Assessing Historic Places Regarding Risks and Vulnerabilities Associated with Climate Change to Inform Conservation Planning—Development of Assessment Methods in Northern Europe

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Abstract
In the face of anthropogenic climate change, the management of cultural heritage must change the world over, in order to adapt historic places to the resulting impacts. Concepts for climate change mitigation and adaptation are well developed, but their application specifically in the context of the historic environment is limited. The number of methods and tools to assess the risks of climate change impacts on historic places and the vulnerabilities of these places to these risks is still small.

In this article, three assessment methods will be discussed, which were developed through projects in Northern Europe: Cultural and Heritage Added Value to Regional Policies for Tourism and Sustainability (CHARTS) disseminated a risk and vulnerability assessment to investigate the impacts of climate change on the historic environment of Wales. The Aurland project, in Norway, piloted a site-specific assessment method through local and expert input. Historic Environment Scotland (HES) is reviewing its portfolio of historic places with a novel impact assessment and mapping method, using a geographical information system (GIS).

This article discusses the differences of the approaches chosen by the projects to assess climate change impacts and plan adaptation measures. The article concludes with outlining a recently started project, Adapt Northern Heritage, involving HES and two Aurland partners, Riksantikvaren and the Norsk institute for kulturminneforskning, as well as Minjastofnun Íslands.

Keywords
Assessment methods, climate change impacts, comparative assessment, historic place adaptation, heritage management, Northern Europe, risk and vulnerability assessments

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Introduction

‘Climate change will have a direct effect on heritage sites, through physical changes in the environment that change the conservation conditions for the materials at the site. We have only seen the beginning of the physical changes’ (Kaslegard, 2011).

In the face of anthropogenic climate change, the management of cultural heritage, and particularly of the historic environment, must change the world over, in order to adapt historic places to the resulting impacts. The north of Europe has already challenging conditions for the conservation of historic places, and climate change is likely to exacerbate those conditions. Precipitation on Ireland’s and Scotland’s west coasts is increasing; ice cover in the Arctic is rapidly receding, causing sea level rise worldwide; erosion is accelerating at Iceland’s coasts; and permafrost is vanishing from Scandinavia—just to name a few impacts affecting countries in Northern Europe (Figure 1).

Concepts for climate change mitigation and adaptation are well developed, but their application specifically in the context of the historic environment is limited. Much of the attention has focused on climate change mitigation by making historic buildings more energy efficient, in order to reduce carbon

Figure 1. Coastal Erosion Was Threatening Fredheim, a Historic Hunting Station on the Norwegian Archipelago of Svalbard in the Arctic Ocean, so it Was Moved Further Inland in 2015
Source: Riksantikvaren/photographer Susan Barr.
dioxide emissions, a principal cause of climate change. The topic of adapting the historic environment to climate change is a more recent development. Although the need has been identified, adaptation measures are seldom specifically planned for and implemented at historic places, and the number of methods and tools to assess the risks of climate change impacts on historic places and the vulnerabilities of these places to these risks is still small.

In this article, three assessment methods will be discussed, which were developed through projects in Northern Europe: The project Cultural and Heritage Added Value to Regional Policies for Tourism and Sustainability (CHARTS) disseminated a risk and vulnerability assessment to investigate the impacts of climate change on the historic environment of Wales, in the United Kingdom of Great Britain and Northern Ireland (UK). The Aurland project in Norway piloted a site-specific assessment method through local and expert input. And, in Scotland, also in the UK, the governmental organization for the historic environment, Historic Environment Scotland (HES), is reviewing its portfolio of 336 historic places, by performing risk and vulnerability assessments with a novel impact assessment and mapping method, using a geographical information system (GIS), to better understand the occurrence, likelihood and impacts of natural hazards on these places. All three assessment methods aim eventually at informing forthcoming management policies developments.

This article discusses the differences of the approaches chosen by the projects to assess climate change impact and plan adaption measures and concludes with outlining a recently started project, Adapt Northern Heritage, involving HES and two partners of the Aurland project, Riksantikvaren (Norway’s Department for Cultural Heritage) and the Norsk institutt for kulturminneforskning (Norwegian Institute for Cultural Heritage Research; NIKU), as well as Minjastofnun Íslands, the Cultural Heritage Agency of Iceland. In the following, the CHARTS project will be discussed first, followed by the Aurland and HES projects, before comparing the projects in a discussion and providing conclusion and an outlook.

**CHARTS Assessments in Wales**

A project in Wales, running from 2011 to 2012, developed a ‘strategic approach for assessing and addressing the potential impact of climate change on the historic environment of Wales’ (Powell, Murphy, Chambers, Ings, & Lewis, 2012, p. 2), the outcomes of which became more widely known through CHARTS. CHARTS was a European INTERREG IVC project on ‘Cultural and Heritage Added Value to Regional Policies for Tourism and Sustainability’ (CHARTS Consortium, n.d.), involving Cadw, the historic environment department of the Welsh government. As a part of CHARTS, Cadw disseminated the assessment method developed by Powell, Murphy, Chambers, Ings and Lewis to an international audience (Cadw, 2013). (For this reason, the Welsh approach is referred to, in this article, as the CHARTS assessment).

Powell et al. defined two objectives for their project: ‘[i]dentify and assess climate change … and [p]roduce a risk assessment for historic assets based upon sensitivity to change, including judgement on the likelihood and impact of the risks identified’ (2012, p. 10). With regard to climate change, they note that ‘[i]t is not worth exploring “Low (carbon) Emissions” scenarios, as these are now regarded as unlikely’ (ibid., p. 16) and, therefore, base their study on ‘medium emission’ scenarios for the 2050s, taken from the UK Climate Projection 2009 (UKCP09) (Met Office, n.d.), which, generally, provide a change in the same direction as ‘high emission’ scenarios, albeit with less severe impacts. Based on these projections, the study assesses historic places against ‘[f]our basic descriptions of climate change [with which] … 8 outcomes of change’ (ibid., p. 15) are associated (Table 1).

‘Twelve classes of historic assets were identified’ for the study. The categories used are combinations of place types and locations (Table 2): Place types include archaeology, buildings and nature.
Table 1. For the CHARTS Assessment, Four ‘Climate Change Description’ Were Established and Eight Associated Climate Change Outcomes Identified

| Climate Change Descriptions                  | Climate Change Outcomes                                      |
|---------------------------------------------|-------------------------------------------------------------|
| Warmer mean temperatures                    | Rise in sea levels                                          |
|                                             | Long term growing season                                    |
|                                             | Migration of pests and diseases                             |
| Hotter, drier summers                       | Drying out, desiccation and erosion of wetlands             |
|                                             | Stress on some trees and plants                             |
|                                             | Drying and shrinking of clay soils                          |
| Warmer wetter winters/wetter summers        | More flooding events                                        |
| More frequent extreme weather               | Frequent high winds/storms                                  |

Source: Powell et al. (2012, p. 15, 30).

Table 2. In the CHARTS Assessment, 12 ‘Classes of Historic Assets’ Were Identified, Which This Table Presents as a Combination of Place Types and Locations

| CHARTS ID and Description                          | Place Type      | Location                               |
|---------------------------------------------------|-----------------|----------------------------------------|
| 1 Historic asset below the 1.0 m contour          | Not specified   | Below 1.0 m contour line               |
| 2 Archaeological sites on farmland                | Archaeology     | Rural                                  |
| 3 Historic assets on the foreshore                | Not specified   | Coastal                                |
| 4 Forestry and woodland                           | Nature          | Rural                                  |
| 5 Historic building                               | Building        | Not specified                          |
| 6 Historic assets on the cost edge, excluding those below the 1 m contour line | Not specified | Coastal                                |
| 7 Historic asset on floodplain and valley bottoms | Not specified   | Floodplain/valley bottom               |
| 8 Historic park and gardens                       | Nature          | Not specified                          |
| 9 Peat, peaty soils and blanket bog               | Nature          | Rural                                  |
| 10 Historic landscape                             | Nature          | Rural                                  |
| 11 Historic assets in sand dunes                  | Not specified   | Sand dune                              |
| 12 Archaeological sites in an upland environment excluding peat bogs | Archaeology | Rural                                  |

Sources: Powell et al. (2012, p.15) and Author.

The locations used could be described as coastal, low-lying land, rural, flood plain, etc. With the chosen mix of place types and locations, Powell et al. attempt to capture as many aspects of climate change impacts on as many historic place types as possible, whilst keeping the assessment scenarios minimal. The categories chosen are very broad .... Some assets will appear in more than one class; for instance listed buildings will have been considered under ‘historic buildings’, but may also have been included in ‘historic parks and gardens’ and ‘historic buildings and archaeological sites below the 1m contour’. Urban was not considered as an individual class, as it is adequately covered under other classes. (ibid.)

The identified 12 historic place types are assessed against the eight identified climate change impact types to produce risk matrices, although not every impact type will necessarily apply to every historic place type. Thereby, a total of 36 matrices were produced (Table 3).
Table 3. Matrix Showing the Results of the 36 CHARTS Assessments (Coloured Boxes), Where Applicable to a Combination of Climate Change Outcome and Historic Place Type

| Description of change | Warmer mean temperatures | Migration of pests and diseases into Britain | Hotter, drier summers | Drying out, desiccation and erosion of wetlands | Stress on some trees and plants | Drying and shrinking of clay soils | Warmer, wetter winters / wetter summers | More flooding events | Frequent high winds / storms |
|-----------------------|--------------------------|---------------------------------------------|-----------------------|-----------------------------------------------|--------------------------------|-----------------------------------|--------------------------------------|------------------------|-----------------------------|
| **Outcomes of change** |
| **Historic environment asset** |
| 1. Historic asset below the 1.0 m contour |
| 2. Archaeological sites on farmland |
| 3. Historic assets on the foreshore |
| 4. Forestry and woodland |
| 5. All historic buildings |
| 6. Historic assets on the coast edge, excluding those below the 1m contour |
| 7. Historic assets on floodplains and valley bottoms |
| 8. Historic parks and gardens |
| 9. Peat, peaty soils and blanket bog |
| 10. Historic landscapes |
| 11. Historic assets in sand dunes |
| 12. Archaeological sites in an upland environment excluding bogs |
| **Source:** Powell, Murphy, Chambers, Ings and Lewis (2012, Table 4.6).

**Note:** The colour coding indicates the degree of significance of the change and if the change is considered being adverse or beneficial.
The risk matrices are based on three assessment criteria: ‘extent’ of impact (on a scale of 1 to 5), ‘severity’ of impact (scale –3 to +3) and ‘sensitivity’ of historic place (scale 0 to 5) (ibid., p. 16).

The extent of impact scale is arrived at by quantifying (or … estimating) the number of historic assets in a class and then estimating the number of assets in the class that are likely to be affected by the outcome of change. Thus if a class contains a large number of assets and all will be affected then the scale point would be five. If a class contains a large number, but only a few will be affected then the scale point would be 1 or 2. (ibid., p. 17)

The severity score was assigned using expert knowledge and allows for indicating if change is beneficial (rating +1 to +3), neutral (rating 0) or negative (rating –3 to –1). Expert knowledge was also used for the severity assessment, judging on a scale from 0 to 5 how easily a place could withstand an impact or be repaired following the impact, with 0 being ‘not sensitive to change’ and 5 being ‘highly sensitive’. ‘An Iron Age promontory fort may be assessed as 5 … as once eroded it cannot be replaced, whereas an historic building may be assessed as 1 or 2 as it can be repaired … following impact by climate change’ (ibid., p.18).

The overall significance of change was calculated by simply multiplying the extent, severity and sensitivity ratings. The result is then assigned a level of significance, as set out in Table 4. The colour coding of the significance levels corresponds to those in the CHARTS results matrix in Table 3, which summarizes the 36 assessments made for the historic place types identified.

The study found that, generally

the impacts of climate change on the historic environment will vary enormously depending on the type of historic asset and location. Some of the projected extreme weather events will undoubtedly have a significant impact on certain classes of historic environment assets, but it is the projected long term trends, such as hotter drier summers, a longer growing season and rising sea levels that potentially have the greatest impacts. (ibid., p. 38)

Concerning Historic Landscapes, the study identified

[n]o single highly significant impact …, but a series of potential impacts … of moderate significance. Cumulatively, these are of high significance, and it is the authors’ opinion that the impact of climate change will be more severe and widespread on historic landscapes than on any other type of historic asset. (ibid., p. 38)

| Scale Point | Description              |
|-------------|--------------------------|
| –75 to –36  | High (negative)          |
| –35 to –11  | Moderate (negative)      |
| –10 to –1   | Small (negative)         |
| 0           | Neutral                  |
| 1 to 10     | Small (positive)         |
| 11 to 35    | Moderate (positive)      |
| 36 to 75    | High (positive)          |

Source: Powell et al. (2012, pp. 17, 32–35).
Somewhat confusingly though, the study found that historic parks and gardens, for example, might benefit from a ‘longer growing seasons’, a ‘small positive’ impact of climate change, whilst the same impact type would be ‘moderate negative’ for historic landscapes. Considering that historic parks and gardens are also a form of a historic landscape, the assessment method appears to be contradictory in places, presumably due to its generalizing nature.

Similarly, with regard to historic buildings, Powell et al. (2012) admit that ‘[i]t is difficult to make any general predictions regarding the impacts of climate change on historic buildings as each is unique, with its own strengths and weaknesses’ (p. 97), but also suggest that ‘some of the… impacts will be mitigated by the fact that many of our historic buildings are well cared for and will be repaired following damage’ (ibid., p. 97).

In conclusion, the CHARTS study provides a good overview about climate change impacts on a range of historic place types in Wales, but, due to its qualitative and generic nature, struggles to develop outcomes meaningful for the assessment of a specific historic place.

**Norway’s Aurland Pilot Project**

Utilizing CHARTS, Riksantikvaren, the government organization concerned with the historic environment in Norway, organized jointly with NIKU a project with the title Kulturminner og klimaendringer—Pilotsprojekt: Aurland kommune (Cultural Heritage and Climate Change—Pilot Project: Aurland Kommune), running from 2012 to 2015.

The motivation for the project was an ‘identified … need to acquire both experience and knowledge of how the central, regional and local heritage administration should develop in a changing climate’ (Riksantikvaren, 2015, p. 6). The project, therefore, had not only to investigate the impacts of climate change on historic places but also what administrative changes were required to manage these places effectively. The project considered, amongst other assessment approaches, the CHARTS approach (ibid., pp. 71–73), but, unlike the top-down method adopted in CHARTS, the Norwegian project focused on a small number of historic places in one select local administrative area, the Aurland kommune. Located in Sogn og Fjordane county, in the southwest of Norway, Aurland is a mountainous area on a side arm towards the end of the Sognefjorden, a long, narrow inlet with steep sides connected to the Norwegian Sea (Figure 2). About 300 km north-east of Oslo and 150 north-west of Bergen, the kommune has a land area about 1,400 km² and a population of about 1,700 living in a small number of villages.

The Norwegian project ‘started with the actual cultural heritage object and cultural environments, together with planning and organisation within one municipality’ (Riksantikvaren, 2015, p. 6). Riksantikvaren and NIKU involved in the project governmental administrations of three different levels—the local administration of Aurland kommune, the regional administration of Sogn og Fjordane Fylkeskommune (county) and the Norwegian government’s representative for the county, the Fylkesmanne i Sogn og Fjordane (county governor)— as well as the public organizations Norges vassdrags- og energidirektorat (Norwegian Water Resources and Energy Directorate) and Nærøyfjorden Verdensarvparken (Nærøyfjorden World Heritage Park), which manages Nærøyfjorden area, covering large parts of Aurland and some neighbouring kommunes, of the UNESCO World Heritage site West Norwegian Fjords: Geirangerfjord and Nærøyfjord (UNESCO World Heritage Centre, 2017).

The aim of the project was to ‘create Risk and Vulnerability analyses for relevant cultural heritage objects and cultural environments … [and to] look at measures that might be relevant to reduce damage and … tried to assess which resources will be required’ (Riksantikvaren, 2015, p. 5). For this, the project
developed user-friendly assessment forms for four place types: archaeology, buildings, infrastructure and landscape. However, regardless of the place type, the form templates were extremely similar. To test the forms, the project participants conducted joint site visits to seven select historic places in Aurland: two archaeological sites, two buildings, one infrastructural site (namely, a well) and two cultural landscapes. The buildings were Flåm Church, the churchyard of which was also one of the archaeological sites, and a complex of farm buildings at Otternes, consisting of several timber log buildings (Figure 3). The church is located in Flåmselva, a village in a valley at a river bend. In 2014, during the project period, severe flooding occurred, causing substantial destructions in Aurland. The church and its churchyard only narrowly escaped the severe flood damage (Figure 4).

The assessment forms, used on site, consisted of four sections: (a) place data (name, type, location), (b) assumptions on climate change, (c) assessment of risks and vulnerabilities by place elements (e.g., for buildings, foundations, roof, walls) and (d) proposed adaptation measures (including preventive measures, monitoring, maintenance, extreme weather preparedness and disaster response) (Table 5). The forms were filled out by the project participants for each selected historic place, using a combination
Figure 3. The Otternes Farm Buildings in the Aurland Kommune, Norway, is a Mountainous Complex of a Variety of Timber Log Buildings. The Complex Was Assessed in the Aurland Pilot Project and Will Also Be Used As a Case Study in the Adapt Northern Heritage Project.

Source: Riksantikvaren/Photographer: Marte Boro.

Figure 4. Flåm Church in Flåmselva, a Village in the Aurland Kommune, Escaped Severe Flooding in 2014 Only Narrowly. The Normal River Width Can Be Judged By the Bridge in the Bottom Left of the Right Photograph. The Church and Its Graveyard Were Assessment Sites in the Aurland Pilot Project.

Source: Left photo: Arnstein Rønning (via Wikipedia, CC BY-SA 3.0)/Right photo: Helge Mikalsen/ VG/ NTB scanpix).
Table 5. Assessment Form for the Otternes Building Complex, as Used in the Aurland Pilot Project, with Four Sections on Place Details, Climate Change Assumptions, Risk and Vulnerability Assessment and Adaptation Planning

**Buildings form – OTTERNES BYGDETUN**

| Cultural heritage/Cultural environment | Otternes Museum - Farm buildings with summer farm and boathouse Between Aurland and Flåm Close to the Nærøyfjorden World Heritage site- outside the protection area |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| **Type**                              |                                                                                                                                 |
| **Location**                          |                                                                                                                                 |

**Possible future changes in the outdoor climate:**

1.1 Increased precipitation
1.2 Increased temperature
1.3 Increased wind
1.4 Increased moisture levels due to increased water levels in watercourses/lakes/springs
1.5 Increased risk of landslides
1.6 Increased risk of flood, water run-off
1.7 Increased risk of erosion
1.8 Increased risk of wind damage (falling trees etc.)
1.9 Increased risk that vegetation will generate increased moisture.
1.10 Increased risk of higher sea levels

| Anticipated future changes in the outdoor climate in the area |
|--------------------------------------------------------------|
| Yes  Yes  Yes  No  Yes  Yes (run-off)  No  No  No |

**Resistance:**

Building component: for example, outer walls, foundations, windows, doors, drainage/water run-off, immediate surroundings that could affect the building etc.

| Which building element does not tolerate the anticipated climate changes (indicated by Yes above)? | Type of damage | Probability | Consequence | Risk assessment |
|-----------------------------------------------------------------------------------------------|----------------|-------------|-------------|-----------------|
| Outer walls                                                                                   | Increased biological deterioration | - unlikely green   | - no danger green  | based on consequence and probability |
|                                                                                               | Stability problems in connection with increased risk of landslides | - quite likely yellow  | - some danger yellow  | |
|                                                                                               |                                                                   | - likely orange      | - danger orange      | |
|                                                                                               |                                                                   | - highly likely red  | - catastrophic red   | |

**Risk assessment:**

Based on consequence and probability.
Foundations

Stability problems in connection with increased risk of landslides
Under-dimensioning in connection with increased water run-off will lead to increased risk of both biological deterioration and stability problems

Drainage / water run-off

Proposed preventative measures

| Measure                                      | When/frequency   | Responsible | Finance                        |
|----------------------------------------------|------------------|-------------|--------------------------------|
| Reduction of longhorn beetle                 | as soon as possible | The Foundation | (check Riksantikvaren’s archives) |
| Diverting water in the meadows across the building environment | as soon as possible | The Foundation | Within operating costs          |
| Investigate danger of landslide              |                  | Technical department? | Within operations |
| Fire protection/alarms                       | as soon as possible | The Foundation | (check status)                  |

Proposed control points/monitoring

| Measure                                      | When/frequency   | Responsible | Finance                        |
|----------------------------------------------|------------------|-------------|--------------------------------|
| Check longhorn beetle                        | Annually         | The Foundation | Within operating costs         |
| Monitor most-exposed outer walls             | Annually         | The Foundation | Within operating costs         |
| Monitor foundations                          | Annually         | The Foundation | Within operating costs         |

Proposal for regular maintenance:

| Measure                                      | When/frequency   | Responsible | Finance                        |
|----------------------------------------------|------------------|-------------|--------------------------------|
| Upkeep plan to be established and implemented (removal of vegetation is important) | On-going         | The Foundation | Within operating costs         |

Proposed measures in the event of extreme weather:

| Measure                                      | When/frequency   | Responsible | Finance                        |
|----------------------------------------------|------------------|-------------|--------------------------------|
| Shuttering windows, anchoring hooks in powerful winds | Weather warnings | The Foundation | Within operating costs         |

Proposed measures after extreme weather event

| Measure                                      | When/frequency   | Responsible | Finance                        |
|----------------------------------------------|------------------|-------------|--------------------------------|

TOTAL

Operating costs (ca NOK 100,000) + longhorn beetle + fire protection

Source: Riksantikvaren (2015, pp. 109–110); (© Riksantikvaren / photographer: Marte Boro).
of local knowledge and specialist expertise. With regard to climate change, the form asked 10 yes/no questions: Are increases expected with regard to precipitation, temperature, wind, moisture levels (due to groundwater), risk of landslides, risk of flood, risk of erosion, risk of wind damage, risk that vegetation will generate increased moisture and risk of sea level rise? Answers in the pilot project were generally given as ‘yes’ or ‘no’, without any quantifications stated.

As for the risk and vulnerabilities assessment, users had to identify first the place elements affected by climate change and then describe the types of damage expected. Thereafter, users had to assign to each place element ratings for probability (likelihood) and consequence (impact/severity) using a colour-coded four-scale rating. This rating system has been derived from that of the CHARTS project and used a colour coding of (a) green, (b) yellow, (c) orange and (d) red. For probability, the rating options are: (a) unlikely, (b) quite likely, (c) likely and (d) highly likely. For consequence, they are: (a) no danger, (b) some danger, (c) danger and (d) catastrophic. Finally, the risk level was generated by assigning the higher number of the probability and consequence ratings. Interestingly, in all assessments of the pilot project, the risk level was associated with the consequence rating; the probability rating appears to not matter.

In the form’s final section, adaptation measures are described. The user has to input ideas for adaptations measures, grouped into: preventive conservation, monitoring, maintenance, extreme weather preparedness and disaster response. The user first has to describe the measure and identify when or in what interval it is to be implemented. Helpfully, the form then requires the user to name the organization responsible for the implementation and describe the associated financing mechanism. Thereby, the forms can identify the costs associated with the adaptation measures suggested.

After completion of all seven forms, the results for all seven historic places assessed in the Aurland project were listed according to risk level ratings and associated damage types and place elements (Table 6). The list contains seven yellow, two orange and three red risk entries. The latter entries include the assessments of the already mentioned Flåm Church and its churchyard, with regard to the impact of flooding and erosion on its underground element (foundations and archaeological artefacts, respectively). The church is also listed under yellow risk, due to increased moisture in building fabric. The third red entry lists the Otternes farm buildings, endangered by landslide/water run-off. Otternes is also listed with orange and yellow risk levels for various other damage types.

The project concluded that the ‘identification, charting and documenting of … cultural heritage … are fundamental to be able to implement measures that can prevent damage and loss’ (ibid., p. 7). The project found further that

[i]t is vital that land-use plans, technical work and culture all work closely together … [and that the local population needs to be informed and involved in the discussions, be given the opportunity to contribute with their knowledge and be allowed to participate actively in decision-making. (ibid.]

The project recommended to expand the pilot to other kommunes and to develop a ‘knowledge bank with … recommendations for correct maintenance and traditional building methods’ smart climate solutions […] … advice on maintenance and upkeep of archaeological cultural heritage, and … good examples of knowledge of measures to reduce the risk of damage and to repair damage’ (ibid., pp. 7–8). The project also suggested that ‘better routines for communication and process rules for emergency measures following catastrophic events [should be developed and] … the financial situation to preventative measures and measure after damages’ (ibid., p. 8) be clarified.

Unfortunately, the linkage between the different sections of the form remains unclear. If the user, for example, identifies ‘increased precipitation’ as an anticipated future climate change, no automated process is used to assign relevant damage types in the risk and vulnerability assessment. The user rather
Table 6. Overview of Historic Places Assessed in the Aurland Pilot Project, Grouped by Risk Types and Also Listing Place Type, Place Name, Climate Change Threat and Place Elements

| Risk type | Type of cultural heritage / cultural environment | Cultural heritage / cultural environment | Directly or indirectly threatened due to climate change | Part of cultural heritage / cultural environment that is threatened |
|-----------|-----------------------------------------------|----------------------------------------|------------------------------------------------------|-------------------------------------------------------------|
| 'Red risk' | Building Flåm church | flood, erosion | foundations |
|           | Building Otternes farm buildings | landslides, water run-off | foundations |
|           | Archaeology Flåm churchyard | flood, erosion | churchyard material |
|           | Building Otternes farm buildings | increased temperature, increased precipitation | outer walls |
| 'Orange risk' | Landscape Styvi-Holm-Bleiklindi | landslides, flooding, erosion, wind damage, regrowth | retaining walls and stone walls |
| 'Yellow risk' | Building Otternes farm buildings | increased moisture in the buildings | gutters, downpipes and drainage system |
|           | Building Flåm church | increased moisture in the buildings | gutters, downpipes and drainage system |
|           | Archaeology Blåskavlen | melting snow | snowdrift finds |
|           | Infrastructure Brekkestien | landslides, erosion | Path / summer farm track |
|           | Landscape Flåmshagen | flood, erosion | retaining walls |
|           | Landscape Styvi-Holm-Bleiklindi | landslides, regrowth | arable land pasture |

Source: Riksantikvaren (2015, p. 111).

takes the climate change assessment as a mnemonic device to consider suitable damage types. Similarly, the risk levels assigned to the place elements are not directly linked to the adaptation planning section, but the user takes the risk levels as a reminder for identifying adaptation measures. Thereby, the prioritization established with the risk level ratings is unfortunately not transferred into the adaptation section.

The adaption option would also benefit from a clearer systematic. Although the split into five categories is helpful, the example given in Table 5 shows that the user input can be either an aim/objective or an adaptation activity/measure. The mentioned ‘reduction of longhorn beetles’, an insect pest attacking timber, is an aim, not a preventative measure, whilst ‘check for longhorn beetles’ is indeed a monitoring measure, which fulfils the aforementioned aim.

The occurrence of an incident of extreme flooding during the project leads to the interesting question if and how this event has influenced the risk and vulnerability assessment, considering that, in lieu of quantitative data, local and specialist expertise was used. The experience of extreme weather phenomena can cause humans to experience exaggerated climate change impressions.

Climate change is a trend in averages and extremes of temperature, precipitation, and other parameters that are embedded in a lot of variability, making it very difficult to identify from personal experience. People often falsely attribute unique events to climate change and also fail to detect changes in climate. (Swim et al., 2009, p. 21)
In summary, the Norwegian project has developed an assessment form which is user-friendly and can be filled out on site involving a group of experts from different fields of expertise. The form, however, is solely based on user assumptions, does not use quantitative data and relies on the user to make appropriate linkages between the form’s four sections. That said, the colour coding communicates well the risk levels for specific place elements and the assignment in the adaptation planning section of responsibilities and financing mechanism gives the Norwegian approach a clear advantage over the method used in Wales. As seen from the Aurland summary, both methods can also be used to draw strategic conclusions for portfolios of historic places.

Assessments by HES in Scotland

Similar to Riksantikvaren in Norway, HES advises on and supports the management of Scotland’s historic environment. However, HES also cares for 336 historic places, by performing maintenance activities, promoting their understanding and operating visitor facilities. These places include the well-visited Edinburgh and Stirling Castles, but also many unstaffed sites in remote locations and exposed to severe weather. Through the Scottish Climate Change Adaptation Programme 2014–2019, HES is required to help (a) understand the effects of climate change impacts on buildings, (b) provide knowledge, skills and tools and (c) increase the resilience of buildings (Scottish Government, 2014, pp. 69, 72–73). The latter includes the preparation of the historic environment for climate change. Therefore, in its Climate Change Action Plan, Historic Scotland, one of HES’ predecessors, has set out that, in order to build resilience, the following activities would be undertaken (Historic Scotland, 2012, pp. 10–11, 16–17, 22–23):

1. Develop a method for assessing the risks of climate change impacts on HES sites, in order to evaluate which sites are most at threat and develop strategies to manage the impacts.
2. Develop a methodology for assessing the impacts of climate change on historic places, including historic buildings, monuments etc.
3. Act as an exemplar for addressing climate change impacts, by working with other organisations to develop new approaches and methodologies and cooperate to share knowledge and expertise.

In 2014, HES has commenced an internal project, a Climate Change Risk Assessment, to evaluate more objectively and systematically the impacts of climate change on its own sites.

To better understand the impacts of current climate threats to the HES Estate, we have undertaken a Climate Change Risk Assessment, focusing … on natural hazard risk. This represents the first steps in the development of: (i) a current climate risk register for the HES Estate, and (ii) a methodology for assessing the impacts of climate change on heritage assets in the wider historic environment. (Harkin, Davies, & Hyslop, 2018, p. ii)

The desk-based project had the principle aims … to: 1. Identify the range of current climate threats to the HES Estate using a desktop spatial GIS mapping exercise … [and] 2. Compile a baseline national risk register for the properties forming the HES Estate … Th[is] … will assist with the development of … methodology for assessing the impacts of climate change on heritage assets. (ibid., p. 1)

The assessment utilized GIS data from the British Geological Survey (BGS) and the Scottish Environment Protection Agency (SEPA). The data sets used provided information on six specific natural
hazards: coastal erosion, ground instability and coastal, fluvial, pluvial and groundwater flooding. ‘By screening for current natural hazard risk, we [i.e. HES] aim to identify the sites most at risk from these threats, and therefore the sites that may be the most susceptible to climate change, going into the future’ (ibid., p. 2).

This was considered a sufficient screening approach to generate baseline data for the current … phase of the risk assessment process. A succession phase is … proposed for work at a property level, in order ‘to include a wider range of climate impacts, more detailed information about the property and the knowledge and expertise of those who manage the site’. (ibid.)

As with the CHARTS and Aurland assessments, the HES risk assessment also generated risk levels using likelihood and impact ratings. A ‘commonly accepted formula for calculating risk [was used]: Risk = Likelihood of an event X Consequences of an Event (Impact)’ (ibid., p. 4). The likelihood rating was derived from GIS data sets. These data were overlaid with polygons, identifying the boundaries of HES sites (Figure 5). Running GIS queries, thereby, generates six hazard profiles specific to the site under interrogation. From these profiles, a likelihood score of 1 to 5 was assigned to each site for each hazard, with 5 being the most likely and 1 the least likely.

Similar to the likelihood, the impact of a hazard event also needs to be quantified, using a similar 1 to 5 scale. But how to measure impact? For this

a new impact scoring system [was] developed … based on a subjective assessment of what the impacts of a hazard occurring, at any given site, could be. The scores are based entirely on the impact to the monument, and

Figure 5. Example of the GIS Mapping Used in the HES Project: In the Left Image, the Turquoise Polygon Marks the Boundary of a HES Site, Threave Castle, on an Ordnance Survey Map, Showing the Site’s Location on an Island in the River Dee. On the Right Image, Three Coloured Layers Have Been Added to the Same Map, Identifying the Likelihood for Flooding to Occur: 1 in 10 Years (Dark Blue), 1 in 100 Years (Mid-blue) and 1 in 1,000 Years (Light Blue)

Sources: BGS/HES/Ordnance Survey/SEPA; © Crown Copyright, Historic Environment Scotland, Natural Environment Research Council, Scottish Environment Protection Agency / Data © British Geological Survey, Centre for Ecology and Hydrology, Ordnance Survey, Scottish Environment Protection Agency).
its surrounding grounds (i.e. not on health and safety (of staff/visitors), site access, business operations, agency reputation etc.). (ibid., p. 6)

The HES sites were grouped into six categories, describing the historic place: occupied and unoccupied roofed buildings, standing or carved stones, other unroofed standing structures with walls of less or more than 1.50 m height and ground archaeology. Experience of managing HES sites over decades was then used to assign to each site category impact ratings for each hazard (Table 7). The impact of fluvial flooding on a roofed building was, for example, considered as being higher than on ground archaeology, with impact ratings of 4 and 2, respectively. The reasoning was that ‘a roofed monument [would] house special collections, have decorative interiors and ... a decreased ability to “dry out” after flood waters have receded’ (ibid., p. 7). In contrast, a landslide was given the highest impact rating, 5, regardless of the site category.

To correlate likelihood and impact, a risk matrix table is generated, using the already mentioned multiplication system (Figure 10). In this system, a combination of impact and likelihood ratings of 1 will result in a risk level of 1. A combination of the highest impact and likelihood ratings results in the highest risk level: 5 x 5 = 25. This form of risk reporting is akin to the corporate risk management system.

| Property class | A | B | C | D | E | F |
|----------------|---|---|---|---|---|---|
|                |   |   |   |   |   |   |
| Roofed monuments |   |   |   |   |   |   |
| occupied        | 5 | 5 | 5 | 5 | 5 | 5 |
| unoccupied      | 5 | 5 | 5 | 5 | 5 | 5 |
| Unroofed monuments |   |   |   |   |   |   |
| masonry >1.5m   | 4 | 4 | 3 | 3 | 3 | 3 |
| masonry <1.5m   | 4 | 4 | 3 | 3 | 3 | 3 |
| Standing stones |   |   |   |   |   |   |
| standing stones | 4 | 4 | 3 | 3 | 3 | 3 |
| carved stones   | 4 | 4 | 3 | 3 | 3 | 3 |
| Field monuments |   |   |   |   |   |   |
| occupied        | 4 | 4 | 3 | 3 | 3 | 3 |
| unoccupied      | 4 | 4 | 3 | 3 | 3 | 3 |

Table 7. The hazard matrix used in the HES project identifies the impact rating according to type of natural hazard and historic place.

| Hazard        | A | B | C | D | E | F |
|---------------|---|---|---|---|---|---|
| Landslide     | 5 | 5 | 5 | 5 | 5 | 5 |
| Coastal erosion | 5 | 5 | 5 | 5 | 5 | 5 |
| Pluvial flooding | 4 | 4 | 3 | 3 | 3 | 3 |
| Fluvial flooding | 4 | 4 | 3 | 3 | 3 | 3 |
| Coastal flooding | 4 | 4 | 3 | 3 | 3 | 3 |
| Groundwater flooding | 4 | 4 | 3 | 3 | 3 | 3 |

Source: Historic Environment Scotland.

Table 8. The impact matrix used in the HES project assigns risk ratings by multiplying ‘Likelihood’ and ‘Impact’ ratings. The risk rating are then grouped into four categories, shown in the matrix in green, yellow, orange and red, to assign responsibilities for actions to respond to the identified risks.

| Likelihood | 1 | 2 | 3 | 4 | 5 |
|------------|---|---|---|---|---|
| Impact     |   |   |   |   |   |
| 1          | 1 | 2 | 3 | 4 | 5 |
| 2          | 2 | 4 | 6 | 8 | 10|
| 3          | 3 | 6 | 9 | 12| 15|
| 4          | 4 | 8 |12 |16| 20|
| 5          | 5 |10 |15 |20| 25|

Source: Historic Environment Scotland.
used by HES, in which a ‘high’ risk level (20 or 25; shown in the table in red colour) is considered an unacceptable level of risk exposure that requires HES’ highest management group, the Senior Management Team, to action mitigation measures. The high risk level category (levels 10 to 19; orange colour) is also considered unacceptable, but will be managed by the responsible directorate and requires only controls to be put in place to reduce risk exposure. The low and medium categories (respectively 1–3 and 4–9; green and yellow) are acceptable risk levels, subject to monitoring, with actions taken at team or directorate levels, respectively (ibid., Table 2).

The HES project resulted in assessments for 352 sites, as some of the larger and more complex 336 HES sites were split into multiple assessment areas. Each site was assessed for each of the six hazards mentioned, resulting in more than 2,000 assessments. The results indicate the risks specific to a site and can also be combined to identify the overall state of the HES estate, by giving the percentage of assessment sites for different risk categories. Combining the percentage of all six hazards led to the shocking insight that 89 per cent of the sites are exposed to hazards in ways that are considered ‘unacceptable’, with 18 per cent ‘very high’ and 71 per cent ‘high’ risk levels. These initial results were considered to describe ‘inherent’ risks.

As an initial step to reduce these inherent risks, controls and mitigants were considered, which would reduce the risk level, thereby generating ‘residual’ risk levels. For this reduction, it was first considered if and for how long sites are accessible to the public (all year, seasonally, permanently closed) and, when accessible, if they are staffed. If sites were accessible, the impact rating was reduced by up to 1 point. Similarly, where sites are staffed, impact levels were reduced by 1, as staff would be available to monitor site conditions and react to hazard events. Second, other reductions were made where controls and mitigants are already in place, including site operations, maintenance and repair programmes and conservation plans. Through this correction of the initial assessment, the overall inherent risk for high and very high was reduced to a residual risk of 53 per cent. Of the 352 sites, 28 sites remained at very high and 160 sites at high risk (ibid., p. 9).

The assessment process can be illustrated by that of Threave Castle, a HES site in Dumfries & Galloway, in south-western Scotland, the fluvial flooding map of which was already used as an example in Figure 5 to illustrate the likelihood assessment with GIS queries. ‘Located on a small island in the River Dee …. Threave Castle is a great, 30 metre tall tower house built in 1369’ (ibid. p. 32) (Figure 6). The GIS mapping suggested that widespread and severe flooding is to be expected. The site is therefore considered at high risk from fluvial (as well as pluvial) flooding. The site has indeed a history of flooding, with severe flooding in 2014 (see left photo in the figure) and in 2016, the worst recorded in living memory, when the highest ever water level was recorded for the river. The other risk assessments indicated that the site was endangered neither by groundwater flooding nor ground instability and, given that Threave Castle lies inland, that coastal erosion or coastal flooding are also not a problem.

The risk assessment project has allowed HES ‘to identify the properties [i.e. sites] we now believe to be most at risk from climate change. Up to this point we have focused on the impacts to the physical fabric and cultural significance of the properties themselves’ (ibid., p. ii). This new assessment method provides a quantifiable baseline for a coordinated climate change response. The associated risk categorization will help to allocate responsibilities within HES for the planning and implementation of climate change adaptation measures.

The major limitation of the HES project is that the underlying data sets are derived from measured, past data—climate projections are not considered. Although Harkin, Davies and Hyslop (2018) outline expected climate change impacts, a succession project is needed to factor this into the heritage management process. The project assumes that climate change will increase the rate of the occurrence of the natural hazards investigated. The results, therefore, provide a screening for climate change risks at
Hermann

Figure 10. Located on the River Dee, Threave Castle is a HES Site in Dumfries & Galloway, Which Has a History of Flooding. The Left Photo Shows the Extensive Flooding in 2014, Which Was Surpassed in 2016. The Site is Used as a Case Study in the HES and Adapt Northern Heritage Projects.

Source: Left Photo: Historic Environment Scotland/Right Photo: National Trust for Scotland; (© left photo: Historic Environment Scotland / right photo: Police Scotland).

HES sites, allowing prioritization for more detailed field surveys. Particularly problematic is that, for example, impacts such as wind-driven rain are not considered in the HES assessment to date, despite this being a substantial factor in the deterioration of material fabric of the historic environment, where exposed to this form of weathering (Hermann, 2013). A further restriction of the project is that ‘the results … are strictly limited to the risks identified within the [site] boundaries, and do not consider risks that may occur just out with these boundaries’ (Harkin et al., 2018, p. ii).

Discussion

The three assessment methods presented above, produced in the Aurland, CHARTS and HES projects, have stark differences, yet also some similarities (Table 9). They all aim at assessing historic places regarding risks, and vulnerabilities associated with direct climate change impacts were discussed. The projects cover very different geographical areas, from a local administrative area in Norway to the complete historic environment in Wales. They are therefore either aiming at strategic policy development or location-specific conservation planning. The HES project is limited to only five natural hazards and does not consider climate projections, whereas Aurland and CHARTS have a much wider scope with regard to climate projections and change impacts considered. The HES project, however, is the only one utilizing extensively detailed quantitative data in the form of GIS mapping. The HES and Aurland projects go beyond the CHARTS project in that they both include some form of adaptation planning, albeit, in the HES project, this is restricted to assessing the accessibility, staffing and maintenance regime of sites. The Aurland project is the only one to consider adaptation planning in a systematic way, including the assignment of responsibilities and the identification of costs associated with adaptation measures.
Table 4. Comparison of the Three Assessment Methods Discussed in This Article

| Matter for Enquiry                  | CHARTS (Wales) | Aurland (Norway) | HES (Scotland) |
|------------------------------------|----------------|------------------|----------------|
| Geographic area                    | Countrywide    | One local admin. area | Countrywide |
| Quantity of historic places        | Historic env.   | 5 select places in one local admin. area | Portfolio of 352 historic places |
| Method type                        | Qualitative    | Qualitative      | Quantitative |
| Heritage designation status        | Not necessarily heritage designated, but registered | All heritage designated | All heritage designated |
| Climate change impacts             | 8 definitions of diverse climate change impacts | User-dependent climate change impacts | Only 5 natural hazards |
| Use of climate projections         | Yes (UKCP09 mid-emissions scenario) | Yes (Klima i Norge 2100) | No |
| Climatic data use                  | General description of climate projections | General description of climate projections | GIS analysis of data from specialist agencies |
| Use of risk matrices               | Yes            | Yes              | Yes            |
| Use of vulnerability assessment    | Yes, but extremely generic (place categories, rather than specific places) | Yes, broken down into place elements | Yes, location-specific but limited |
| Led to prioritized adaptation planning | No            | No               | Yes            |
| Principal aim                      | National policy | Example case study | Organizational policy |

Source: Author.

The HES project also assigned responsibilities, but does not include adaptation planning in any form. The CHARTS project fails to deliver any form of adaptation planning, as its assessments are not location specific, but thereby is the only one of the three projects providing a countrywide strategic overview of climate change impacts on the historic environment.

Conclusion

In this article, three assessment methods from Northern Europe to assess historic places regarding risks and vulnerabilities associated with direct climate change impacts were discussed. The CHARTS method provided a strategic overview of the current and predicted climate change impacts on the historic environment of Wales. The Aurland project performed seven site-specific assessments in a local administrative area in south-west Norway and developed first ideas for adaptation measures, including assignment of responsibilities and initial cost estimates. The HES project conducted risk assessments for a portfolio of historic places in Scotland, but was limited to only five natural hazards and did not consider climate projections in the risk assessments. However, the HES project was the only one utilizing extensively quantitative data in the form of GIS mapping. Although the project had similar aims and used similar tools, namely risk matrices derived from impact and vulnerability assessments, the ways how the assessments were conducted differed significantly—each with its advantages and disadvantages.

To bring the methodologies of the Aurland, CHARTS and HES projects together and develop them further, particularly with a focus of making them more easily available for local governments and communities, HES and Riksantikvaren have started in June 2017 the three-year project, Adapt Northern
Hermann, working together with NIKU and Minjastofnun Íslands. With European, Icelandic and Norwegian funding from the Interreg programme for the Northern Periphery and Arctic (Interreg NPA), the project’s aim is to ‘adapt northern cultural heritage to the environmental climate change impacts and associated natural hazards through community engagement and informed conservation planning’ (Adapt Northern Heritage Consortium, 2017).

The project’s 10 case studies spread across Iceland, Ireland, Norway, Russia, Scotland and Sweden, and include the Otternes farm buildings, already a case study in the Aurland project, and Threave Castle, Dumfries & Galloway, Scotland, which was already mentioned as part of the HES project. Adapt Northern Heritage will specifically focus on providing communities and local governmental administrations with adequate tools to adapt historic places in their care to our changing climate. Engagement with stakeholders from various disciplines is a principal objective of the project. The importance placed on stakeholder engagement is a direct lesson from the analysis of the three assessment methods discussed in this article: Although differing substantially, all three methods had in common a strong interdisciplinary approach to working, often as a combination of local and specialist knowledge. As Riksantikvaren (2015) notes: ‘The emphasis must be on cooperation, dissemination, information and dialogue’ (p. 7).

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**Author’s bio-sketch**

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