Historic England, (2017). Research Agenda.
[5] Historic England, (2023). Corporate Plan.
[6] Historic England, (2022). Climate Change Strategy.
[7] Department for Environment, Food and Rural Affairs, (2023). Third National Adaptation Programme (NAP3).

approaches suitable for a heritage context was also undertaken. The following questions were used to inform this research:

- Where are data, tools, methods already available or that other organisations are developing Historic England can signpost to?
- Where do these already cover (directly or indirectly) heritage assets?
- Are there opportunities to feed heritage data into these existing data, tools, methods?
- What existing data, tools, methods can heritage data be added to?
- What would a good package of information look like to enable heritage managers to carry out proportionate and useful risk assessments given the volume of data?

The data and tools catalogue forms a library of resources relevant to modelling the long-term impacts of climate change on cultural heritage caused by a variety of Climatic Impact-Drivers and climate hazards. The data and tools catalogue will assist Historic England in achieving its objectives in relation to its research on 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 society can respond to those threats within a strategic English context. The catalogue will also aid Historic England in advising and signposting heritage owners and managers to appropriate resources to understand the exposure of physical heritage assets to climate change hazards, therefore informing future adaptation.

The data catalogue covers the hazards identified with the Third UK Climate Change Risk Assessment[8] (CCRA3) and NAP3. The catalogue includes details of which organisation developed the data or tool, hazards included, how current the data is, spatial scales and whether the data is publicly available or not. Data was included from both UK and non-UK organisations.

The methodologies of CCRAs for the heritage sector, comparable arm's-length bodies (ALBs), along with sector-specific standards and approaches to CCRA have been assessed for their suitability for both Historic England to carry out CCRA and to advise heritage managers undertaking their own CCRA. This will enable Historic England to understand the different approaches relevant to heritage and to enable the development of new ways of assessing risk by combining multiple approaches.

[8] Climate Change Committee (CCC), (2021). The Third UK Climate Change Risk Assessment.

Methodology

The methodology developed and carried out for this project is detailed below and is demonstrated visually in Figure 1.

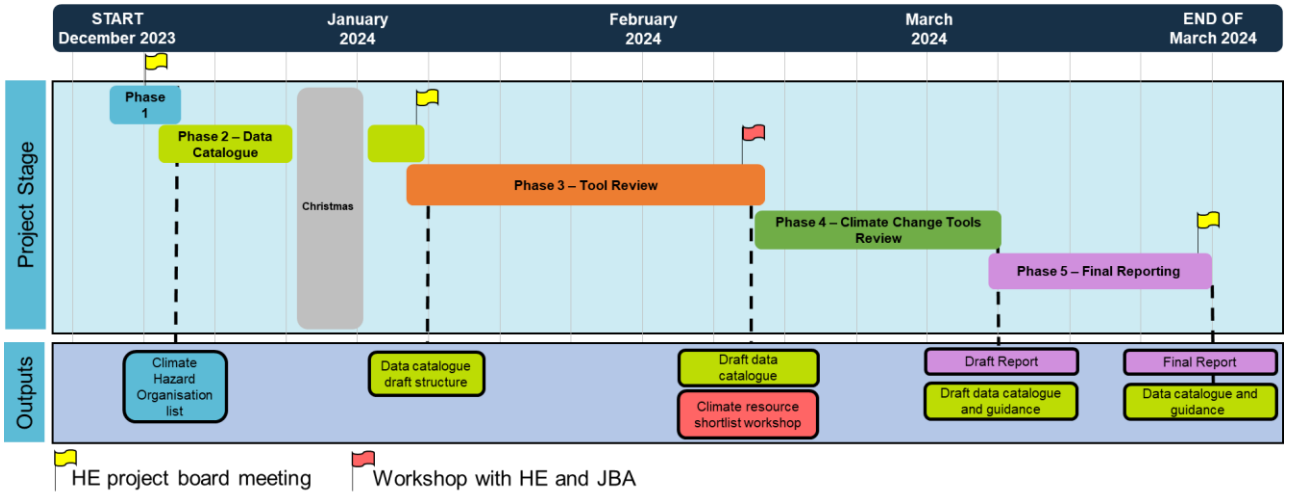

Figure 1. Infographic of the project's methodology and stages.

Definitions

For the purposes of this project it was necessary to define what was meant by “tool” and “data”. Definitions were agreed with Historic England at the start of the project and have been refined in consultation with Historic England throughout the project.

Data: Data is taken to be facts and statistics which can be accessed and downloaded. Data can be viewed through data visualisation in web browsers, but this does not make it a tool. Data can come in a range of formats.

Tool: A tool is a resource that can be interacted with, manipulated and changed to produce a different outcome.

Climatic Impact-Driver (CID): A physical climate condition, for example, mean ocean temperatures or mean wind speed (aligned with the 'Developing a standardised climate change hazard vocabulary for cultural heritage' ongoing Historic England research project definition).

Climate hazard: The potential occurrence of a negative event. This is extrinsic to the heritage system (aligned with the 'Developing a standardised climate change hazard vocabulary for cultural heritage' definition). A full list of the hazards can be found here[9].

[9] Thomas, H., Philip, C., Guest, K., Guiden, N., Orr, S. a. (2024) A standardised climate change hazard vocabulary for heritage.

Direct impacts: We have drawn on Historic England's definition of direct impacts in the first instance. These are: flooding, coastal change, temperature rise, water availability and extreme weather, and biogeography: distribution of animals, plants and pathogens.

Where the above interpretations did not cover certain impacts, a Climate Change Committee (CCC)[10] definition was referred to: direct impacts involve simple impact pathways, e.g. higher temperatures on cooling demand.

Indirect impacts: We have drawn on Historic England's definition of indirect impacts in the first instance. These are: the addition of renewable energy sources, the enhancement of flood resistance measures, the management of coastal retreat, pro-active changes in land management and environmental stewardship, changes to buildings to improve comfort, and safety and/or running costs.

Where the above interpretations did not cover certain impacts, a CCC[11] definition was referred to: 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.

Data and tools identification

Data and tools were identified through desk-based research of publicly available climate hazard resources. Initially, this research focused on organisations that interacted with the last national CCRA (CCRA3). A stakeholder and organisation list was collated in consultation with Historic England to identify potential sources of data and tools. This stakeholder list is included in Appendix 1. The website of each organisation was searched for sources. Internal JBA colleagues and contacts within the broader environmental sector were also approached to add to this research to identify the broadest range of data and tools possible.

Each entry in the catalogue was assigned a unique ID number prefixed with “Data” or “Tool”. When data or a tool are discussed within this report it is tagged with its unique ID number.

Surveying stakeholders

An online survey, conducted via Microsoft Forms, was distributed to identified organisations to capture any data sources that were not identified through the desk-based research. The survey consisted of questions that requested relevant information for the

[10] Warren et al. (2016). UK Climate Change Risk Assessment Evidence Report: Chapter 2, Approach and Context.

[11] ibid

catalogue. The survey aimed to gather information about potential data sources, around the following categories:

- Users of the data
- Climatic Impact-Drivers included in the data
- Description of the data
- Applicable heritage assets
- Metadata (update frequency, licence, format)
- Climate projections scenarios timescales
- Spatial coverage and resolution
- Strengths and weaknesses of the data
- Whether the data is being used for CCRA.

46 organisations were approached from across Government Departments and ALBs, academia and research, international bodies and other groups such as Local Government, non-profit organisations and consultancies. To date, this survey has had three responses. It should also be noted that a significant number of organisations were only contactable via a generic inbox, or an online contact form, which do not appear to be monitored regularly or consistently. We made use of our network of contacts at JBA Consulting and within the sector, to request responses from individuals at the organisations, however, responses have not been forthcoming. However, we are confident that this has not resulted in the omission of any major data sources or tools, as the desk-based research exercise was extensive and we have drawn on the experience of internal colleagues to cover any potential data gaps.

The full survey is available in Appendix 3.

Desk-based review

A desk-based review of all identified climate hazard information (tools and data) was conducted after identification. This involved accessing tools and data online where possible, assessing strengths and weaknesses of each identified resources. Tools and data that incurred a payment to access, or were restricted to specific categories of user, were not in scope and have therefore not been accessed.

Data was explored and analysed, noting the following:

- The name of the data / platform
- The developer / organisation
- A brief description

- Heritage asset relevance
- Hazard type (climatic impact-driver and climate hazard)
- Metadata (update frequency, source country)
- Spatial coverage and resolution
- Whether there are any licence requirements
- Available file format of the data (NetCDF, GIS, Excel (CSV))
- Whether the data comes with data visualisation
- Strengths and weaknesses of data
- A link to the data.

Strengths and weaknesses of data sources considered the following components at a minimum:

- Resolution of the data
- Presence/absence of data visualisation
- Ease of interpretation of data (resources required to interpret)
- How widely the data is used within the sector?
- How robust the data is in terms of its production?
- Number of scenarios / time horizons considered?
- General utility (is the data useful for multiple purposes or is it very niche?)
- How easy the data is to extract and download.

Tools were explored and analysed, noting the following:

- Description of the tool
- Metadata
- Heritage asset relevance
- Hazard type (climatic impact-driver and climate hazard)
- Metadata (update frequency, source country
- Spatial coverage and resolution
- Strengths and weaknesses of the tool
- Suitability of the tool for Historic England to use and/or signpost to other users.

Strengths and weaknesses were assessed based on the usability of the tool. The following attributes were considered, where relevant:

- Resolution of the data
- Model uncertainties
- Interrogability of data
- Whether a tool is conducting ‘black box’ calculations (where the calculations, assumptions and weightings behind the outputs are unknown)
- Number of climate scenarios available
- Length of time series, and temporal resolution
- Ease and accessibility of data download, including whether a data viewer or download is integrated
- Ease of necessary (data) analysis
- Appropriateness for certain situations
- Frequency of update
- General industry opinion
- Uniqueness in regard to other hazard datasets and tools.

Considering in-combination and compound hazards

In-combination and compound hazards were considered via a review of CCRA3’s risks pertinent to heritage (H3, H4, H5, H11, and N18) and in discussion with a heritage specialist familiar with heritage climate change effects.

Throughout the table (presented within Appendix 2) there are in-combination hazards which are in themselves relevant CID types, these were scoped out. However, the primary relevant in-combination hazards were as follows:

- Combination flooding – from multiple sources (e.g. combined tidal and fluvial flooding or river, sea and surface water flooding)
- Wind driven rain
- Moisture damage
- Biological growth – Bioturbation
- New pest species
- Oceanic changes
- Multiple (in the context of change to landscapes).

Some of the above hazards can be described as climate risks (e.g. pests), as the potential damage caused by climate change depends not only on the climate-related hazards themselves, but also on the vulnerability and exposure of human and natural systems.

Where possible, reference was made in the data catalogue to tools and data that featured in-combination hazards, as well as their constituent CID drivers.

Alternative options considered were a review of WSP's mapping of in-combination hazards following CCRA2[12]. This was discounted due to the outdated nature of the risk and hazard terminology used in the climate impact flow mapping. A matrix considering all of the hazard's interactions with each other was also considered, however, with 58 unique climate hazards identified, this would have result in 3,364 hazard combinations and so was not considered proportionate or in scope.

Tools workshop

An online virtual workshop was undertaken on the 15th of February with representatives from Historic England, where a range of climate hazard tools were presented to draw out Historic England's priorities for shortlisting the 38 identified tools. A representative range of tools from very simple and easy to interpret, to highly complex and specialised were presented. These are presented below in order of simplicity (simplest first, most complicated last):

- Environment Agency – Climate Impacts Tool (Tool_15 in data catalogue)[13]
- Forestry England – Climate Matching Tool (Tool_13 in data catalogue)[14]
- Environment Agency – Flood Map for Planning (Tool_2 in data catalogue)[15]
- Environment Agency – Shoreline Management Plan Explorer (Tool_27 in data catalogue)[16]
- UK Climate Resilience Programme – UK Climate Risk Indicators Explorer (Tool_1 in data catalogue)[17]
- EHT Zurich – CLIMADA (Tool_19 in data catalogue)[18].

The workshop helped to determine the characteristics of tools that may be beneficial to Historic England and the wider sector and refine the categories which were used for the shortlisting process. Notably, the workshop helped to identify that key priorities for Historic

[12] WSP (2020), Climate Change Impacts Flow Map
[13] Environment Agency, (2023). Climate Impacts Tool.
[14] Forestry Research, (2021). Climate Match Tool.
[15] Environment Agency, (2024). Flood Map for Planning.
[16] Environment Agency, (2024). Shoreline Management Plan Explorer.
[17] UK Climate Resilience Programme, (2023). UK Climate Risk Indicators Explorer.
[18] EHT Zurich, (2024). CLIMADA.

England were the ease of use of the tool and the overall complexity of the tool. Additionally, the workshop reaffirmed the need for a two tiered approach to shortlisting – prioritising tools for Historic England to use and prioritising tools for Historic England to signpost for others. This reflects Historic England's dual role as both a national statutory adviser to Government on heritage and adviser to the wider sector.

Shortlisting

Shortlisting of tools was conducted in the data catalogue for two categories: is the tool suitable for Historic England's use (day to day operations); and is the tool suitable for Historic England to signpost to others. Options available for shortlisting the tools are presented below in Table 1.

Table 1. Options for shortlisting tools with descriptions.

Option	**Description**
Yes, as provided	The tool is suitable for use as provided.
Yes, with an explanation/guidance	The tool is suitable as provided, with the caveat that explanation and/or guidance, either in how to use the tool or what the tool is for, is required.
Potentially, tool has some useful elements	This option applies to tools where some characteristics of the tool are useful, or where the tool might be useful at a higher level, but the tool might only be useful for providing limited statistics, figures or information.
No, tool is overly complex or inappropriate	Where a tool is less effective (more complex process, poor user interface or worse outputs) than an existing, comparable, UK specific tool it has been assigned this option.
No, tool is not useful in a heritage context	If a tool is presenting information at a very high granularity, or the outputs are tangential and don't relate to a heritage context they have been assigned this option.
No, tools data cannot be verified	If the data underpinning a tool cannot be verified or attributed, then it has been assigned this option.
Tool is a paid for service and could not be assessed to be shortlisted	This option applies to tools which are paid for services and therefore out of scope for this contract.
Tool is inaccessible due to restrictions on users and could not be accessed to be shortlisted.	This option applies to tools which were inaccessible to the project team at the time of shortlisting. This was primarily due to restrictions which meant the tool could only be accessed by research organisations, or they were not yet released.

Limitations and assumptions

Historic England have adopted the Inter-Governmental Panel on Climate Change (IPCC) definitions of Climatic Impact-Drivers and climate hazards. For the purposes of this project all Climatic Impact-Drivers were considered in scope, however, given the global nature of climate hazards created as part of the 'Determining climate hazards' project, some of these are not directly relevant to the UK and so were listed as out of scope. These included the following climate hazards:

- Desertification
- Tropical cyclones
- Glacial melt
- Permafrost thaw
- Low oxygen events
- Dissolved oxygen.

Despite the project team's best efforts to gather as much information as possible through a survey to identify data sources and tools, the survey did not gather as much information as was originally envisaged. Of the 46 stakeholders surveyed, seven stakeholders responded, of these three filled out the survey, whilst the other four contacted the project directly but did not complete the survey. A full list of the stakeholders surveyed for this project is included in Appendix 1.

Due to the scope and budgetary constraints of the project, this project was unable to access and assess commercial tools and data sources. For these tools and sources of data, a high level assessment has been undertaken, drawing on the information that is freely available. Commercial tools were identified in their own category during the shortlisting process.

Identified climate change hazard information

This section details the tools and data identified within the data catalogue.

Data identified

New datasets are being developed and current ones are being revised and updated all the time. In January 2024 alone, 19 datasets were updated on the Met Office's Climate Data Portal, ranging from annual growing degree days and projected changes in temperature and precipitation, to historical observations. The key producers of climate datasets identified for this project were meteorological institutions (such as the Met Office), ALBs (such as the Environment Agency), research institutions (including the UK Centre for Ecology and Hydrology, alongside universities and academic institutions), and the private sector. In the UK, a considerable number of datasets are derived from UKCP18[19] outputs produced by the Met Office. UKCP18 outputs represent the most reliable climate data currently freely accessible for the UK.

This project has identified 73 different datasets, the majority of which within the public domain. There are several exceptions to this: four require proprietary licences, two require non-commercial licences and two are not for public use. Identified data is stored in a range of formats, predominantly NetCDF, alongside Excel/CSV and GeoTiff/GIS. Some datasets are only available in raw form (NetCDF) which requires users to have some experience in coding, whereas others have integrated viewers for initial data visualisation.

Of the 73 datasets, 66 were suitable for use in relation to landscapes, 53 for buildings, 46 for archaeology and 28 for marine heritage (see Figure 2 below). In terms of CID coverage, 41 datasets covered mean air temperature, with the next most common being mean precipitation in 24 datasets, closely followed by 23 covering radiation at surface. A high number of datasets relating to radiation at surface have been identified due to the categorisation process. Datasets that consider multiple Representative Concentration Pathways (RCPs) cover different levels of radiative forcing. Datasets that meet this criteria have therefore been categorised as suitable for 'radiation at surface', despite them not having been produced for this explicit purpose. It is important to note that radiation at the surface is generally not a significant hazard for heritage managers. Figure 3, below, demonstrates the coverage of CID across the identified datasets. In terms of climate hazard coverage of the 73 datasets identified, average temperature patterns (33) was the most common hazard, followed by average humidity patterns (28) and average precipitation patterns (20). Figure 4, below, demonstrates the coverage of climate hazards across the identified data in greater detail.

[19] Met Office (2018) UK Climate Projections 2018

The datasets themselves cover a range of spatial scales. 30 datasets have data at the local scale, 35 at the regional scale and six at the national scale. One dataset's scale is unknown as it is still in development. The larger the spatial scale of the dataset, the less likely that the fine-scale spatial variations, which are important for local/regional impact assessments will be captured. Local scale datasets lend themselves for assessing smaller, individual heritage sites, whereas regional scale datasets will be more relevant for broader, heritage landscapes.

Datasets containing values for the future are derived from climate models which provide an indication of how Earth may respond under different future scenarios. It is important to note that there are general climate model limitations with simplifying complex processes, and that they may not capture abrupt climate shifts or tipping points due to this. There are also few models that represent compound or cascading hazards where hazards interact upon each other. The vast majority only model single climate variables. In addition, some datasets are only suitable for specific purposes, for example, some are primarily for ecological purposes (such as the UKCEH's climate change exposure estimates for the UK at 1km resolution, 1901-2080 (Data_60)[20]. Others like the national water temperature river modelling (Data_11) are likely to have limited relevance for most asset sites[21]. However, using multiple datasets in tandem will support analysis across the historic environment or for individual assets. In addition, a considerable number of datasets allow for the simulation and understanding of potential future changes under different scenarios. This allows for a wide range of impacts to be considered in CCRAs and will help to identify suitable adaptation measures to be adopted.

[20] Climate change exposure estimates for the UK at 1 km resolution, 1901-2080 - UK-SCAPE (ceh.ac.uk)

[21] Scoping a flexible framework for producing river water temperature projections - GOV.UK (www.gov.uk)

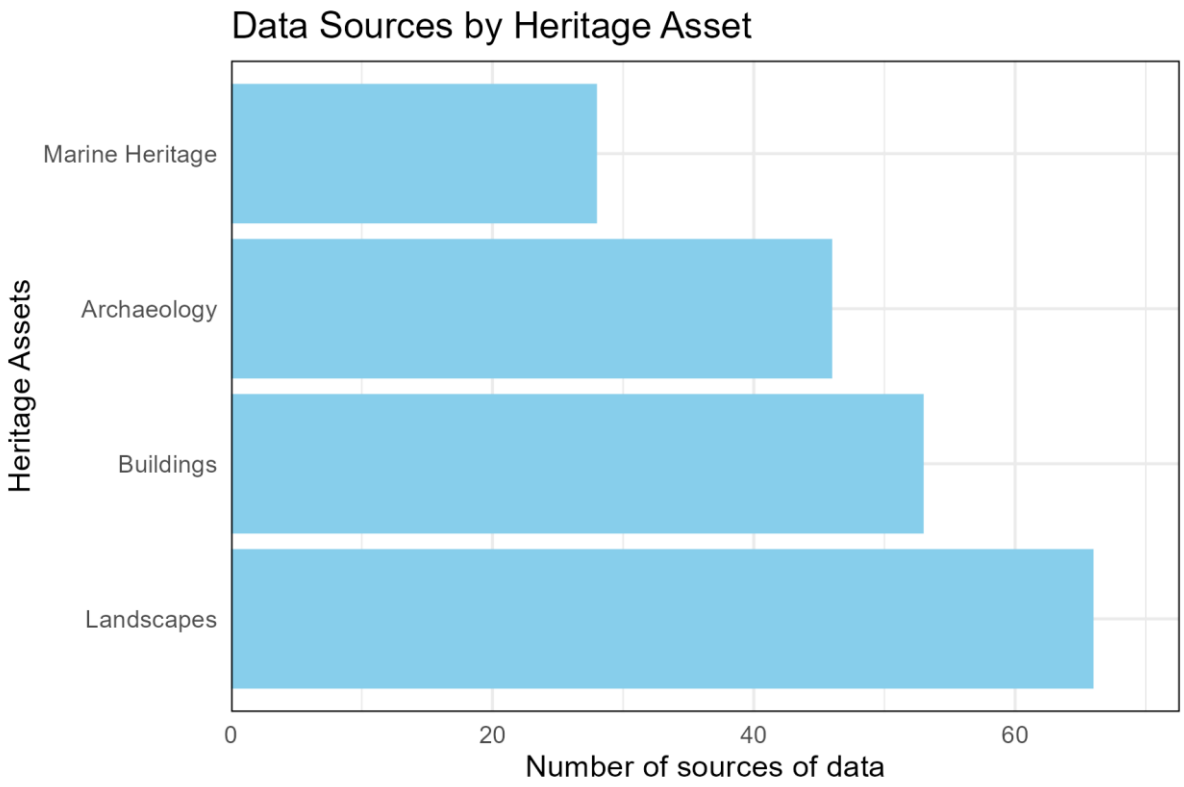

Figure 2. Identified data suitability according to heritage asset type

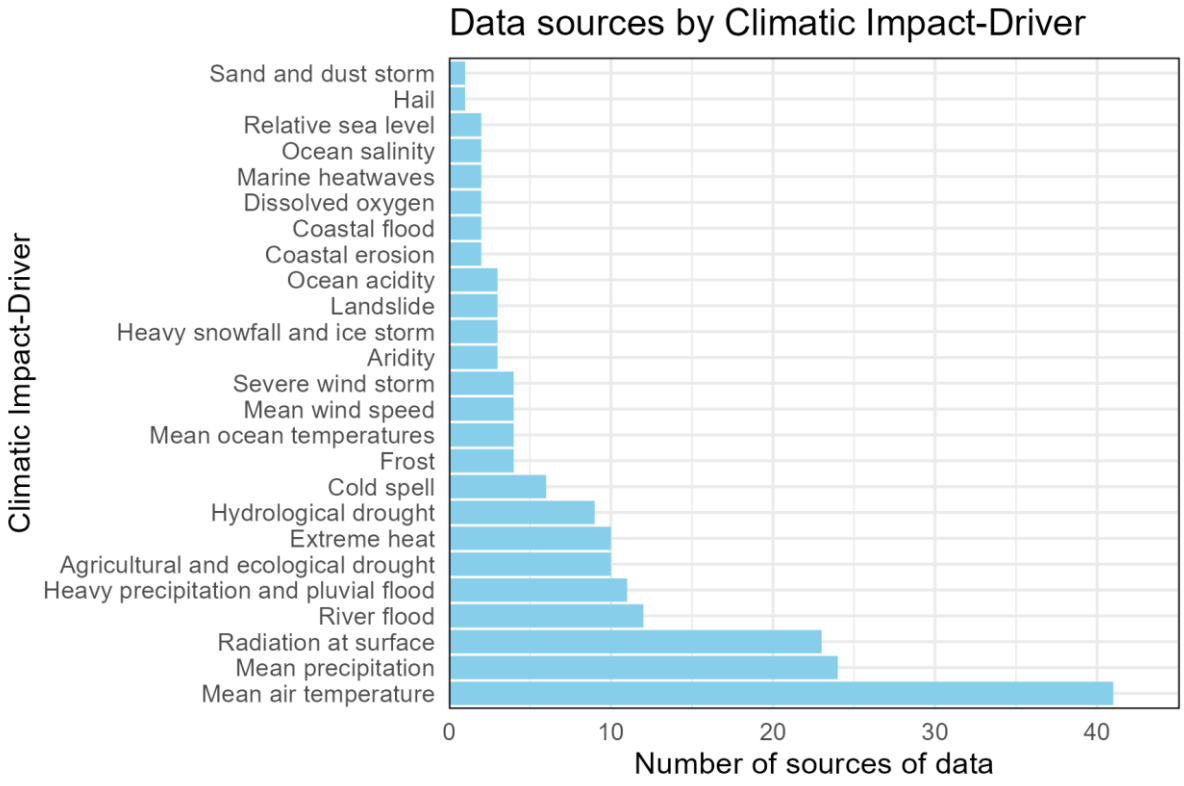

Figure 3. Identified data coverage of Climatic Impact-Driver.

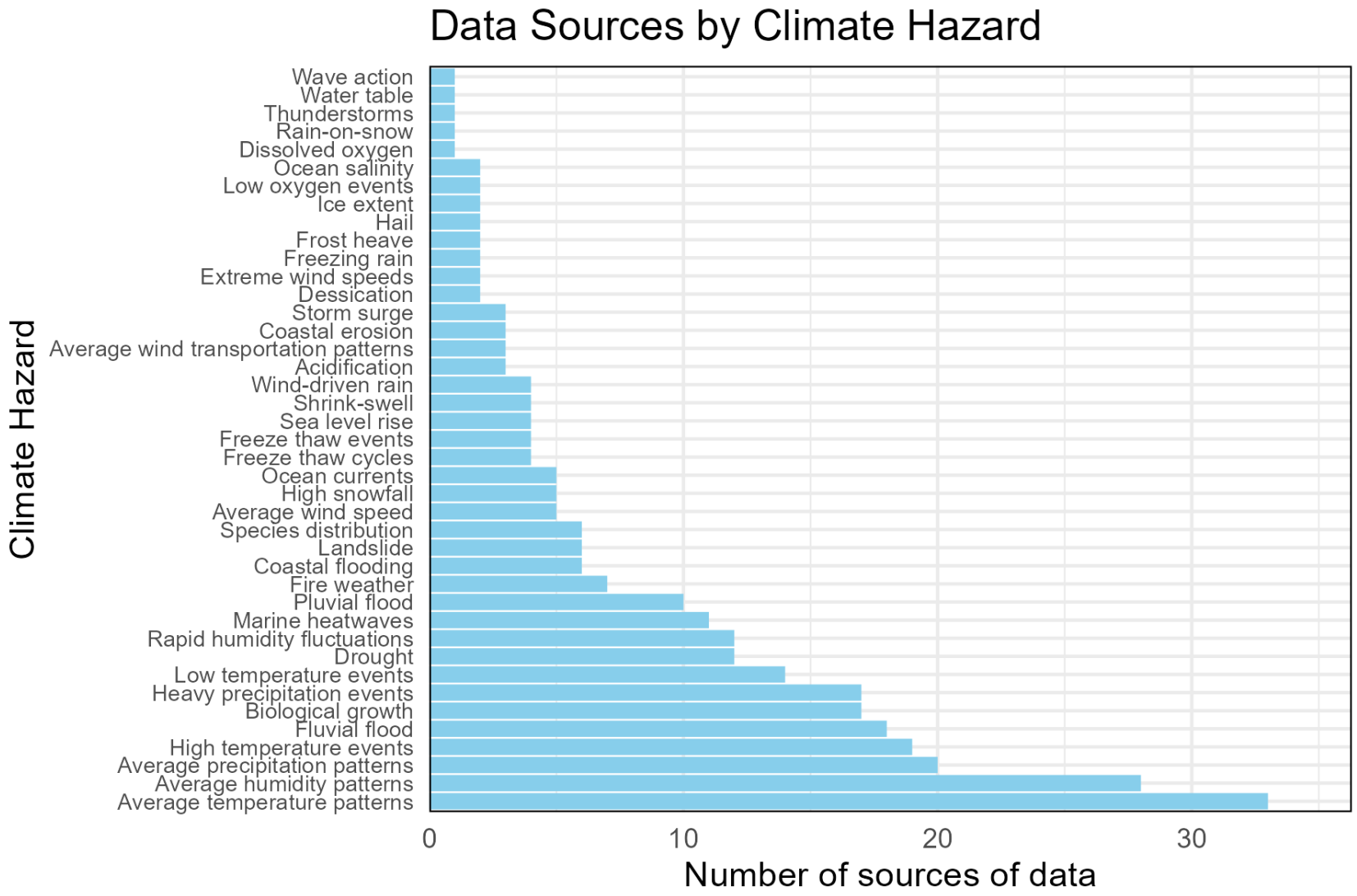

Figure 4. Identified data coverage of climate hazards.

Tools identified

New climate hazard tools are being developed all the time. Between preparation of the draft and final catalogue, two new tools were released: the Local Climate Adaptation Tool (Tool_36) [22] and the Climate Pulse tool (Tool_38)[23]. There are an increasing number and proliferation of climate hazard tools being released, produced by a range of organisations. The key producers of climate hazard tools identified for this project were meteorological institutions (such as the Met Office), Arm's-Length Bodies (such as the Environment Agency), research institutions (such as universities and academic institutions), and the private sector.

This project has identified 38 different tools. These range in style and format from pdf documents (the Environment Agency's – Climate Impacts Tool, for example), to complex tools requiring users with experience in Python and Jupyter (the recently released CLIMAAX tool[24], for example).

Of the 38 tools identified 37 were suitable for landscapes, 30 were suitable for buildings, 19 for archaeology and 7 for marine heritage (see Figure 5 below). In terms of CID coverage, the majority of tools (21) covered mean air temperature, with mean precipitation (18) and river flood (13) also frequently considered CIDs. Figure 6, below, demonstrates the coverage of CIDs across the identified tools.

The most covered climate hazards were average precipitation patterns (19) and average temperature patterns (19), followed by high temperature events (14). Figure 7, below, demonstrates the coverage of climate hazards across the identified tools in greater detail.

[22] University of Exeter, Then Try This, Cornwall Council, and The Alan Turing Institute, (2024). Local Climate Adaptation Tool.
[23] Copernicus Climate Change Service (C3S), (2024). Climate Pulse.
[24] European Union, (2024). CLIMAAX Tool.

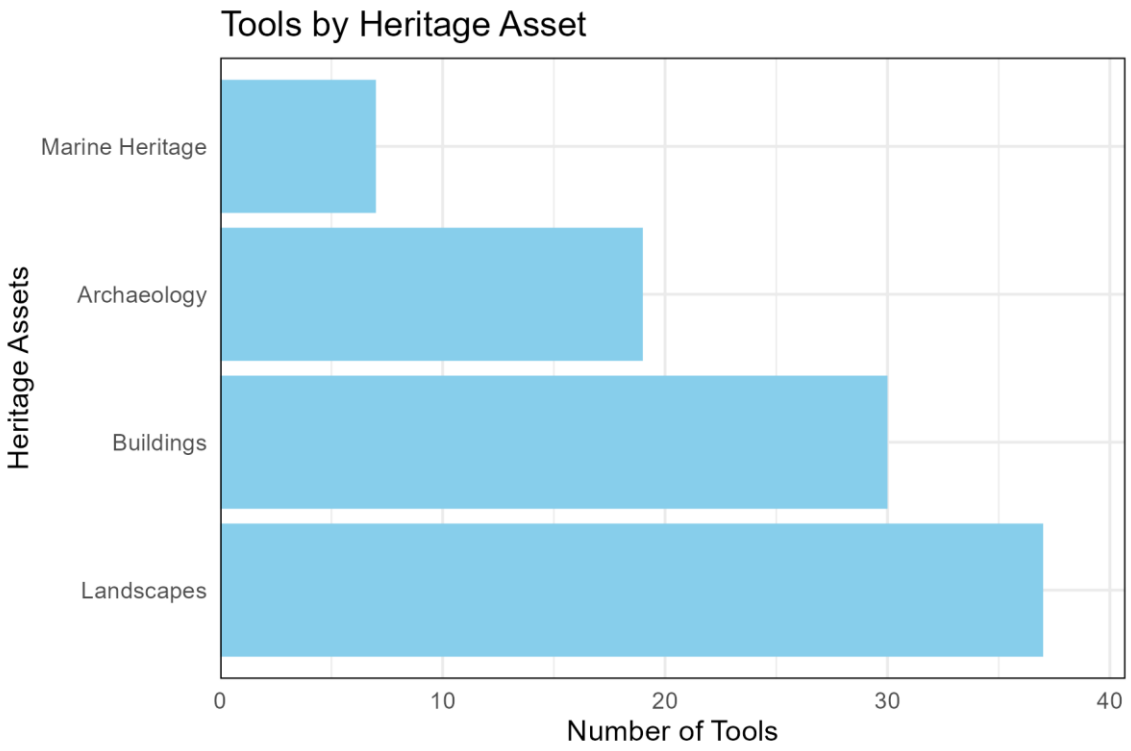

Figure 5. Identified tools suitability according to heritage asset type.

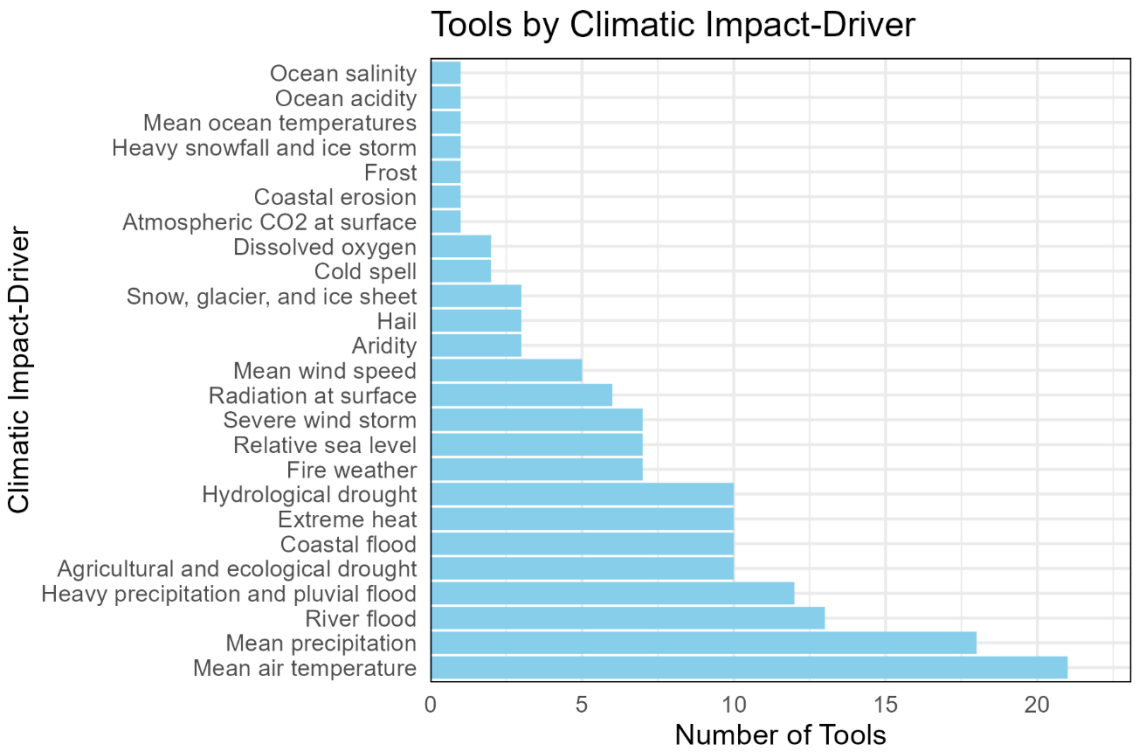

Figure 6. Identified tools coverage of Climatic Impact-Driver.

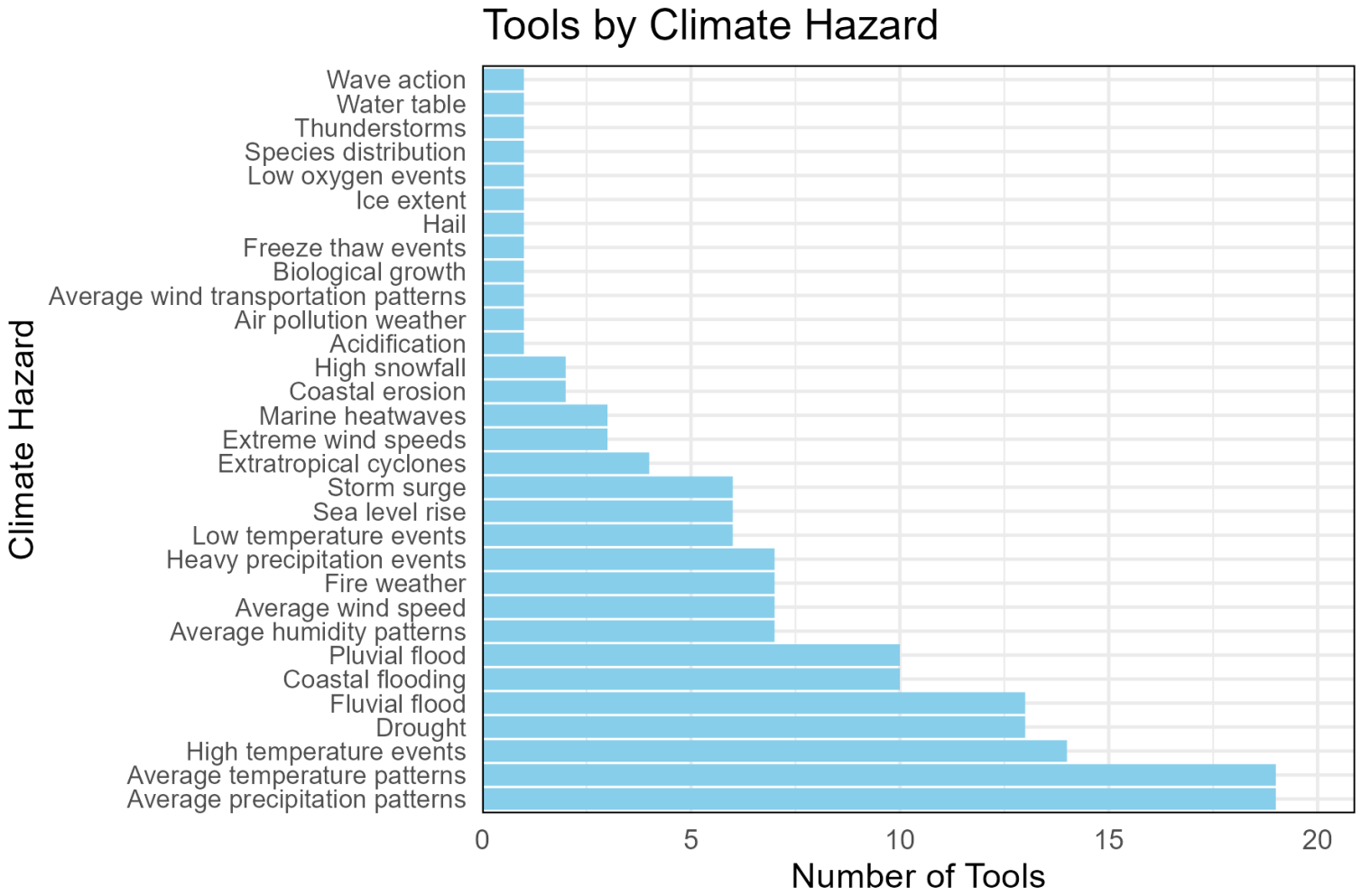

Figure 7. Identified tools coverage of climate hazards.

Suitable tools for Historic England or wider sector use

The following tools in Table 2 were identified as suitable for Historic England to use in undertaking strategic assessment and advice activities (15 tools) or for Historic England to signpost to others within the heritage sector (9 tools) in their role as advisers to the wider heritage sector.

These tools were identified according to the options outlined in Table 1 in the Shortlisting section.

Table 2. Shortlisted tools for Historic England to use and signpost others to.

Unique ID	**Tool / resource**	**Developer / organisation**	**Brief description**	**Is the tool suitable for Historic England to use?**	**Is the tool suitable for Historic England to signpost to other users?**
Tool_1	UK Climate Risk Indicators	University of Reading, UKCEH, The Institute for Environmental Analytics	This website provides information on future changes to indicators of climate risk across the UK. The information is provided at scales ranging from the district to the four nations of the UK, and for several different scenarios describing how global emissions of the greenhouse gases that cause climate change might increase in the future. Users can plot maps showing the variation in indicators across the UK and can plot and download time series for specific locations.	Yes, with an explanation/guidance	Yes, with an explanation/guidance
Tool_2	Flood Risk Map for Planning	Environment Agency	Maps areas in England by flood zones 1, 2 and 3.	Yes, as provided	Yes, as provided

Unique ID	Tool / resource	Developer / organisation	Brief description	Is the tool suitable for Historic England to use?	Is the tool suitable for Historic England to signpost to other users?
Tool_3	Projecting Future Sea Level (ProFSea)	Met Office	These local sea-level projections can be used to assess the impact of future sea-level change on coastal regions.	Potentially, tool has some useful elements	No, tool is overly complex or inappropriate
Tool_4	Climate Impact Explorer	Climate Analytics	This tool shows how the severity of climate change impacts will increase over time in continents, countries and regions at different levels of warming, starting with 1.5°C, the limit in the Paris Agreement. It also allows access to the underlying data.	Potentially, tool has some useful elements	Potentially, tool has some useful elements
Tool_8	EuroCORDEX-UK plot explorer	University College London	UKCP18 suite of climate projections by augmenting them with information from a broader range of high-resolution climate simulations, obtained from the EuroCORDEX downscaling experiment. The additional projections provide a more comprehensive sampling of uncertainty in high-resolution UK climate projections. In turn, this offers the potential to develop better informed strategies for adapting to, and mitigating the effects of, future weather and climate.	Yes, as provided	Yes, with an explanation/guidance
Tool_12	UK climate-pest risk web tool	MetOffice, Defra	Scientists from the Met Office Hadley Centre, in collaboration with partners from Defra (Plant health risk and horizon scanning team), Fera Science, University of Exeter and University of Warwick, have developed the climate-pest risk web tool to help pest risk analysts to easily identify the timings and locations across the UK that show highest risk from selected climate-sensitive pests.	Potentially, tool has some useful elements	No, tool is overly complex or inappropriate
Tool_13	ClimateMatch	Forest Research	Compare a site's future climate to current locations in Europe (Climate match uses UKCP18 climate data at 12km resolution	Yes, with an explanation/guidance	Yes, with an explanation/guidance

Unique ID	Tool / resource	Developer / organisation	Brief description	Is the tool suitable for Historic England to use?	Is the tool suitable for Historic England to signpost to other users?
			using the RCP8.5 pathway in future projections) - shows how trees will perform in a future climate but does not consider adaptation.		
Tool_15	Climate Impacts Tool	Environment Agency	Pdf that allows for high-level assessment of climate impacts against 3 scenarios.	Yes, with an explanation/guidance	Yes, with an explanation/guidance
Tool_18	Toolbox	Climate Data Store	Climate Data Store (CDS) Toolbox links raw data to online computing power through a programming interface. In an online workspace users can create applications in Python (a programming language) and run them on the CDS computers, allowing users to retrieve data they are interested in, make the calculations required and display the results in the format that suits their needs. Users can also download graphs, maps and data, and share online creations with other users.	Potentially, tool has some useful elements	No, tool is overly complex or inappropriate
Tool_23	World Bank	World Bank Climate Change Knowledge Portal (CCKP)	The CCKP provides a web-based platform to assist in capacity building and knowledge development. The tool contains environmental, disaster risk, and socio-economic datasets, as well as synthesis products, such as the Climate Adaptation Country Profiles and Climate Smart Agriculture Profiles, which are built and packaged for specific user-focused functions in a particular country or sector. The portal also provides intelligent links to other resources and tools.	Potentially, tool has some useful elements	No, tool is overly complex or inappropriate
Tool_27	Shoreline Management Plan Explorer	Environment Agency	Search engines for Shoreline Management Plans (SMPs) to identify the most sustainable approach for managing the risk from coastal flooding and erosion over the short (0 to 20	Potentially, tool has some useful elements	No, tool is overly complex or inappropriate

Unique ID	Tool / resource	Developer / organisation	Brief description	Is the tool suitable for Historic England to use?	Is the tool suitable for Historic England to signpost to other users?
			years), medium (20 to 50 years) and long (50 to 100) term. Local authorities and the Environment Agency have led the development of these plans, working together in regional Coastal Groups.		
Tool_35	UKCIP Wizard Tool	UKCIP	The Wizard is a 5-step process to help organisations assess their vulnerability to current climate and future climate change, identify options to address their key climate risks, and help develop and implement a climate change adaptation strategy. Developed in the wake of UKCP09 and so is quite dated now, lots of suggested further resources are not working and thinking has moved on in many areas. Has some good case studies and is still a reasonable tool for organisations to assess their climate risk and adaptation options. Website is notably very slow. A tool in the same sense as the Environment Agency's Climate Impacts Tool.	Potentially, tool has some useful elements	Potentially, tool has some useful elements
Tool_36	Local Climate Adaptation Tool	European Centre for Environment and Human Health and Cornwall Council with input from The	The Local Climate Adaptation Tool (LCAT) brings together complex climate models, adaptation options and health impact evidence to help the user understand the health implications of climate change in their local area. Importantly, LCAT also generates recommendations for appropriate adaptation approaches, based on the best available evidence, to support the health and wellbeing of local people. LCAT is being co-developed with, and for, local authorities and local service providers.	Yes, as provided	Yes, with an explanation/guidance

Unique ID	Tool / resource	Developer / organisation	Brief description	Is the tool suitable for Historic England to use?	Is the tool suitable for Historic England to signpost to other users?
		Alan Turing Institute			
Tool_37	Climaax	Deltares	The CRA Toolbox contains data, projections and risk assessment algorithms (contained in so-called “risk workflows”) designed to support the compilation of regional climate multi-risk assessments. It is structured to accommodate the needs of users at varying expert levels: General information and visualization of hazards, exposure, and vulnerability is accessible via a dashboard, usable also for non-expert users; Advanced users can explore and download pre-existing risk workflows for selected natural hazard profiles, and apply these workflows to a specific European region; Expert users can create a fully customized regional risk assessment package allowing the inclusion of own local data on hazard, exposure, and/or vulnerability, and adjusted risk assessment methods.	Potentially, tool has some useful elements	No, tool is not useful in a heritage context
Tool_38	Climate Pulse	Copernicus Climate Change Service (C3S)	Climate Pulse is an interactive web-based tool developed and maintained by Copernicus Climate Change Service. It aims to make climate monitoring more accessible. It provides daily charts and maps of global surface air temperature and sea surface temperature updated in close to real-time (2 day delay).	Potentially, tool has some useful elements	Potentially, tool has some useful elements

Approaches to Climate Change Risk Assessment (CCRA)

CCRA is a diverse area of work and new approaches are being developed all the time. Within the heritage sector numerous approaches have been adopted to assess climate risk. Despite the existence of ISO guidance on CCRA (ISO14091: Adaptation to Climate Change (See section regarding Industry standard approaches to CCRA for full explanation), there is currently no single, agreed climate sector standard for CCRAs. This research has reviewed a range of approaches to CCRA and assessed their suitability for adoption and/or adaptation for assessing risks to the historic environment.

Historic England have already undertaken work in this space, including an integrative international literature review of CCRA approaches[25]. This piece of work concluded that there was no single "off-the-shelf" solution that successfully leveraged granular data about site vulnerability, capacity, or significance of assets for multiple sites over a large geographic area. The primary issue to identifying a universal CCRA approach was that site/asset-level work is highly resource intensive, and difficult to scale up and draw conclusions about groups of places because of the level of detail involved. On the other hand, large scale hazard mapping depends on secondary datasets and fails to capture granular data on the characteristics and vulnerabilities of specific sites/assets.

Historic England have also commissioned a review of recent research relating to the impacts of climate change on heritage[26]. This project identified research from 2018 onwards that investigates the ways in which climate change affects heritage assets, across a broad range of research categories. The projects relevant to CCRAs have been extracted from this research matrix and assessed for this project. Further CCRA examples were contributed by JBA Consulting colleagues, and a desk-based review was undertaken to identify further CCRAs undertaken by organisations within the heritage sector and other ALBs.

It is worth noting that, whilst approaches conducted by Historic England were uncovered during this review, these have been excluded from this assessment as Historic England are well aware of their own work. Equally, CCRA3 has been omitted from this assessment given Historic England's familiarity with the document and approach.

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[25] Harlow Consulting, (2023). Approaches to Heritage Climate Change Risk Assessment: an integrative literature review

[26] JBA, (Forthcoming). Climate Change and Heritage – A review of recent, current and planned research.

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The CCRAs were assessed based on whether the approach was suitable for Historic England to adopt for strategic assessment, or suitable for them to advise heritage managers to undertake at either a strategic or site/asset level. This judgement was broadly based on:

- *Date of publication*: CCRAs published earlier were deemed less suitable due to the different climate change projections used and the advances in the academic definitions of risk assessment.
- *How many hazards were considered*: CCRAs encompassing just one or two hazards were deemed unsuitable as a methodology, but included in the approaches as they offer a framework for assessing other hazards and thus could be expanded to include more hazards or used in combination with other methods.
- *Accessibility*: CCRAs that were easy, clear and reproducible were deemed suitable for use.
- *Scale*: Methodologies reviewed were either site-specific case studies, or higher level frameworks for assessment. Both were deemed suitable. Case studies were assessed based on their methodology alone and not the outcomes of the CCRA. Frameworks were assessed based on their usability.
- *Applicability to future work*: CCRAs were judged on their ability to be replicated elsewhere, so methods that could be reused were deemed suitable. However, CCRAs based on entirely secondary sources such as literature reviews were deemed less suitable because the research assessed had already been analysed and thus did not need to be reproduced. Instead, this method could be applied to a new context or scenario and could be repeated.

Approaches to CCRA in a heritage context

This section will detail the approaches to CCRA in a heritage context, drawing on examples from across the heritage sector.

High-level frameworks

Several approaches have been used by other UK heritage bodies, such as Historic Environment Scotland (HES), the Northern Ireland Department for Communities and the Historic Environment Group (a Welsh national forum led by Cadw consisting of public sector bodies, representatives of voluntary sector organisations and historic site owners). These could be replicated by Historic England, and are suitable to advise other stakeholders to use, as they are general and can be applied to any asset. A variety of specific methodologies were used, but the underlying framework utilised by all of them was:

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1. Define and identify assets
2. Establish hazards and identify risk factors specific to the asset
3. Analyse and evaluate risks (e.g. via a risk matrix or map)
4. Prepare mitigation measures to improve resilience to climate change
5. Implement adaptation measures
6. Evaluate adaptation progress.

This approach is common to CCRAs in other sectors and it broadly follows the same structure as a traditional risk assessment and so should be familiar to heritage managers. Several examples of this broad framework approach have been identified and these have been successfully applied to a variety of heritage assets types. As such the approach is applicable to built heritage, landscapes, marine heritage and archaeology. Full CCRAs using this broad framework include:

- Assessing risks and planning adaptation: Guidance on managing the impacts of climate change on northern historic places (Historic Environment Scotland and partners)[27]
- Climate Vulnerability Assessment (several case studies) (Historic Environment Scotland)[28]
- UK Climate Risk Independent Assessment (UKCCRA3) (UK Climate Risk)[29]
- Resilient Church Guidance (Cathedrals Fabric Condition for England)[30]
- Screening for natural hazards to inform a climate change risk assessment of the properties in care of Historic Environment Scotland (Historic Environment Scotland)[31]
- Impacts of climate change on the historic built environment: A report and guide (Department for Communities Northern Ireland, Historic Environment department)[32]

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[27] Historic Environment Scotland, Minjastofnun Islands, Norsk Institutt for Kulturminneforskning and Riksantikvaren (2020) Assessing risks and planning adaptation: Guidance on managing the impacts of climate change on northern historic places
[28] Historic Environment Scotland (2023) Scotland's World Heritage and Climate Change: An overview of the application of the Climate Vulnerability Index (CVI)
[29] UK Climate Risk (2021) Independent Assessment of UK Climate Risk.
[30] Cathedrals Fabric Condition for England (2023) Resilient Church Guidance
[31] Historic Environment Scotland (2018) Screening for natural hazards to inform a climate change risk assessment of the properties in care of Historic Environment Scotland.
[32] Department of Communities Historic Environment Division (2021) Impacts of climate change on the historic built environment: A report and guide.

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- A Strategic Approach for Assessing and Addressing the Potential Impact of Climate Change on the Historic Environment of Wales (Historic Environment Group)[33]
- A framework for assessing the vulnerability of archaeological sites to climate change: Theory, development and application (Daly, 2014)[34].

Undertaking and presenting CCRA outcomes

These CCRAs were generally based on a risk assessment matrix methodology and/or a mapping methodology. Risk assessments are generally carried out by assessing the level of risk associated with each hazard and are presented in a matrix. Mapping methodologies manipulate spatial data in order to present the risk level on a map.

An example of a risk assessment approach presented in a matrix is Historic Environment Group's Sector Adaptation Plan (2020)[35]. This approach is easy to understand and risk can be visualised in simple terms, with colour coding making it clear to see where immediate action needs to be taken (Figure 8). When supplied alongside documentation of the detail behind the matrix the results can be interrogated and the logic behind decision making is clear.

Description of climate change	Warmer mean temperatures				Hotter, drier summers		Warmer, wetter winters	More frequent extreme weather
Predicted outcome of climate change on environment	Rise in sea levels	Migration and proliferation of pests, diseases and invasive species	Longer growing season	Changes in lifestyle and leisure patterns	Drying out, desiccation, shrinkage and erosion	Wild fires	More flooding events, increased ground moisture and precipitation	Frequent high winds, storms and heat/cold events
Buildings and settlements	SL1 SL2	PD1	LGS1	LEI1 LEI2	DRY1 DRY4	WF1	FL1	EX1 EX2
Marginal and upland		PD2	LGS1	LEI1 LEI2	DRY2 DRY3 DRY4	WF2	FL2 FL3	EX1 EX2

Significance of impact:

High negative

Moderate negative

Small negative

Positive

Blank = limited/no impact

Figure 8. An example of a risk assessment matrix from Historic Environment Group's Historic Environment sector adaptation plan.

[33] Historic Environment Group – Climate Change Subgroup (2012) A strategic approach for assessing and addressing the potential impact of climate change on the historic environment of Wales

[34] Daly, C. (2014) A framework for assessing the vulnerability of archaeological sites to climate change: Theory, development and application.

[35] Historic Environment Group (2020) A Strategic Approach for Assessing and Addressing the Potential Impact of Climate Change on the Historic Environment of Wales

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Another approach to undertaking and displaying the results of a CCRA is via mapping. Geographic Information System (GIS) can be used to visually display the risk posed by different climate hazards in any location and can be easily analysed, using GIS software applications (including free software such as QGIS) to provide insights into the data. This would require some technical expertise, but instructions for this are freely available online. An advantage of this method is that an engaging visual resource is produced to display risk, and this can be displayed online using web map viewers such as those provided through ESRI products. Mapping can be used to drive engagement and is an accessible way to communicate the impacts of climate change to stakeholders, without the need for them to digest lots of complex information.

An example of a combination of these two approaches (matrix and map) is HES's report 'Screening for natural hazards to inform a climate change risk assessment of the properties in care of Historic Environment Scotland' [36]. This took the following approach:

1. Overlay spatial site boundaries with natural hazard datasets. Where a hazard intersected with an area of HES's guardianship or ownership, they could identify the likelihood of that hazard occurring at each property. This was determined by assessing (i) what the hazard was and (ii) what type of 'likelihood' score (included within the data) that particular dataset indicated.

2. Impact was assessed by considering property type, staffing and visitor access and assigning this a score. A risk (inherent and residual) score for each hazard at every property was calculated by multiplying likelihood and impact scores (on a scale of 0-5) together, forming a risk matrix.

This approach is suitable for large and diverse groups of assets and can be adapted for any asset, location or hazard. It is conceptually simple in that it takes the form of a standard risk assessment, so managers are more likely to already be familiar and comfortable with the process. The process requires GIS skills, although the requirements are basic and could be undertaken using free software (e.g. QGIS), which has a wealth of free supporting information online.

Climate Vulnerability Index

A unique approach to CCRA was the development of the Climate Vulnerability Index (CVI) methodology adopted by HES[37], originally developed in conjunction with UNESCO and James Cook University[38], specifically developed for use with World Heritage Sites. This is

[36] Historic Environment Scotland (2018) Screening for natural hazards to inform a climate change risk assessment of the properties in care of Historic Environment Scotland
[37] Historic Environment Scotland (2023) Scotland's World Heritage and climate change: An overview of the Climate Vulnerability Index (CVI)
[38] Heron, S., Day, J., Venkatachalam, T. and Heron, K. (2019) Climate Vulnerability Index

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a community focussed assessment that uses a systematic risk assessment approach. It assesses the impact of climate change on the Outstanding Universal Values (OUVs) of World Heritage Sites, as well as the Community Vulnerability, which is the economic, social and cultural dependency on the site. The approach has been trialled, with excellent feedback from stakeholders on the projects, on the World Heritage sites of the Old and New Towns of Edinburgh, the Heart of Neolithic Orkney, St Kilda, and the Antonine Wall.

This approach is different to other vulnerability assessments because it encompasses the risk posed to the site, (something common to all CCRAs), but also the vulnerability of the community around the asset. The local community are involved in workshops during the assessment process which increases public awareness of the impacts of climate change and the resultant effects on economic, social and cultural connections.

Individual hazard assessments

Some assessments assessed just one, or several individual hazards, but not enough to provide a full picture of climate change risk, only an assessment of one element. These are more accurately termed hazard assessments rather than CCRAs and included:

- Wind-driven rain and future risk to built heritage in the United Kingdon: Novel metrics for characterising rain spells (Orr et al*.,* 2018)[39]
- CHERISH: Investigating Heritage and Climate Change in Coastal and Maritime Environments (Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW))[40]
- Keep Bristol Cool mapping tool (Bristol City Council, with the Met Office and the Tyndall Centre for Climate Change Research) (Data_73)[41]
- Baseline Study and Gap Analysis of Coastal Erosion Risk Management Northern Ireland (Department of Agriculture, Environment and Rural Affairs, and the Department for Infrastructure, Northern Ireland)[42]
- Monitoring the Buried Archaeology of Vindolanda (Vindolanda Charitable Trust)[43]

[39] Orr, S. A., Young, M., Stelfox, D., Curran, J. and Viles, H., (2018). Wind-driven rain and future risk to built heritage in the United Kingdom: Novel metrics for characterising rain spells
[40] Royal Commission on the Ancient and Historical Monuments of Wales, (2023). CHERISH: Investigating Heritage and Climate Change in Coastal and Maritime Environments
[41] Bristol City Council, (2023). Keep Bristol Cool mapping tool
[42] Department of Agriculture, Environment and Rural Affairs, (2018). Baseline study and gap analysis of coastal erosion risk management NI
[43] Vindolanda Charitable Trust, (2024, upcoming). Monitoring the buried archaeology of Vindolanda

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- Toward a UK Fire Danger Rating System (University of Manchester, University of Birmingham, University of Exeter, Swansea University, London School of Economics, Portsmouth University and Forest Research)[44]

The most frequently used data sources were the UKCP18 climate projections, the Environment Agency's flood maps (Tool_2) and the British Geological Survey's datasets related to erosion and shrink-swell risks (Data_2). These are sometimes supplemented with primary data, such as site monitoring data and site-specific information relating to assets (e.g. social characteristics and building materials).

A key example of the risk assessment of an individual hazard is the Keep Bristol Cool map (Figure 9, Data_73)[45]. Although not developed specifically to consider heritage assets, the results can be used in conjunction with heritage asset data sets to identify implications for the historic environment. This uses population census data, satellite imagery on land surface temperatures and housing characteristics to produce a Heat Vulnerability Index. A ranking system was developed to enable different parts of the city to be compared, and highlights where interventions may be useful to tackle urban heat risks. Climate projections were also used to show the differences in vulnerability today, 2030 and in the 2070s. The output of the project was a GIS map, where layers could be toggled on and off to build up a picture of risk posed by heat. The data behind the interface is also available as a .csv. This approach is interactive and easy to understand, and particularly informative as it incorporates the social dimensions of risk as well as environmental dimensions.

[44] Clay, G., Milin-Chalabi, G., Pascagaza, A. (2024) Toward a UK fire danger rating system: Understanding fuels, fire behaviour and impacts
[45] Bristol City Council, (2023). Keep Bristol Cool mapping tool

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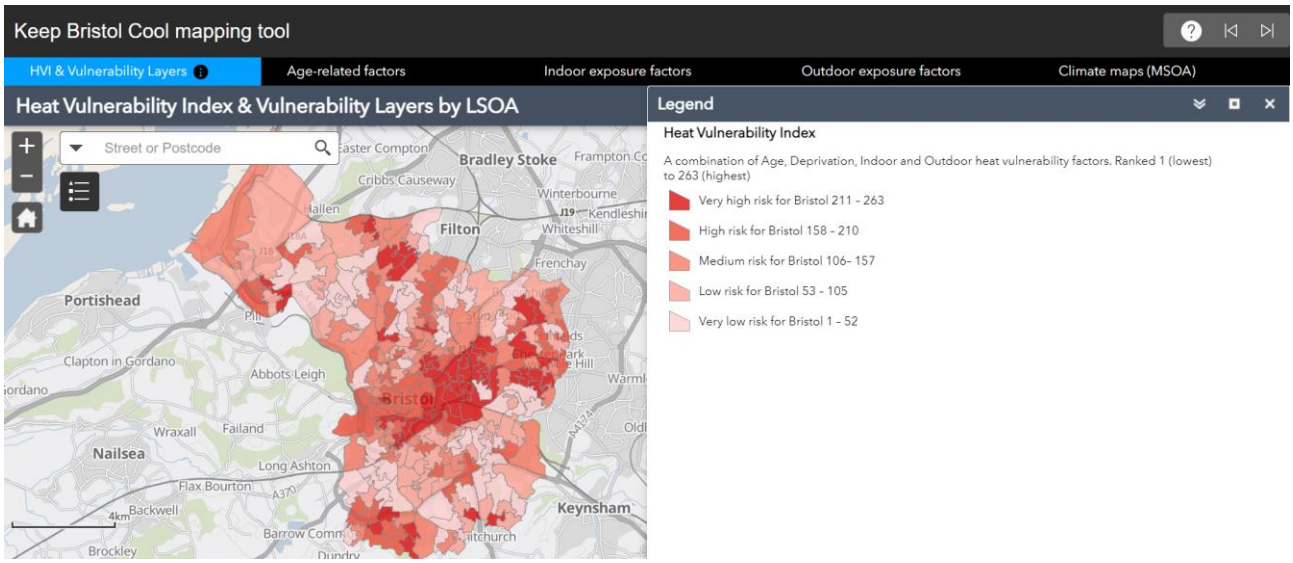

Figure 9. The web interface of the Keep Bristol Cool mapping.

A similar resource, the ‘Climate Change Hazard Mapping Tool’ was developed by the National Trust[46] (Figure 10, Data_48). This resource maps the risk of climate hazards occurring across the UK. The web interface is similar to the Keep Bristol Cool data, and is easy to use and manipulate, with the data available for download. The map has layers for different climate change hazards both now and in the future (worst-case scenario) that can be toggled on and off. National Trust properties are plotted as points on the map, and the hazard layers overlaid in a hex grid. This enables the user to see the risk level for a property or location for each hazard. This method of displaying risk is user-friendly and easy to understand as it avoids inaccessible scientific language. However, this method does not offer a framework for assessing the likelihood of hazards occurring, nor does it show the overall risk to properties and areas based on their individual characteristics.

[46] National Trust (2023) National Trust Climate Hazards

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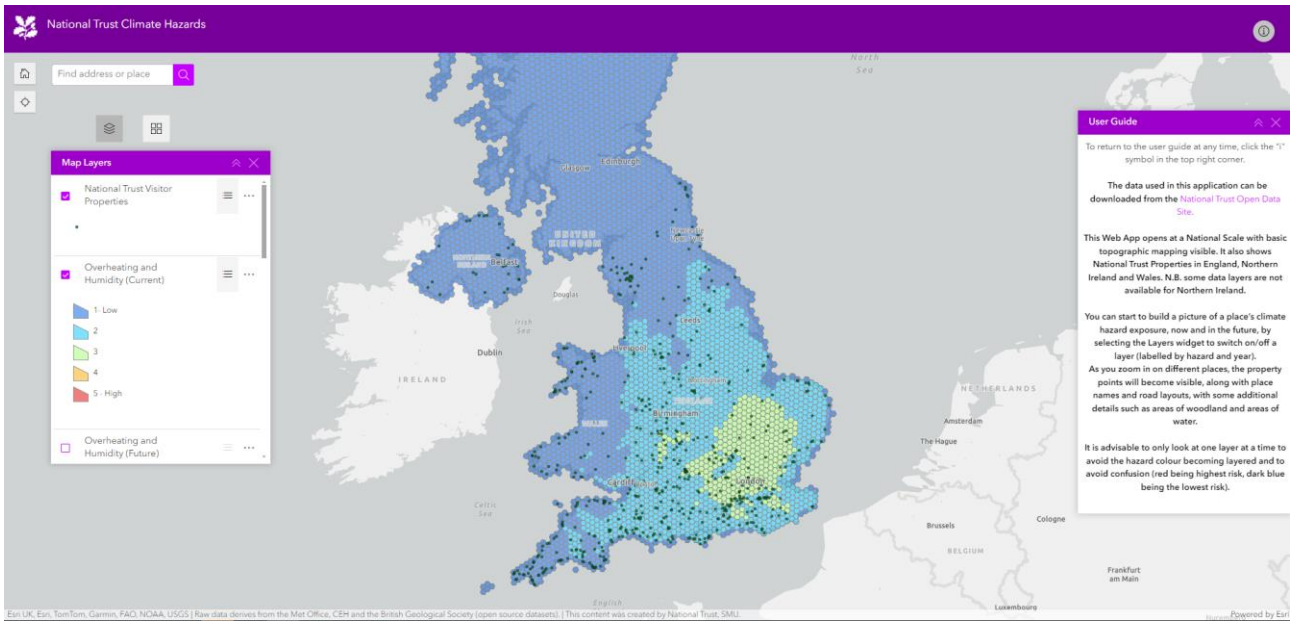

Figure 10. The web interface of the National Trust Climate Hazard mapping tool.

Literature reviews

Some CCRAs assessed risk using a literature review methodology. These use standard literature review procedures. These included:

- Climate Change: Implications for Tourism. Key findings from the Intergovernmental Panel on Climate Change Fifth Assessment Report (University of Cambridge)[47]
- Tree Roots and Archaeology (Forestry Commission)[48]
- Climate Change Impacts on Cultural Heritage: A Literature Review (University of West Scotland)[49]
- Of Time and Tide: The Complex Impacts of Climate Change on Coastal and Underwater Cultural Heritage (University of St Andrews)[50].

[47] University of Cambridge (2014) Climate Change: Implications for tourism
[48] Forestry Commission, Oxford Archaeology (2024) Tree roots and archaeology
[49] Sesana, E., Gagnon, A. S., Ciantelli, C., Cassar, J. and Hughes, J. (2021) Climate change impacts on heritage: A literature review.
[50] ibid

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The Forestry Commission's ongoing 'Tree Roots and Archaeology'[51] project will combine a literature review with stakeholder engagement to ensure that any unpublished knowledge is captured, minimising research gaps. An evaluative framework will be developed to assess the impact of tree roots on archaeology (both from trees as mitigation and greater root growth due to CO_2 levels). This will later be 'ground-truthed' to confirm the assessment. This helps to root the methodology in primary data, making it more likely to provide a clearer indication of risk. However, although the approach taken in this assessment is suitable for the purpose for which it was developed, this approach is not recommended to Historic England for CCRAs intending to consider multiple hazards. This is because it is specific to one climate change impact, and the methodology is unlikely to be appropriate for other hazards where more data exists.

Approaches to CCRA by other Government Arm's-Length Bodies

In tandem with the review of heritage CCRA approaches, a selection of CCRAs by comparable ALBs were reviewed to determine their suitability for use by Historic England and the heritage sector. Most of these documents feature outputs necessary to fulfil reporting required under the third round of the climate change adaptation reporting power (ARP3) and so could help to inform Historic England's reporting requirements.

ARP3 enables the UK Government to request reports from critical infrastructure providers on the current and predicted effects of climate change on their organisation; their proposals for adapting to climate change; and progress made towards their implementation. Reporting bodies are given fairly limited guidance from government in how to undertake and present the assessment. However, within this round of reporting organisations have alluded to ARP3 risk assessment guidance that Defra has provided to multiple organisations which has broadly shaped the outputs (this guidance is not publicly available but is mentioned throughout ARP3 reporting).

This assessment identified useful aspects of each report, whilst also seeking to determine whether the approaches would be suitable for Historic England to conduct, for them to advise the wider sector to adopt, or potentially both.

The following organisations, and their comparable CCRAs were considered:

- Network Rail[52]

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[51] Forestry Commission, Oxford Archaeology (2024) Tree roots and archaeology

[52] Network Rail, (2021). Network Rail Third Adaption Report.

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- Transport for London[53]
- Natural England[54]
- Environment Agency[55]
- HS2 Ltd[56]
- Heathrow Airport[57].

General approaches

Of the reports reviewed, 4 out of 6 of the reporting bodies referenced, or aligned their risk assessment approach with ISO14091: Adaptation to Climate Change (See section regarding Industry standard approaches to CCRA for full explanation) (HS2 Ltd, Heathrow Airport, Environment Agency, Network Rail). However, in most cases organisations also sought to integrate their own comprehensive risk management and governance structure. For example, Network Rail reporting considers route specific weather plans[58], which feature more localised climate change risk projections, tied to route impact assessments. Climate projections trends are also compared against schedule 8 costs (Payments for disruption on the railway) across a range of impact types.

In some cases, references to other forms of CCRA were made. Heathrow Airport's approach to CCRA follows broadly the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD), dividing climate-related risks into two major categories – physical and transition risk. This is likely because of the role of mitigation (and greenhouse gas reduction) required for their operations. Despite this, for the measurement of climate change risk, their approach to quantifying risk from climate hazards and identifying adaptation measures is based on ISO 14091:2021.

Where broad outline approaches (such as ISO14091) were not mentioned, reporting bodies heavily referenced or reiterated the findings of CCRA3. These approaches sought to match the findings of CCRA3 against their individual organisational aims, programmes of climate adaptation and work being done across several broader themes (e.g. future science and evidence). These documents also referenced the aforementioned template issued by Defra[5960].

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[53] Transport for London, (2021). Transport for London Adaptation Reporting Power Submission.
[54] Natural England, (2021). Natural England's climate change risk assessment and adaptation plan.
[55] Environment Agency, (2021). Living better with a changing climate.
[56] HS2 Ltd, (2021). Climate Change Adaptation and Resilience Report.
[57] Heathrow Airport, (2021). Climate Change Adaptation Report.
[58] Network Rail (2021). Adapting to Climate Change.
[59] Defra (2022). Strategy for the Fourth Round of Climate Adaptation Reporting
[60] Natural England (2022). Natural England's climate change risk assessment and adaptation plan

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Generally, where risk assessment took place, these organisations used a mixture of quantitative and qualitative risk assessment matrices (Figure 11, Figure 12 and Figure 13) (likelihood of the risk occurring, and the impact if it occurs). This was accompanied by more detailed risk assessment documents, with supporting narrative to place results in context, to identify risks and to qualify the level or risk. Some are specialist led, using risk terminology, such as interdependencies, thresholds and trigger points and confidence ratings. These are often developed in partnership with stakeholders, with matrices featuring bespoke categories for financial and non-financial magnitude scoring.

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Measurement of Risk

Horizons: 2020, 2050, 2080		Impact				
		Low	Medium	High	Very High	Critical
Likelihood	Almost Certain	moderate	major	major	severe	severe
	Likely	moderate	moderate	major	major	severe
	Possible	minor	moderate	moderate	major	major
	Unlikely	minor	moderate	moderate	moderate	major
	Highly Unlikely	minor	minor	minor	moderate	moderate

TfL are using UKCP18 RCP 6.0 90th percentile

Impact (SHE, Customer & Stakeholder, Finance & Stakeholder Confidence)	
Rating	**Definition**
Critical	The asset represents an unacceptable risk to network safety and/or reliability and TfL's reputation, action must be taken to reduce the level of risk
Very High	Network safety and/or reliability are at or below broadly acceptable levels, and action must be taken to improve safety and reliability
High	Action must be taken to maintain network safety, reliability and/or State of Good Repair at or above acceptable levels, interventions may be further justified
Medium	Action should be taken to deliver preferred levels of network safety, reliability and State of Good Repair, to fully achieve Surface Transport and TfL outcomes,
Low	Action may be appropriate on the basis of whole life cost savings and reducing future disruption.

Likelihood	
Rating	**Definition**
Almost certain (80%+)	The risk in the process of materialising and may already be under active management as an event
Likely (50%-79%)	Past events have not been fully resolved, efffective mitigations not yet identified, control weakness are known and are being managed.
Possible (26%-49%)	Past events satisfactorily resolved, mitigations are in place or are on track to be in place, control improvements are under active management
Unlikely (5%-25%)	Events are rare, required mitigations in place, controls are effective
Highly unlikely (less than 5	No known event or if known extremely rare, extreme industry-wide scenarios

Figure 11. An example of a risk matrix developed by Transport for London

Version 3.1 04 July 2019

Impact area	Subcategory	1	2	3
Safety/Health/ Environment	Safety	Event with the potential for less than 20 'any other injuries' or a single specified injury (less than 0.1 FWI).	Event with the potential of a single specified injury to 5 specified injuries (between 0.1 and 0.5 FWI).	Event with the potential of between 5 specified injuries and 2 fatalities (between 0.5 and 2 FWI).
	Health	An event causing health effects which could potentially require short-term modifications and adjustments or redeployment e.g. workrelated stress.	An event causing health effects which could potentially require long term modifications and adjustments or redeployment e.g. HAVS.	An event causing health effects leading to a potential of between 1 and 2 fatalities e.g. silica and asbestos or an event which results in permanent incapacity to work e.g. severe HAVS.
	Environment	A temporary but reversible event which causes negligible impact to an on-site area of low environmental value, managed immediately by internal control procedures.	Minor reversible short-term (<1 month) event which impacts the local environment (i.e. onsite and beyond site boundary).	Moderate reversible medium-term event (< 6 months) which causes impact to the wider environment (i.e. up to district area), requiring mitigation or restoration works.
	Energy & Carbon	No increase in operational energy use and greenhouse gas emissions.	Slight increase (<5%) in operational energy use and greenhouse gas emissions.	Moderate increase (5-10%) in operational energy use and greenhouse gas emissions.
Performance	Network Disruption	Un-planned passenger or freight disruption for up to a day on any one route.	Unplanned passenger or freight disruption (for >1 day and <3 days) on any one route.	Unplanned passenger or freight disruption (>3 days and <1 week) on any one route or up to a day on multiple routes.
	Service Delivery	Poor performance or non-performance of noncritical activities with negligible /very minor customer disruption.	Poor performance or non-performance of noncritical activities causing moderate customer disruption as a result which may continue intermittently for up to 1 week.	Poor performance or non-performance of some critical activities with moderate customer disruption to one or more customers for up to 1 week.
	Asset Reliability	<2% of asset reliability CP6 targets missed (including Composite Reliability Index (CRI) and Service Affecting Failures (SAF) or <2% decline from previous year's performance.	2-5% of asset reliability CP6 targets missed (including Composite Reliability Index (CRI) and Service Affecting Failures (SAF) or 2-5% decline from previous year's performance.	5-10% of asset reliability CP6 targets missed (including Composite Reliability Index (CRI) and Service Affecting Failures (SAF) or 5-10% decline from previous year's performance.
Finance	(£)	£0 – £2m.	£2 – 10m.	£10 – 50m.
	Budget	Less than 3% of allocated budget.	Between 3% - 5% of allocated budget.	Between 5% and 7% of allocated budget.
	Efficiency	Efficiency target 100% deliverable.	Efficiency target >90% deliverable.	Efficiency target 80-90% deliverable.
	Asset Sustainability	<£25m renewals deferred.	£25-100m renewals deferred.	£100-500m renewals deferred.

Figure 12. An extract of sub-categories 1-3 (of 5) demonstrating Network Rails approach to risk assessment featuring quantitative and qualitative indicators for magnitude scoring.

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			Baseline				2030s				2070s			
Code	Climate variable	Risk	Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence
Direct physical risks														
2021 R1	Maximum temperature	Infrastructure damage affecting the structural integrity of airfield structures such as runway and apron tarmac	3	3	9	M	4	3	12	M	5	3	15	M
2021 R2	Maximum temperature	Impacts on the surface integrity of surface access routes leading to and around the airport	3	2	6	M	4	2	8	M	5	2	10	M
2021 R3	Maximum temperature	Impacts on maximum take-off weight	1	2	2	L	1	2	2	L	2	2	4	L
2021 R4	Maximum temperature	Impacts thermal comfort of staff and passengers in terminal buildings and aircraft on stands	3	3	9	M	3	3	9	M	4	3	12	M
2021 R5	Maximum temperature	Delays to construction / maintenance works and operational activity	1	3	3	M	2	3	6	M	4	3	12	M
2021 R6	Extreme winds and wind direction	High wind speeds or gusts impacting take off procedures	3	3	9	M	3	3	9	M	3	3	9	M
2021 R7	Extreme winds and wind direction	High wind speeds or gusts causing damage to high structures	1	3	3	M	1	3	3	M	1	3	3	M
2021 R8	Extreme winds and wind direction	Change in prevailing wind direction impacting take off procedures and air space management	2	3	6	L	2	3	6	L	3	3	9	L

Figure 13. Preliminary quantification of physical risks for Heathrow airport following magnitude scoring[61].

All of the above approaches and implementations, recognise that during the course of conducting a risk assessment the appropriateness of using quantitative or qualitative (value-based judgments) data can vary depending on the availability of data and the methods used. This differs to the approaches of some business and financial CCRAs and catastrophe models, which do not assess qualitative data.

Hazards considered

In all cases, the hazards considered varied between each CCRA. This follows general CCRA guidance, and standards such as ISO14091, which encourage organisations to screen and identify the hazards, combinations of hazards, sensitivities and exposures applicable to the system at risk[62].

[61] Heathrow, (2022). Climate Change Adaptation Report.
[62] ISO 14091, 2021., (2021). Adaptation to climate change Guidelines on vulnerability, impacts and risk assessment

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Industry standard approaches to CCRA

The (ISO) 14091:2021 guidance[63] sets out a standardised methodology for conducting a CCRA. It also details some sector-specific example CCRAs conducted recently, notably, the Climate Adaptation Strategy for Devon, Cornwall, and Isles of Scilly (DCIoS) 2023 - 2027[64] and the City of London Climate Adaptation Pathways Study[65].

ISO 14091:2021 was produced by a technical committee made up of a range of leading experts and specialists and provides a detailed methodology, which outlines how to conduct a CCRA for a site or organisation. The guidance is broken down into 4 main stages: an introduction to CCRA; guidance on how to prepare a CCRA; guidance on implementing a CCRA; and guidance on how to report and communicate CCRA results. The guidance is a paid for resource and this is, anecdotally, one of the main barriers to its uptake. However, it is referenced and recognised throughout the industry and many approaches to CCRA, and tools, refer to it or align their approaches with its methodology.

The guidance also appears to be gaining further prominence within the sector and was recommended as an approach in Environment Agency guidance released last year. This guidance relates to a new requirement to integrate climate change adaptation into industry management systems under an environmental permit [66]. It should be noted that the ISO guidance is more onerous than many other approaches currently undertaken, however, the guidance does allow for the approach to be modified to meet the needs of the user.

The City of London Adaptation Pathways Study offers an alternative methodology with more strategic nuance. This methodology includes an initial climate vulnerability assessment, rounds of stakeholder engagement, and the use of a multi-criteria tool for evaluating resilience measures, which could be made adaptable to various contexts.

The DCIoS Adaptation Strategy was commissioned by Devon County Council on behalf of the DCIoS Climate Impacts Group. The strategy was underpinned by a climate change risks and opportunities assessment (CCRAO). The CCRAO used a baseline of 1981-2000 and a time horizon of 2050 for analysing risks and relied on the 61 risks and opportunities outlined in CCRA3. The assessment tailored these risks and opportunities to the DCIoS region, rather than leaving them as UK national-level risks. The CCRAO also added in risks specific to the DCIoS (notably a risk arising from the ‘impact of fog on maritime and air travel’), whilst international risks over which DCIoS had limited opportunity to affect or change were omitted. 62 risks and opportunities were considered in total. Identified risks

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[63] ISO 14091: 2021, (2021). Adaptation to climate change. Guidelines on vulnerability, impacts and risk assessment.
[64] Devon, Cornwall, and Isles of Scilly, (2023). Adaptation Strategy.
[65] City of London, (2022). Climate Resilience Adaptive Pathways Study.
[66] Environment Agency, (2023). Climate Change Risk Assessment and Adaptation Planning.

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and opportunities were categorised according to sectors (natural environment, infrastructure, health and built environment, business and industry, cross-cutting (including international dimensions risks)), in a similar approach to that undertaken for CCRA3. Four sector specific workshops for each sector were held, excluding cross-cutting. In the workshops each sector specific risk was assigned a magnitude and likelihood score for 2050 under a 4°C scenario (RCP 6.0). Urgency scores were then applied to each risk, based on the England-level urgency scores identified in CCRA3. Appendix 3 of the DCIoS report includes the identified risks, their magnitude, likelihood, risk score and their urgency scoring.

This approach, whilst somewhat novel, relies heavily on work conducted in CCRA3 for its outline and structure. Whilst it is important to include stakeholders in approaches and it is generally accepted that not all risks can be quantified or assessed quantitatively, by assessing risk only through stakeholder engagement the assessment is essentially qualitative and therefore lacks some of the scientific rigour that the use of quantitative data may have generated.

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Discussion

This section outlines recommendations for Historic England in terms of recommendations regarding identified data and tools, and approaches to CCRA.

Recommendations regarding how data, tools and CCRA approaches could be presented to external stakeholders is covered below in the 'Dissemination' section.

Recommendations for data

This commission has identified 73 different sources of climate hazard data. As discussed in the 'Data identified' section, these sources cover a range of different climate hazards. Whether a source of data is appropriate will depend on the assessment, and the data catalogue (in combination with the data catalogue guidance) can therefore be used to quickly identify appropriate data.

Met Office data (Data_18 to Data_46 in the data catalogue) will be a useful and reliable source of climate hazard information for any assessment conducted in an UK context. The Met Office produce a range of UKCP18-based outputs that are useful in projecting future changes for key climatic hazards (average precipitation, average temperature patterns, high temperature events, etc.) in an UK context. An added benefit in using Met Office data is the existence of the Met Office's Climate Data Portal[67], which allows for web-based data visualisation of some datasets. CHESS-SCAPE[68] (Data_63) is another free data source provided by UKCEH which provides future projections of key climate hazards at a 1km^2 resolution across the UK.

In terms of establishing baselines, for flooding the Environment Agency provides key datasets relating to flooding from a range of sources. Whether that be flooding from rivers and seas[69] (Data_6), flooding from surface water[70] (Data_7), or flooding from reservoirs[71] (Data_8), the Environment Agency hold the best freely available data on flooding for providing a baseline of current risk.

For hazards which are likely to be more geographically and site-specific, a range of one off climate hazard datasets have been identified within the data catalogue.

It should also be noted that a limited number of data sources are only accessible as paid for resources. A notable example is the British Geological Survey's dataset on

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[67] Met Office, Climate Data Portal
[68] UK-CEH, (2022). CHESS-SCAPE: Future projections of meteorological variables for the UK.
[69] Environment Agency, (2024). Risk of Flooding from Rivers and Seas.
[70] Environment Agency, (2024). Risk of Flooding from Surface Water.
[71] Environment Agency, (2023). Risk of Flooding from Reservoirs.

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groundwater flooding[72] (Data_12). Given the cost incurred for using paid datasets, they are only likely to be worth purchasing in specific contexts where a hazard is known to pose a risk (i.e. where groundwater flooding is a clear and present issue). Equally, some datasets could not be accessed as they are restricted to UK research organisations only. A key example here is the OpenClim[73] (Data_50), from the Tyndall Centre. The majority of common hazards, however, do have a freely available dataset.

Recommendations for tools

This report has identified a range of tools suitable for Historic England's use, these are listed in Table 2. Shortlisted tools can be used to assist in the undertaking of a CCRA or the assessment of a single climate hazard. Unfortunately, this project has not identified any tools which allow for heritage data to be fed in directly (whether that be spatial GIS data, or non-spatial data). However, in terms of utilising identified tools for Historic England's operations, some of the identified tools are suitable for Historic England's use as they currently exist. These tools, along with tools that may require an explanation/guidance and tools which are potentially suitable, are identified in Table 2.

Of the tools that have been identified as suitable for Historic England's use, these tools are generally self-explanatory and could be incorporated into Historic England's activities relating to climate change and adaptation immediately. Some of these tools such as the Local Climate Adaptation Tool (Tool_36)[74], produced by the European Centre for Environment and Human Health and Cornwall Council, will be helpful in allowing users to understand the local impacts of climate change. Others such as the Flood Map for Planning, produced by the Environment Agency (Tool_2)[75], will be helpful for users in terms of baselining the climate hazards applicable to their local area (Figure 14).

[72] British Geological Survey, Groundwater Flooding Dataset
[73] Tyndall Centre, (2021). OpenClim
[74] European Centre for Environment and Human Health & Cornwall Council (2023) Local Climate Adaptation Tool
[75] Environment Agency (2021) Flood Map for Planning

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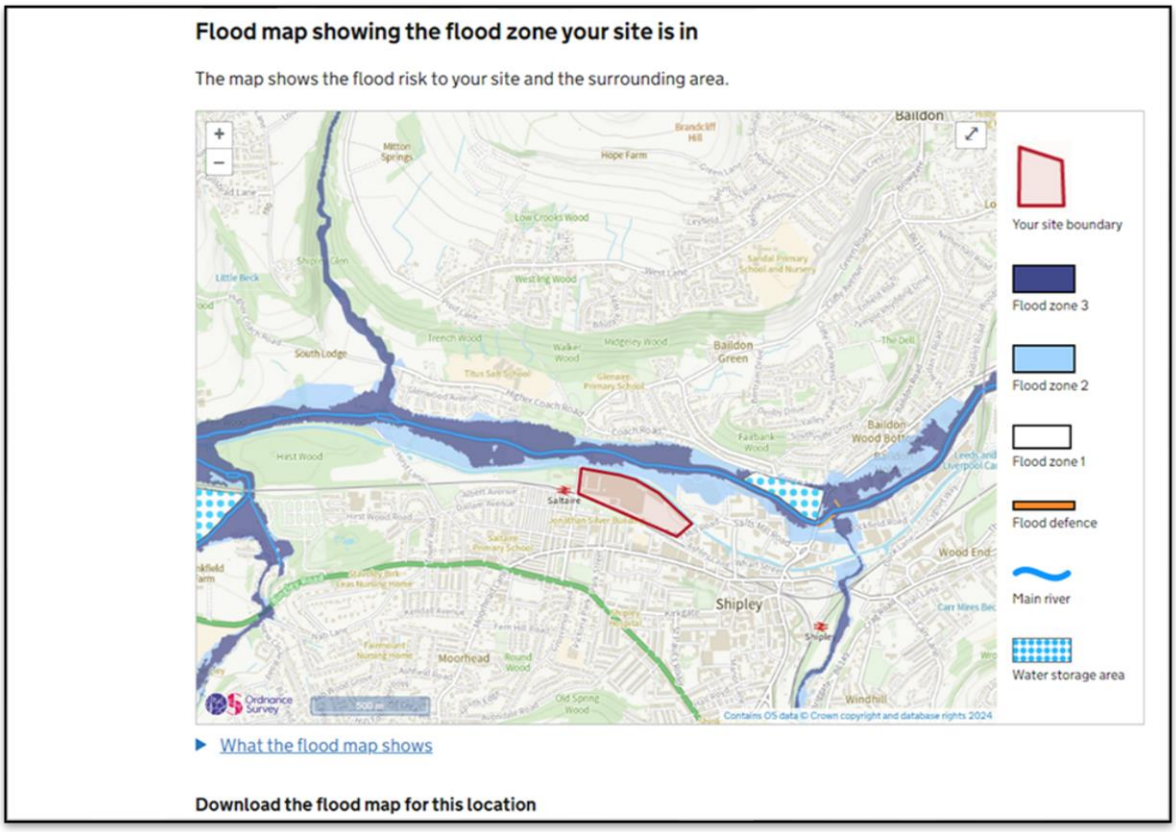

Figure 14. The Environment Agency's Flood Map for Planning (Tool_2)[76].

Tools that have been identified as suitable but with a need for an explanation or guidance include tools which are generally useful in that they can help to drive engagement. An example of a tool meeting this description is the Forestry Research's ClimateMatch tool (Figure 15. Forest Research's Climate Matching Tool). Whilst developed to guide how trees will perform in a future climate, it serves to demonstrate how the climate will change in the future at the landscape scale and draws comparisons with geographies with which stakeholders may already be familiar. Tools in this category are often more complex than the tools identified as suitable for immediate use and would benefit from some additional guidance to allow users to be able to draw out the most from the tool. An example of this type is the UK Climate Risk Indicators Tool, which was developed as part of the UK Climate Resilience Programme. The UK Climate Risk Indicators (Figure 16. The UK Climate Risk Indicator (UK-CRI) Explorer Tool_1)[77] tool relies on users having a base understanding of representative concentration pathways (RCPs), for example.

[76] Environment Agency (2021) Flood Map for Planning
[77] UK Climate Risk Indicators (2018) University of Reading, The Institute for Environmental Analytics and UKCEH

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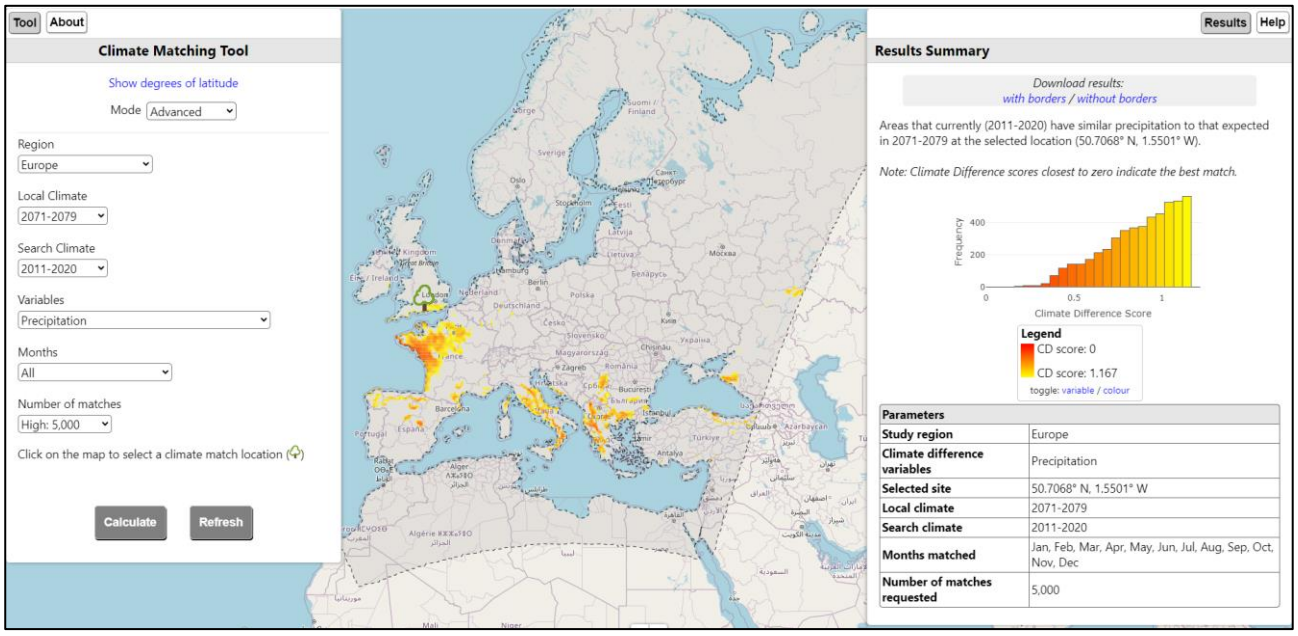

Figure 15. Forest Research's Climate Matching Tool (Tool_13)[78].

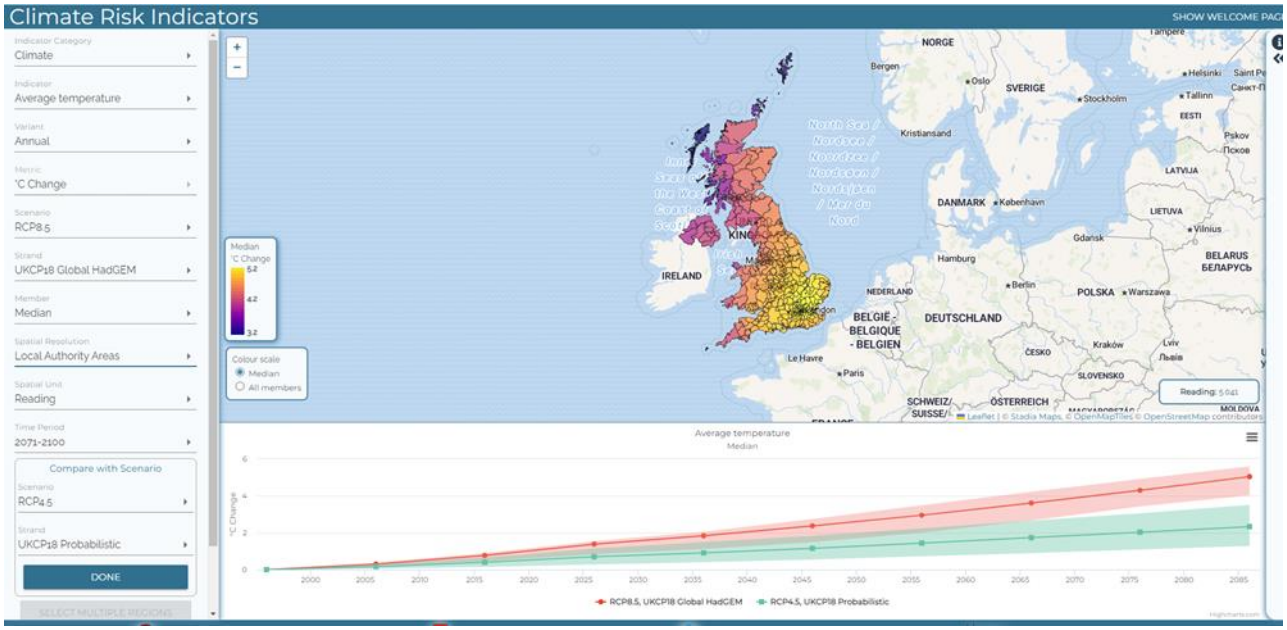

Figure 16. The UK Climate Risk Indicator (UK-CRI) Explorer (Tool_1)[79].

Where tools have been categorised as potentially suitable, this has been selected to highlight that the applicability of the tool for Historic England's operations should be

[78] Forest Research (2020) ClimateMatch
[79] UK Climate Risk Indicators (2018) University of Reading, The Institute for Environmental Analytics and UKCEH

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reviewed by Historic England. Tools which have been identified as potentially suitable for Historic England's operations, predominantly fall into one of three subcategories:

- **The tool is very specific so will only be useful in a narrow range of instances.** An example tool meeting this category is the UK Climate-Pest Risk Web Tool (Tool_12)[80] developed by Defra and the Met Office. Additionally, the Shoreline Management Plan Explorer (Tool_27)[81] from the Environment Agency and Projecting Future Sea Level (ProFSea) tool from the Met Office (Tool_3) also fall in this subcategory.

- **The tool could be an important approach but may be dated**, a key example here being the UKCIP Impacts Wizard tool (Tool_35)[82].

- **The tool could be challenging to use and may require specialist skills** such as coding. Examples meeting this description include the Toolbox produced by Climate Data Store (Tool_18)[83]and Climaax produced by Deltares (Tool_37)[84].

Recommendations regarding approach to CCRA

There are a proliferation of existing CCRA approaches as the 'Approaches to Climate Change Risk Assessment (CCRA)' section identifies. Comparable actors (Environment Agency, Natural England, Forestry Commission, National Highways, Network Rail) have all taken different approaches. There is no single best approach. This is mirrored by international approaches; nations from across the world have approached CCRA in a range of ways[85]. In addition, despite the publication of the ISO guidance, there is currently no single, agreed, standardised approach to CCRA. With this in mind, this section outlines a range of recommendations regarding approaches to CCRA, noting strengths of existing approaches and effective formats for outputs.

Rooting the CCRA's methodology in the ISO guidance is key in ensuring that the approach is methodologically robust. This does not mean that the assessment has to follow the ISO guidance to the letter; the guidance could be used as a broader framework for assessment and adapted to Historic England's or other users' needs. The key components of the ISO guidance are:

- Identification of the key climate hazards;

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[80] Defra and the Met Office (2023) UK Climate-pest risk web tool
[81] Environment Agency (2024) Shoreline Management Plan Explorer
[82] UKCIP (n.d.) UKCIP Wizard Tool
[83] Climate Data Store (n.d.) Toolbox
[84] Deltares (n.d.) Climaax
[85] CLIMAAX (2023), Desk review of existing CRA approaches

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- Understanding the exposure of a given system or site to the identified hazards;
- Understanding the sensitivity of a given system or site to the identified hazards;
- Understanding the potential climate change impacts without adaptation; and
- Understanding the residual risks with adaptation.

Application of ISO 14091:2021 would be suitable for Historic England as it outlines a clear methodology that can be undertaken. It should be noted that the guidance functions most effectively at a site level so it would be best suited to conducting CCRAs on a site-by-site basis. Given the robustness of the methodology within the guidance this may be excessive or overly resource-intensive for Historic England's needs. However, the guidance itself is a methodology that can be adopted and adapted to meet the user's needs and therefore a broader, less resource-intensive approach may be designed around the framework.

In terms of conducting a CCRA, some example approaches identified within this report could be adapted for the heritage sector purposes and are explored further below.

One approach that could be adapted by Historic England or others undertaking strategic level assessment is that of Network Rail[86], detailed in the 'Approaches to CCRA by other Government Arm's-Length Bodies' section. There are elements of this approach the sector could use for a similar assessment. For example, a standardised magnitude scoring mechanism could help with the prioritisation of climate change risks (inclusive of financial and non-financial criteria). These criteria could also be scaled based on relevance and could be applicable across asset types. Additionally, in place of Network Rail's consideration of climate projections trends compared against schedule 8 costs, schedule 8 costs could be replaced by visitor numbers to heritage sites or a comparable metric.

Another CCRA approach that could be adapted is that of the Environment Agency[87], which was conducted for ARP3. The overall approach could be deployed where a strategic understanding of climate change risk is applied - a similar methodology would be ideal for a future ARP4 submission rather than a site-specific assessment. Alternatively, the sector could draw on the adaptive pathways approach undertaken in the City of London's Climate Resilience Adaptive Pathways Study[88]. The City of London's approach could be tailored to assess climate risks specific to heritage assets and to develop adaptive pathways that

[86] Network Rail (2021) Network Rail Asset Management: Weather Resilience and Climate Change Adaptation Plan
[87] Environment Agency (2021) Climate adaptation reporting third round
[88] City of London, (2022). Climate Resilience Adaptive Pathways Study

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enhance their resilience while preserving their historic value. This process would require effective communication through stakeholder engagement sessions and some organisations may require assistance in producing useful long-term plans on a site-by-site basis.

Several heritage specific CCRAs have been identified in this report and these provide a high level framework which could be applied to any site, or group of assets. An approach similar to Historic Environment Scotland's 'Screening for natural hazards to inform a climate change risk assessment of the properties in care of Historic Environment Scotland'[89] report could be undertaken due to its relevance to traditional risk assessment processes, and the thoroughness of the method. It uses a combination of GIS analysis of hazards and site specific characteristics to assign risk scores in a matrix. The process can be adapted for any asset, location or hazard. This is also suitable for heritage managers to undertake due to its flexibility and ease of use.

At a site-specific scale, an assessment that could be adopted and adapted is the Climate Vulnerability Index[90]. As noted in the 'Climate Vulnerability Index' section, this has been already undertaken for multiple sites by HES. This approach is included as a CCRA method due to its consideration of communities. However, it should be considered as part of a wider framework, as it provides less emphasis on the material impact of hazards, which is crucial for heritage managers. This is a unique approach, specifically designed for World Heritage Sites, but should be considered for adaptation into one appropriate for other assets due to the strengths outlined above.

Hazard-specific risk assessments could also be used to feed into framework CCRAs. Alternatively, secondary data could be used as a substitute for this as required. Literature reviews can supplement this information to provide context to hazards or to determine which hazards to gather data for. However, solely undertaking a literature review is not recommended due to the difficulty in making this applicable to specific sites.

As has been highlighted in the 'Approaches to CCRA in a heritage context' section, presenting outputs through mapping using GIS and through matrices are effective ways of communicating CCRA results. Organisations could use the matrices within Historic Environment Group's Sector Adaptation Plan[91] as examples for informing production of similar outputs.

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[89] Historic Environment Scotland (2018) Screening for natural hazards to inform a climate change risk assessment of the properties in care of Historic Environment Scotland'

[90] Historic Environment Scotland (2023) Scotland's World Heritage and Climate Change: An overview of the application of the Climate Vulnerability Index (CVI)

[91] Historic Environment Group (2020) A Strategic Approach for Assessing and Addressing the Potential Impact of Climate Change on the Historic Environment of Wales

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For large areas, a spatial risk assessment may be suitable. These can incorporate data on a variety of hazards, and also be used to assess vulnerability where other spatial datasets, such as census data, are required. This is particularly appropriate for comparing locations, or for assessments covering larger areas. Mapping is less appropriate for smaller sites. This is due to the resolution of most climate hazard datasets. For example, UKCP18 data (most commonly used for many hazards), is only available at a 2.2km^2 resolution and so is not suitable for displaying the risk to individual buildings on a map. Displaying data in a map is not generally suitable for any analysis smaller than this scale and is not recommended for highly localised site-specific CCRAs as a result.

A combination of a matrix assessment and a spatial assessment is also possible. Spatial data can be manipulated as part of an assessment, used to form the basis of the evaluation, with the results presented in a risk assessment matrix. Presenting these side by side can illustrate the spatial element of risk, which is particularly important when large areas are being assessed.

Options for Historic England to undertake a CCRA

The section above has made a range of recommendations regarding approaches to CCRA which Historic England and the wider sector could pursue depending on specific priorities and needs. This section focuses on the implementation of CCRA, with specific reference to how Historic England could undertake a CCRA. It starts by touching on the tools and data that are likely to be most useful for Historic England in undertaking a CCRA before moving onto key considerations for undertaking a CCRA.

Tools identified can assist in undertaking a CCRA but none will allow for completion of the entire process. The Local Climate Adaptation Tool (LCAT)[92] (Tool_36) can help to provide important contextual information down to Medium Super Output Area granularity in England for two scenarios – existing global policies (RCP 6.0), and a worst case scenario (RCP 8.5) for a 2070 time horizon, see Figure 17 below. The LCAT also provides further information on climate details, which draws on CHESS-SCAPE data (Data_63). Along with further information on key climate hazards, information on climate impact pathways and information on adaptations. This tool is useful for providing information about how local climates will change, what possible local adaptations there are, and who will be most vulnerable and why. It was designed with local decision makers in mind and as such should be useful for Historic England's purposes.

[92] University of Exeter, et al., (2024). Local Climate Adaptation Tool.

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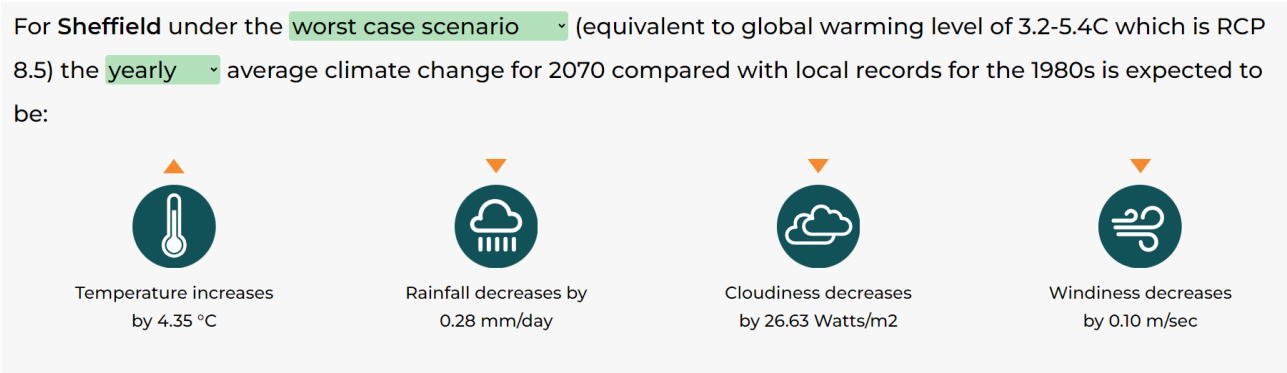

Figure 17. Screenshot of Local Climate Adaptation Tool (Tool_36), showing results for a worst case scenario for Local Authority of Sheffield.

Another tool that will be helpful in undertaking a CCRA is the UK-CRI tool[93] (Tool_1). This tool is more complex than the LCAT but allows for users to interrogate data down to a 12km^2 resolution. It also contains a range of indicators which are not accessible within the LCAT and allows for users to download the data they are interacting with, which can be very helpful when conducting a CCRA. One downside of the UK-CRI tool (Tool_1), is that coastal indicators are not incorporated and notably, for many of the 12km^2 squares coastal areas are either not fully covered, or not covered at all (see Figure 18 below).

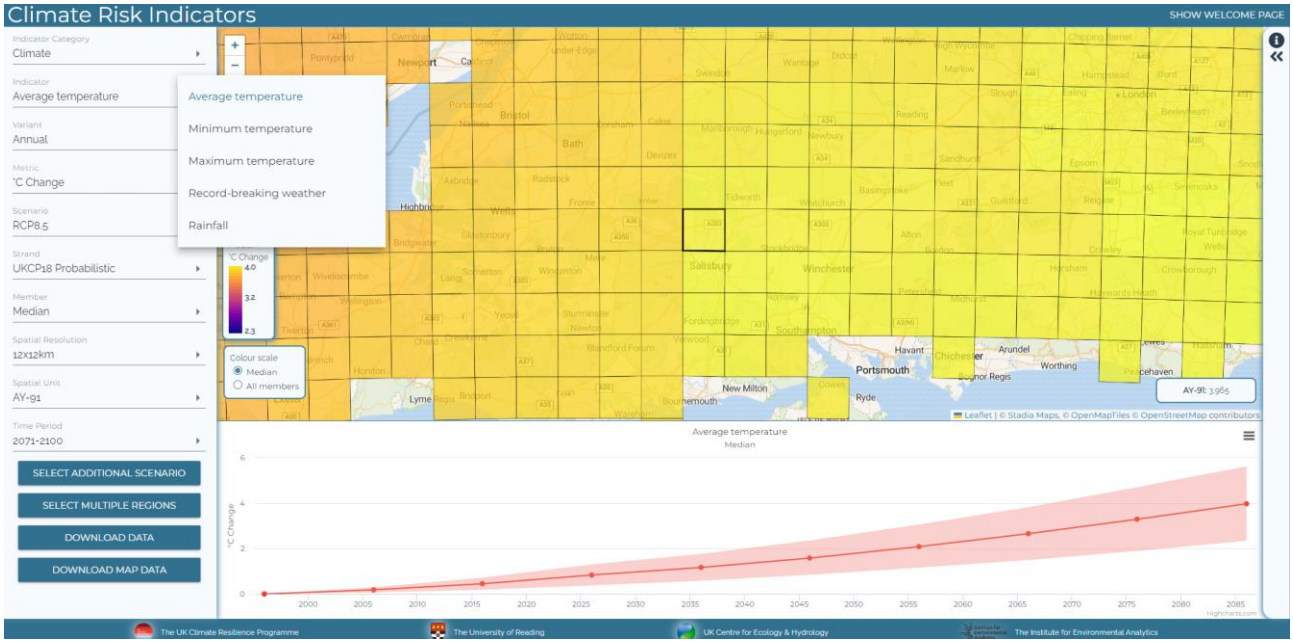

Figure 18. Extract from the UK-CRI tool, demonstrating the 12km^2 view.

[93] UK Climate Resilience Programme, (2023) UK Climate Risk Indicator Explorer.

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Another tool that would be useful when undertaking a CCRA, especially for establishing baselines, is the Flood Map for Planning[94] (Tool_2). This tool allows users to enter a location (whether that be an address, eastings and northings, or grid reference) and outputs the flood risk in terms of flood zones 1, 2 and 3 on a 50m^2 grid. This is the best freely available flood mapping in England and is a very useful tool in understanding fluvial and coastal flood risk down to a local level.

As mentioned in the 'Recommendations for data' section, the choice of data for assessment will to a degree depend on the needs of the assessment. Some key considerations when choosing datasets are:

- **Spatial scale:** is the data granular enough (or too granular) for the scale of assessment desired?
- **Time horizons:** does the data project (far enough) into the future?
- **Scenarios:** does the data consider more than one scenario, do the scenarios covered align with the needs of the assessment?
- **Required processing and manipulation:** to what extent does the data need to be interpreted and processed for the assessment?

Historic England are likely to be well served by data from the Met Office regarding climate hazard data that projects future changes. Equally, the CHESS-SCAPE dataset (Data_63) from UK-CEH is a useful data source in this regard.

Regarding key considerations for undertaking a CCRA, this has been covered in some detail in the previous 'Recommendations regarding approach to CCRA' section. However, some key elements to consider when undertaking a CCRA are:

- Alignment with an existing methodology: Drawing on an existing methodology will likely lead to a more rigorous assessment and provide a template around which additional or alternative aspects can be included.
- Strategic or site specific: Deciding whether to pursue a site-specific CCRA or a strategic CCRA is a critical first step. A strategic CCRA is more likely to be suitable for Historic England's purposes (informing ARP reporting and the CCRA4 call for evidence).

[94] Environment Agency, (2024) Flood Map for Planning.

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- Scoping hazards: The range of hazards included within the assessment should be decided early on either through a scoping exercise or by aligning with an existing methodology. The nature of the hazards (e.g. extremes, changes in the mean and variability) should also be decided early on.
- Setting time horizons: When setting the time horizons for assessment Historic England should consider at a minimum: the timescales over which impacts of climate change are likely to reach critical thresholds; the availability of data; the lead time for adaptation to address impacts; and the lifetime of the site or system at risk.
- Quantitatively assessing risk where possible: Where possible risk should be assessed quantitatively through the use of indicators. Where this is not possible qualitative data can be used. Indicators that represent other elements such as vulnerability and significance, whilst potentially challenging to include, will improve the quality of the assessment.
- Risk with and without adaptation: Quantitatively where possible, the risk with and without adaptation should be assessed. This may be challenging to assess quantitatively and should it prove overly difficult a semi-quantitative or qualitative assessment would suffice.
- Presentation of results: Results should be presented in engaging formats. Matrices and maps can help to provide more visually engaging outputs.

Options for others to undertake a CCRA

This section focuses on the implementation of CCRA by other stakeholders, in effect, how Historic England could advise the stakeholders identified by this project on how to conduct a proportionate CCRA. It will consider CCRA approaches which are proportionate and which could be undertaken by minor heritage managers, and national and major heritage managers.

Regarding signposting proportionate option for minor heritage managers (i.e. those that are likely to be managing single sites or within a limited geographic context), the ‘Guidance on managing the impacts of climate change on northern historic places’[95] is a useful resource that could be recommended. This guidance is recommended for assessing risks to specific assets because it contains a workbook-style approach that is highly accessible and requires minimal technical expertise to undertake. Templates and examples are also

[95] Historic Environment Scotland, Minjastofnun Islands, Norsk Institutt for Kulturminneforskning and Riksantikvaren (2020) Assessing risks and planning adaptation: Guidance on managing the impacts of climate change on northern historic places

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provided, making it easy to follow, and these help to ensure that all elements of risk are assessed in turn. The method is thorough and has opportunity to incorporate more detailed assessment if the heritage manager wishes.

Alternatively, a more challenging option would be for Historic England to develop a simple site-specific CCRA for heritage managers, this could align with associated guidance (similar to that provided by the EA in their Climate Impacts Tool[96] (Tool_15)). A site-specific CCRA for heritage managers could dictate or recommend the use of certain indicators, risk components and risk assessment matrices to ensure methodological consistency. It could also make reference to the data and tools shortlisted as suitable for Historic England to signpost others to.

In relation to signposting options suitable for major heritage managers (i.e. those managing multiple large sites, such as the National Trust or English Heritage Trust (EHT)) it is important to acknowledge that some of these major heritage managers are already developing their own approaches and resources. Engagement with the Climate Resilience Lead at EHT for this project revealed that EHT are progressing with site-specific CCRAs and are trialling suitable template CCRAs. They have also conducted work to collate climate hazard data useful for assessment. Equally, the National Trust have produced climate hazard mapping[97] (Data_48) and have produced 'Adaptation Guidance'[98] in collaboration with the International National Trusts Organisation.

Given these developments, Historic England should consider creating an accessible online resource similar to the EA's guidance on 'Climate change: risk assessment and adaptation planning in your management system'[99]. This resource could also include the tools identified as suitable for Historic England to signpost others to, where appropriate and should make mention of the ISO 14091:2021 guidance as an important methodology.

[96] Environment Agency, (2023). Climate Impacts Tool
[97] National Trust, (2024). National Trust Climate Hazard Mapping.
[98] International National Trusts Organisation, (2023). Adaptation Guidance.
[99] Environment Agency, (2023). Climate change: risk assessment and adaptation planning in your management system.

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Dissemination

How to communicate and publicise this project's findings

This section outlines how user stakeholders have been categorised for this project and how this could link in with ongoing work at Historic England to understand different user groups. It also touches on ways in which Historic England could present identified data to interested stakeholders.

The categorisation of stakeholders for this project

It should be noted that Historic England are currently undertaking research to identify different user groups relevant to the heritage sector. These are user groups who may access Historic England advice and services across the historic environment, not just in relation to climate change. This work is still ongoing at the time of writing this report, but we are aware that it has distinguished 12 different broad user group types[100].

For the purposes of this project, we have categorised these stakeholders into three key groups, in addition to Historic England, that may be interested in the project outputs: national and major heritage managers (for example: the National Trust, English Heritage Trust, Ministry of Defence, etc.), minor heritage managers of all scales, and others (not considered as key stakeholders in this research, they may have an interest but are unlikely to be undertaking climate based risk assessment).

Table 3. Heritage user groups categorised by groups used for this project.

National and major heritage managers	**Minor heritage managers of all scales**	**Others**
National multi-site trust Arm's Length-Bodies Large commercial owner Government Department owner	Local single / multi-site trust Small local government Local authority department Specialist developers Non-specialist developers. Single-site amenity groups	Non-Governmental Organisation (NGO) (non-heritage) Local decision-makers Government policy maker Heritage funders Research departments Expert advocacy groups

[100] Correspondence with Kate Guest, Historic England, (04/03/2024).

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Options for Historic England to present data and tools to stakeholders

In terms of presenting data and tools to external stakeholders, Historic England have a range of options which should be explored.

Option 1. Integration into existing resources – short term option.

One option is to integrate the outputs of this project into existing advice on the Historic England website on 'Delivering on Climate Change Action and Heritage'[101]. We understand that the uploading of Microsoft Excel spreadsheets onto the Historic England website is not possible, however, a PDF version of the data catalogue along with the data catalogue guidance could be uploaded to a Historic England web page, although this would only likely to be useful to a small number of informed users in its current form.

The creation of a dedicated web page, focused on providing links to the data and tool sources identified as suitable for heritage managers could be created. However, this would require some work to translate the existing Microsoft Excel data catalogue and guidance into a webpage with hyperlinks and a suitable structure. If this option is pursued it would also be beneficial to produce a short guidance document explaining which data sources may be best suited to which audiences. A number of tools were identified as suitable for use with additional guidance and if these tools were included this guidance would also need to be produced.

Option 2. Disseminating project findings through webinars – medium term option.

Another alternate or complementary option is to deliver a webinar on the project and its outputs, highlighting in particular, the data catalogue and data catalogue guidance. Historic England's Technical Tuesday[102] webinar sessions offer an existing format into which this could be integrated. This webinar could also serve to inform internal stakeholders simultaneously and a recording of the webinar as part of the archive of Technical Tuesday webinars, could maximise the ongoing benefit of this.

Option 3. Creation of an GIS portal – long term option.

The creation of an interactive web-based GIS portal, similar in appearance and function to the MAGIC[103] data portal managed by Natural England, with partners in the Department for Environment Food and Rural Affairs (Defra), Historic England, the Environment Agency (EA), the Forestry Commission (FC), and the Marine Management Organisation (MMO)[104]. This portal could include all of the spatially defined data identified within the data

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[101] Historic England, Delivering on Climate Change Action and Heritage
[102] Historic England, Technical Tuesday Webinars
[103] Defra, MAGIC Interactive Web-based Mapping
[104] Defra, MAGIC – What is MAGIC?

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catalogue, with data categorised by CID and climate hazard as appropriate. It is worth noting here that some data sources would fall under multiple sections if this approach were undertaken given their suitability for multiple hazards and impact-drivers.

Establishing and maintaining a data portal in this style, complete with all of the spatially defined data identified within the data catalogue, could be challenging. Whilst most data identified is publicly licensed, permissions and accreditation would need to be supplied for some datasets. In addition, given the volume of data identified and the fact that many are commonly updated, such a resource would require consistent resourcing in the future to keep the portal current and up to date. Finally, whilst such a portal would be beneficial for stakeholders in allowing them to quickly identify data sources relevant to the climatic impact-drivers and hazards they are interested in accessing data for, there are questions arising around who should manage such a database. Arguably an organisation such as the Met Office would be better placed to manage such a portal, given their experience producing much of the data that would be hosted and their existing UK Climate Projections Interface[105] and their Met Office Climate Data Portal[106].

[105] Met Office, UK Climate Projections Interface
[106] Met Office, Climate Data Portal

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Further work and future research opportunities

This project has identified a range of potential future work packages that could be undertaken by Historic England following completion of this project.

Conducting a CCRA of England's historic environment

Historic England could conduct a CCRA of England's historic environment drawing on the identified approaches within this report. Approaches could be adopted, adapted or amalgamated to meet Historic England's needs and priorities. It is important to note that there are many possible approaches to CCRA and whilst the ISO 14091:2021 guidance is the closest standard for CCRA, it should be noted that the review of ALBs CCRA approaches undertaken for this commission revealed that all of the ALBs have taken different approaches.

A CCRA can be undertaken at a range of different spatial scales, geographies, as well as for different asset types, depending on Historic England's aims and objectives. This exercise would both gather evidence for CCRA4 and provide a clearer picture of the risks faced by the historic environment, enabling the development of suitable adaptation plan(s).

Creating an online repository of climate hazard information (tools and data)

Historic England could develop an online repository of climate hazard information (tools and data), this could take a range of formats as listed in the 'Options for Historic England to present data and tools to stakeholders' section, above.

Integrating suitably formatted outputs into existing Historic England webpages would be a good starting point for this activity and this could be built upon by disseminating information through webinars.

Collaboration with national heritage managers and arm's-length bodies to develop shared resources

Historic England could seek to expand the existing Heritage Adaptation Working Group (consisting of the UK heritage agencies, the National Trust and the English Heritage Trust). This group could be expanded to include groups with additional expertise such as the Department of Housing, Local Government and Heritage (Ireland), the National Trust (Scotland), the Forestry Commission, the Crown Estate, the Environment Agency and National Highways. This expansion of the working group could serve a dual purpose: acting as a means of sharing information and best practice, as well as means of pooling

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resources in order to develop more advanced climate hazard tools and data visualisation in the future, which could benefit all of the UK.

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Appendix 1

46 stakeholders were surveyed, from across Government departments and agencies, academia and research, international bodies, and other areas groups such as (local Government, non-profit organisations and consultancies). Those who replied are in bold. However, not all of these stakeholders provided data or completed the survey.

- Government departments
    - Government Open Source Data portal
    - DCMS
    - Cabinet Office
    - Department for Energy Security and Net Zero (DESNZ)
    - Department for Levelling Up, Housing and Communities (DLUHC)
    - Department for Environment, Food and Rural Affairs (Defra)
    - Department for Science, Innovation and Technology
- Government agencies
    - Met Office
    - **Environment Agency (EA)**
    - Scottish Environment Protection Agency
    - Natural England
    - Forestry Commission
    - National Highways
    - **Network Rail**
    - Forestry England
    - Climate Change Committee
    - Cadw
    - Historic Environment Scotland
    - Historic Environment Division Northern Ireland (NI)
    - Natural Resources Wales
- Academic and research
    - UK Centre for Ecology & Hydrology
    - **UK Climate Risk Indicators (UKCRI)**
    - UK Climate Impact Programme (UKCIP)
    - Environmental Change Institute – Oxford University
    - Copernicus
    - OpenCLIM
    - UK Climate Resilience
    - ClimateJust
    - ARIES
    - **British Geological Survey**
    - Centre for Environmental Data Analysis (CEDA)

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- International bodies
    - International Union for Conservation of Nature (IUCN)
- Other
    - National Network of Coastal Monitoring Programmes
    - Lead local flood authorities
    - **Coastal protection authorities**
    - Flood Re
    - Marine Climate Change Impacts Partnership
    - Ground Movement Group
    - **Cornwall Council (re. their project to understand flood risk)**
    - Royal Society for the Protection of Birds (RSPB)
    - National Trust
    - English Heritage Trust
    - GB Non-native Species Secretariat
    - Sayers and Partners
    - Centre of Expertise for Waters
    - Tyndall Centre

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Appendix 2

Table 4. In-combination hazards as identified by UKCCRA3

Risk	Relevant in-combination/compound hazards	Relevant CID Type(s)	In-text CCRA3 quote	How was hazard combo identified	Scoped in/out
H3/4	Combination flooding - e.g., combined tidal/fluvial flooding or river, sea and surface water flooding	Mean precipitation, Relative sea level, Coastal flooding, Pluvial flood	The likelihood of compound effects from tidal flooding and extreme rainfall is increasing, which can greatly exacerbate flood impacts (MCCIP, 2020) (Chpt 5 pg.90) Combined sources of flooding - the combined effect of coastal and surface flooding results in significant impacts for the built environment (Chpt 5 pg. 94)	Identified from CCRA3	Scoped in
H11	Wind driven rain	Mean wind speed, Heavy precipitation, Fire weather	In combination, impacts of high winds and driving rain impacting building structures. Erosion from rain and wind following wildfire and/or loss of vegetation. (Chpt 5 pg. 193)	Identified from CCRA3	Scoped in
H11	Shrink-swell	Shrink swell, Heavy precipitation, Mean air temperature, Frost thaw cycles,	Shrink swell resulting from changing levels of groundwater can impact land structures and embankments. Chpt 5 pg. 193	Identified from CCRA3	Already a scoped in hazard: Shrink-swell

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Risk	Relevant in-combination/compound hazards	Relevant CID Type(s)	In-text CCRA3 quote	How was hazard combo identified	Scoped in/out
H5	Moisture damage	Mean air temperature, Mean wind speed, Radiation at surface, Mean precipitation, River flooding, Heavy precipitation and Pluvial flooding, Coastal flood, Mean precipitation, Frost, Frost thaw cycles, Mean air temperture, Severe wind storm, Mean wind speed	Poorly insulated structures which can have low surface temperatures. Vapour concentration in the indoor environment which depends on the water content of outdoor air, moisture generation and ventilation. High vapour concentrations, especially if combined with low surface temperatures, can lead to mould growth. (Chpt 5 pg. 110) Water ingress which is associated with flooding but also with rainwater or groundwater penetration through building materials or defects. Building materials with a porous external surface, such as exposed bricks, can absorb rainwater and groundwater. Cracks in the building fabric and poorly-detailed junctions are also a cause of rainwater ingress, which can lead to damp, wood rot in timbers, corrosion in metal elements, as well as frost damage and salt efflorescence in the building fabric (Chpt 5 pg. 110)	Identified from CCRA3	Scoped in
H11	Biological growth - Bioturbation	Mean air temperature, Mean precipitation,	Increased temperature and humidity can increase plant and fungal growth that in turn increases the rates of decay for stone and wood structures and the bioturbation of archaeological sites, as well as posing a challenge for indoor heritage, both moveable and immovable (Bertolin et al., 2014; Leissner et al., 2015). (Chpt 5 pg. 189)	Identified from CCRA3	Scoped in

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Risk	Relevant in-combination/compound hazards	Relevant CID Type(s)	In-text CCRA3 quote	How was hazard combo identified	Scoped in/out
H11	Desiccation	Mean precipitation, Aridity,	Desiccation of waterlogged archaeological sites (Chpt 5 pg. 190). Exposure of new archaeological sites Invisible deterioration of archaeological deposits (buried and full impact only apparent when excavated).	Identified from CCRA3	Already a scoped in hazard: Desiccation
H11	New pest species	Mean air temperature, Mean precipitation, Water temperature,	Increased bioturbation of archaeological site. Increased water temperatures lead to new pests affecting marine archaeology. Pests and diseases of landscape plants (increased numbers, and new types) (Chpt 5 pg. 190)	Identified from CCRA3	Scoped in
H11	Oceanic changes	Ocean salinity, Ocean acidification, Dissolved oxygen, Mean ocean temperatures,	Changes to water chemistry leading to breakdown of marine heritage (Chpt 5 pg. 191).	Identified from CCRA3	Scoped in
N18	Multiple	Multiple	In this CCRA chapter we have especially highlighted this relationship through the role of landscapes (and seascapes) and sense of place (risk N18), recognising also the important interaction with cultural heritage (Risk H12). Changes in landscapes can have complex effects on individual and collective well-being, such as through the association between 'sense of place' and identity, as for example recognised in the diagnosis of 'solastalgia'-type negative impacts on people due to loss of cherished landscape features (Chpt 3 pg., 338).	Identified from CCRA3	Scoped in

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Risk	Relevant in-combination/compound hazards	Relevant CID Type(s)	In-text CCRA3 quote	How was hazard combo identified	Scoped in/out
H4/H11	Coastal change/erosion	Flooding, increased storm events, mean wind speed, heavy precipitation	Loss of archaeological sites (e.g. Iron Age promontory forts), buried archaeology, built heritage on the coast.	Heritage specialist identified in-combination hazard	Already a scoped in hazard: Coastal erosion
H5/H11	Subsidence	Aridity, mean air temp, mean air temp, mean humidity	Caused by increased mean air temps, drought reducing moisture in buildings which develops cracks and reduces the stability of the building. Also if foundations are built into clay/other non-bedrock materials then drying out will also increase risk of subsidence.	Heritage specialist identified in-combination hazard	Already a scoped in hazard: Subsidence
H11	High summer temps/Heat waves	Mean temp, mean precipitation	Can negatively affect fabric of buildings as well as collections they may contain.	Heritage specialist identified in-combination hazard	Already a scoped in hazard: High temperature events
H11	Drought	Aridity, mean air temp, mean humidity, mean precipitation, groundwater levels, wind erosion	Impact on historic landscapes (including registered parks and gardens) through loss of water features, plants etc. Changes in types of plant can affect character of historic landscapes. Loss of plant cover can increase soil erosion resulting in impacts on buried archaeology through exposure (crossing over with desiccation a bit). Can also result in changes in soil pH which can negatively impact on certain archaeological remains (wood, leather, iron etc.).	Heritage specialist identified in-combination hazard	Already a scoped in hazard: Drought

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Appendix 3

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Heritage and Climate Change: Climate Data Questionnaire

* Required

Introduction

JBA Consulting is working on behalf of Historic England to identify existing and future data on climate hazards relevant to heritage, to support risk assessment and management of climate change impacts. This research will enable the development of a catalogue of resources relevant to modelling the long-term impacts of climate change on cultural heritage caused by a variety of climate change pressures.

This survey aims to capture information on any existing and future climate hazard data being developed. Your contributions will help Historic England to empower and assist owners and managers of heritage assets to understand the exposure of heritage assets to climate change hazards. This in turn, will help to inform future adaptation.

If you don't feel that you are best placed to complete this survey, please forward to others who may be able to assist in our review.

The deadline for completing this survey is 2/2/24.

Privacy and Data Protecion

Privacy notice

JBA Consulting is the data controller for this survey. A data controller determines how and why personal data is processed.

Our privacy page explains your rights and how we deal with your personal information in full compliance with the General Data Protection Regulation (GDPR). You can access the page here:
https://www.jbaconsulting.com/privacy/

We will use the information in this survey to help us understand existing and future data relating to the impact of climate change on heritage. Only JBA Consulting's designated research team will have access to the questionnaire responses. The information will not be passed on to any third parties by JBA or used for any other purposes than this study. Responses are anonymous and individuals will not be identifiable in any research outputs.

About you

1. What is the name of your organisation? *

2. What is your role/title? *

3. Are you happy for us to contact you if we have any further questions regarding your/your organisation's work? *

- ◯ Yes
- ◯ No

4. What is your name? *

5. What is your email address? *

6. What is your telephone number? *

Data and tool details

This section will ask for details about your organisation's climate change data. Please only provide details for **one data set** in this section. If you/your organisation have multiple data sources that are relevant to this review, please provide details for these in the following sections.

7. Name of the data *

8. If known, who are the main users of the data (Govt bodies, private sector, research organisations, internal use, etc.)? *

9. Please select which climate impact drivers are included within the dataset(s).

A climatic impact-driver is a physical climate condition that directly affects society or ecosystems. Climatic impact drivers may represent a long-term average condition (such as the average winter temperatures that affect indoor heating requirements), a common event (such as a frost that kills off warm-season plants), or an extreme event (such as a coastal flood that destroys homes). *

- [ ] Heat and cold (high and low temperatures)
- [ ] Wet and dry (precipitation and dry weather)
- [ ] Coastal (flooding and erosion)
- [ ] Wind (including sand and dust storms)
- [ ] Snow and ice
- [ ] Open ocean
- [ ] Other

10. Please provide a brief description of the data *

11. Which heritage assets could the data apply to? *

- [ ] Buildings
- [ ] Archaeology
- [ ] Landscapes
- [ ] Marine heritage

12. Is the data regularly updated? *

- ◯ Yes
- ◯ No

13. When was the data last updated? *

14. How often is the data updated? *

15. If spatial, what spatial scale is the data suitable to use at? *

- ◯ National (>60 km)
- ◯ Regional (2.2-60km)
- ◯ Local (2.2km)
- ◯ Other

16. If the data is projections based, which timescales does it consider? *

17. If the data utilises climate change scenarios, which scenarios are they based on? *

- [ ] RCP 1.9
- [ ] RCP 2.6
- [ ] RCP 3.4
- [ ] RCP 4.5
- [ ] RCP 6
- [ ] RCP 7
- [ ] RCP 8.5

18. What licence applies to the data? *

- ◯ Public domain
- ◯ Non-commercial licence
- ◯ Proprietary licence
- ◯ Not for public use

19. What format is the data in? *

Microsoft Excel file, GIS layer, other

20. Is there a publicly available tool or resource to view the data? *

21. What is the extent of the data's coverage? *

- ◯ England
- ◯ UK
- ◯ Europe
- ◯ Global
- ◯ Other

22. If other, please state the data's coverage *

23. Are there any particular strengths about the data you would like to note? *

24. Are there any particular weaknesses about the data you would like to note? *

25. If possible, please provide a link to the data *

26. Are you using the data to consider climate change risk assessment for your sector/activities/assets? *

- ◯ Yes
- ◯ No
- ◯ Maybe

27. If yes, how so? *

28. Are you considering risks to heritage? *

- ◯ Yes
- ◯ No
- ◯ Maybe

29. If yes, how are you doing this? *

30. Do you have another dataset that you would like to share with us? *

- ◯ Yes
- ◯ No

Data and tool details

This section will ask for details about your organisation's climate change data. Please only provide details for **one data set** in this section. If you/your organisation have multiple data sources that are relevant to this review, please provide details for these in the following sections.

31. Name of the data *

32. If known, who are the main users of the data (Govt bodies, private sector, research organisations, internal use, etc.)? *

33. Please select which climate impact drivers are included within the dataset(s).

A climatic impact-driver is a physical climate condition that directly affects society or ecosystems. Climatic impact drivers may represent a long-term average condition (such as the average winter temperatures that affect indoor heating requirements), a common event (such as a frost that kills off warm-season plants), or an extreme event (such as a coastal flood that destroys homes). *

- [ ] Heat and cold (high and low temperatures)
- [ ] Wet and dry (precipitation and dry weather)
- [ ] Coastal (flooding and erosion)
- [ ] Wind (including sand and dust storms)
- [ ] Snow and ice
- [ ] Open ocean
- [ ] Other

34. Please provide a brief description of the data *

35. Which heritage assets could the data apply to? *

- [ ] Buildings
- [ ] Archaeology
- [ ] Landscapes
- [ ] Marine heritage

36. Is the data regularly updated? *

- ◯ Yes
- ◯ No

37. When was the data last updated? *

38. How often is the data updated? *

39. If spatial, what spatial scale is the data suitable to use at? *

- ◯ National (>60 km)
- ◯ Regional (2.2-60km)
- ◯ Local (2.2km)
- ◯ Other

40. If the data is projections based, which timescales does it consider? *

41. If the data utilises climate change scenarios, which scenarios are they based on? *

- ◯ RCP 1.9
- ◯ RCP 2.6
- ◯ RCP 3.4
- ◯ RCP 4.5
- ◯ RCP 6
- ◯ RCP 7
- ◯ RCP 8.5

42. What licence applies to the data? *

- ◯ Public domain
- ◯ Non-commercial licence
- ◯ Proprietary licence
- ◯ Not for public use

43. What format is the data in? *

Microsoft Excel file, GIS layer, other

44. Is there a publicly available tool or resource to view the data? *

45. What is the extent of the data's coverage? *

- ◯ England
- ◯ UK
- ◯ Europe
- ◯ Global
- ◯ Other

46. If other, please state the data's coverage *

47. Are there any particular strengths about the data you would like to note? *

48. Are there any particular weaknesses about the data you would like to note? *

49. If possible, please provide a link to the data *

50. Are you using the data to consider climate change risk assessment for your sector/activities/assets? *

- ◯ Yes
- ◯ No
- ◯ Maybe

51. If yes, how so? *

52. Are you considering risks to heritage? *

- ◯ Yes
- ◯ No
- ◯ Maybe

53. If yes, how are you doing this? *

54. Do you have another dataset that you would like to share with us? *

- ◯ Yes
- ◯ No

Data and tool details

This section will ask for details about your organisation's climate change data. Please only provide details for **one data set** in this section. If you/your organisation have multiple data sources that are relevant to this review, please provide details for these in the following sections.

55. Name of the data *

56. If known, who are the main users of the data (Govt bodies, private sector, research organisations, internal use, etc.)? *

57. Please select which climate impact drivers are included within the dataset(s).

A climatic impact-driver is a physical climate condition that directly affects society or ecosystems. Climatic impact drivers may represent a long-term average condition (such as the average winter temperatures that affect indoor heating requirements), a common event (such as a frost that kills off warm-season plants), or an extreme event (such as a coastal flood that destroys homes). *

- [ ] Heat and cold (high and low temperatures)
- [ ] Wet and dry (precipitation and dry weather)
- [ ] Coastal (flooding and erosion)
- [ ] Wind (including sand and dust storms)
- [ ] Snow and ice
- [ ] Open ocean
- [ ] Other

58. Please provide a brief description of the data *

59. Which heritage assets could the data apply to? *

- [ ] Buildings
- [ ] Archaeology
- [ ] Landscapes
- [ ] Marine heritage

60. Is the data regularly updated? *

- ◯ Yes
- ◯ No

61. When was the data last updated? *

62. How often is the data updated? *

63. If spatial, what spatial scale is the data suitable to use at? *

- ◯ National (>60 km)
- ◯ Regional (2.2-60km)
- ◯ Local (2.2km)
- ◯ Other

64. If the data is projections based, which timescales does it consider? *

65. If the data utilises climate change scenarios, which scenarios are they based on? *

- ◯ RCP 1.9
- ◯ RCP 2.6
- ◯ RCP 3.4
- ◯ RCP 4.5
- ◯ RCP 6
- ◯ RCP 7
- ◯ RCP 8.5

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- ◯ Proprietary licence
- ◯ Not for public use

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Microsoft Excel file, GIS layer, other

68. Is there a publicly available tool or resource to view the data? *

69. What is the extent of the data's coverage? *

- ◯ England
- ◯ UK
- ◯ Europe
- ◯ Global
- ◯ Other

70. If other, please state the data's coverage *

71. Are there any particular strengths about the data you would like to note? *

72. Are there any particular weaknesses about the data you would like to note? *

73. If possible, please provide a link to the data *

74. Are you using the data to consider climate change risk assessment for your sector/activities/assets? *

- ◯ Yes
- ◯ No
- ◯ Maybe

75. If yes, how so? *

76. Are you considering risks to heritage? *

- ◯ Yes
- ◯ No
- ◯ Maybe

77. If yes, how are you doing this? *

78. Do you have another dataset that you would like to share with us? *

- ◯ Yes
- ◯ No

Data and tool details

This section will ask for details about your organisation's climate change data. Please only provide details for **one data set** in this section. If you/your organisation have multiple data sources that are relevant to this review, please provide details for these in the following sections.

79. Name of the data *

80. If known, who are the main users of the data (Govt bodies, private sector, research organisations, internal use, etc.)? *

81. Please select which climate impact drivers are included within the dataset(s).

A climatic impact-driver is a physical climate condition that directly affects society or ecosystems. Climatic impact drivers may represent a long-term average condition (such as the average winter temperatures that affect indoor heating requirements), a common event (such as a frost that kills off warm-season plants), or an extreme event (such as a coastal flood that destroys homes). *

- [ ] Heat and cold (high and low temperatures)
- [ ] Wet and dry (precipitation and dry weather)
- [ ] Coastal (flooding and erosion)
- [ ] Wind (including sand and dust storms)
- [ ] Snow and ice
- [ ] Open ocean
- [ ] Other

82. Please provide a brief description of the data *

83. Which heritage assets could the data apply to? *

- [ ] Buildings
- [ ] Archaeology
- [ ] Landscapes
- [ ] Marine heritage

84. Is the data regularly updated? *

- ◯ Yes
- ◯ No

85. When was the data last updated? *

86. How often is the data updated? *

87. If spatial, what spatial scale is the data suitable to use at? *

- ◯ National (>60 km)
- ◯ Regional (2.2-60km)
- ◯ Local (2.2km)
- ◯ Other

88. If the data is projections based, which timescales does it consider? *

89. If the data utilises climate change scenarios, which scenarios are they based on? *

- ◯ RCP 1.9
- ◯ RCP 2.6
- ◯ RCP 3.4
- ◯ RCP 4.5
- ◯ RCP 6
- ◯ RCP 7
- ◯ RCP 8.5

90. What licence applies to the data? *

- ◯ Public domain
- ◯ Non-commercial licence
- ◯ Proprietary licence
- ◯ Not for public use

91. What format is the data in? *

Microsoft Excel file, GIS layer, other

92. Is there a publicly available tool or resource to view the data? *

93. What is the extent of the data's coverage? *

- ◯ England
- ◯ UK
- ◯ Europe
- ◯ Global
- ◯ Other

94. If other, please state the data's coverage *

95. Are there any particular strengths about the data you would like to note? *

96. Are there any particular weaknesses about the data you would like to note? *

97. If possible, please provide a link to the data *

98. Are you using the data to consider climate change risk assessment for your sector/activities/assets? *

- ◯ Yes
- ◯ No
- ◯ Maybe

99. If yes, how so? *

100. Are you considering risks to heritage? *

- ◯ Yes
- ◯ No
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101. If yes, how are you doing this? *

102. Do you have another dataset that you would like to share with us? *

- ◯ Yes
- ◯ No

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103. Name of the data *

104. If known, who are the main users of the data (Govt bodies, private sector, research organisations, internal use, etc.)? *

105. Please select which climate impact drivers are included within the dataset(s).

A climatic impact-driver is a physical climate condition that directly affects society or ecosystems. Climatic impact drivers may represent a long-term average condition (such as the average winter temperatures that affect indoor heating requirements), a common event (such as a frost that kills off warm-season plants), or an extreme event (such as a coastal flood that destroys homes). *

- [ ] Heat and cold (high and low temperatures)
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- [ ] Coastal (flooding and erosion)
- [ ] Wind (including sand and dust storms)
- [ ] Snow and ice
- [ ] Open ocean
- [ ] Other

106. Please provide a brief description of the data *

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Historic England

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