Chapter 7
The Importance of Information Availability for Climate Change Preparedness in the Cultural Heritage Sector: A Comparison Between the UK and Japan

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Abstract Greenhouse gases produced by human activities are widely accepted to be warming the earth and causing an immediate and observable global impact. This has led to the need for different industry sectors to investigate how climate change will impact their interests. In this context this research looks into what is being done in Japan in the cultural heritage sector through a case study of Itsukushima Shrine. Itsukushima Shrine is a UNESCO World Heritage Site, located on Miyajima Island in Hiroshima Prefecture. Since 1963, tide gauge data from the Japan Meteorological Agency shows that sea levels in the region have been rising and causing an increase in flooding events at the site. This rise mirrors a global increase in sea levels, with many researchers arguing it is a direct result of global warming. Research into global warming and its impacts upon climate systems over the next century strongly suggest that global sea levels will continue to rise. This paper makes use of examples from the United Kingdom to identify ways in which the situation in Japan can be improved. In the UK the cultural heritage industry and researchers have actively sought to investigate, mitigate and adapt to potential threats posed by climate change. Those efforts are helped in part through Government-funded climate change information dissemination and education. This paper details how different sectors are embracing this freely available information to mitigate the impact of climate change on their own interests. Finally, recommendations are made based on the findings from the Itsukushima Shrine case study and also through a detailed appraisal of the UK's approach. These recommendations are applicable to organizations and cultural heritage sites across Japan and would also benefit other sectors.

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Background

Global warming is a widely accepted phenomenon, whereby anthropogenic greenhouse gas emissions cause temperatures to rise, which has a direct impact on weather patterns, sea levels and other aspects of the natural and built environment. In recent years, climatic changes associated with this warming are becoming increasingly evident. This has been confirmed through the work of countless researchers, and is especially clear in their contributions to the Intergovernmental Panel on Climate Change's (IPCC) regular reporting on the issue. In Assessment Report 5 (AR5) they noted that global warming over the period 1800–2012 had led to a 0.85 °C increase in the globally averaged combined land and ocean surface temperature. These and other temperature-related changes have occurred alongside other observed long-term trends, including changes in precipitation and sea level.

Extreme weather events in recent years also have many individuals, including scientists, pointing the finger at climate change as a contributing factor and even a cause. A recent report on the relationship between climate and extreme events, jointly produced by climate scientists from the US's National Oceanic and Atmospheric Administration (NOAA), UK's Met Office, and other institutions, noted that it is not possible to blame climate change for every extreme event (Peterson et al. 2012). However, the same group did attribute climate change to a number of extreme events that occurred in recent years. Similarly, a report published in the Bulletin of the American Meteorological Society (BAMS), suggested the conditions that led to a drought in Texas, USA in 2011 are twenty times more likely to occur now than they were in the 1960s due to increased atmospheric concentrations of greenhouse gases and associated climatic changes. The BAMS report also points to the exceptionally cold winter of 2010/11 in the UK as an example. With the coldest December in more than 100 years, it was characterized by lows reaching 5.0 °C below average, and with the highest number of air frosts for at least 50 years. BAMS concludes this event was the result of anthropogenic climate change and further that it was half as likely to have occurred just 50 years ago.

Recent observational findings are further confirming climate change as an important field of study throughout the world; with future projections suggesting climatic changes and associated extreme events will become more and more commonplace. Indeed, the emissions path the world follows will have a significant impact on how much global temperatures will increase in the future, which in turn will determine the nature, severity and number of associated extreme weather events. Recent emissions data suggests that mitigation efforts to date have not done enough to curb global GHG emissions. A report, published in December 2012, notes that current CO_2 emissions are tracking high-end emission scenarios, "making it even less likely global warming will stay below 2.0 °C" (Peters et al. 2012). It was the European Union (EU) that set a target of limiting global temperature increase to below 2.0 °C in order to prevent irreversible climate change. This number has since been accepted by scores of Governments across the world as a point at which climate change becomes "dangerous".

However, with current carbon emissions exceeding even the highest widely agreed scenario for a safe level of emissions, this 2.0 °C target is becoming increasingly difficult to achieve. This is even more concerning given the fact that on January 1st 2013, the only legally binding international climate regulation, the Kyoto Protocol, expired. In a special report in the journal 'Nature' on the Kyoto Protocol, it is noted that even though those industrialized countries that struck with the treaty were able to cut their collective emissions by 16%, worldwide emissions have surged by 50% from 1990 levels in the same time period (Schiermeier 2012). The uncertain future regarding mitigation targets and actions means that preparing for projected climatic changes is more important than ever.

Part One—Climate Change and Cultural Heritage in Japan: A Case Study of Itsukushima Shrine

Introduction

Many sites of historical significance in Japan are located along low-lying coastlines. One such place is Itsukushima Shrine, located on Miyajima Island, Japan (Fig. 7.1). The site itself is located on the shore of the Seto Inland Sea, which is connected to

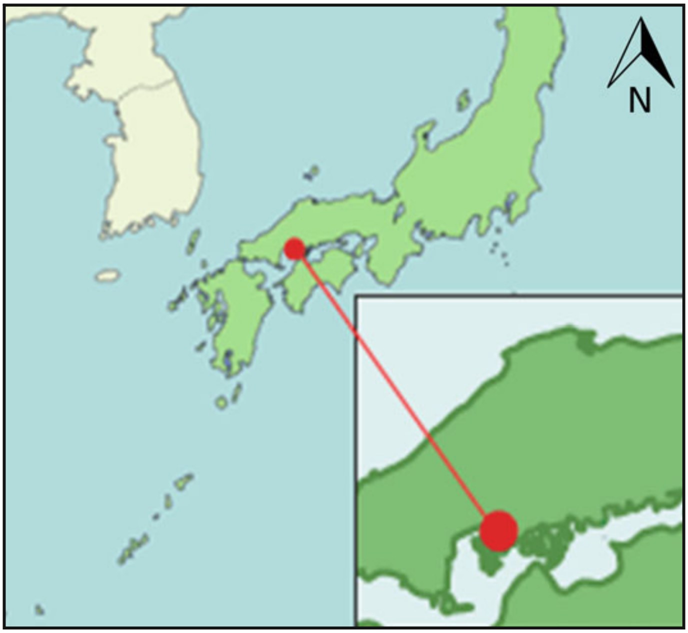

Fig. 7.1 Map showing location of Itsukushima Shrine

Fig. 7.2 Itsukushima Shrine at low (*above*) and high tide (*below*)

both the Pacific Ocean off Japan's east coast and the Sea of Japan to the west. Itsukushima Shrine is a UNESCO World Heritage Site and a designated Japanese National Treasure. The shrine is built on posts sunk into the seabed that allow it to appear as if it's floating on the sea during high tide (Fig. 7.2). The effect of this design is visually stunning but leaves it very vulnerable to flooding events. Indeed, rising sea levels are a real threat to the site's continuity. This is particularly concerning as current local government and site-level management plans do not include any information on climate change.

Objective

The objective of this case study was to investigate the observed and projected impact of climate change on Itsukushima Shrine. The site was chosen due to the fact that it is an important cultural heritage site in Japan and as such would serve as a high profile example of the potential impact of global warming. A further reason for the site's selection is its coastal location and its proximity to the sea, particularly during high tides. The major threat to the shrine posed by climate change is sea level rise and as such this is the focus of the case study. However, other impacts are also considered as part of this chapter.

The case study aims to ascertain whether any sea level change has been witnessed in the vicinity of Itsukushima Shrine and, if so, whether this is attributable to climate change. Furthermore, climate models allow future climatic changes to be identified, and their projected impacts visualized, based on differing greenhouse gas emission scenarios. Such data can be used to clearly show the potential threat climate change, and its associated sea level change, will have for the site. It is also an opportunity to demonstrate the importance of making data of this kind readily available to those who require it.

Hypothesis

Following an initial visit to Itsukushima Shrine in December 2011 as well as background research into climate change and cultural heritage in Japan, the following hypotheses were proposed for this case study:

- Projected climate change in the future will cause sea levels at Itsukushima Shrine to continue to rise
- Itsukushima Shrine will experience increased flooding events in the future as result of this sea level rise
- A lack of available information regarding sea level rise means stakeholders are unprepared for its potential impact.

Methodology

In the absence of readily available climate change data for Japan, the methodology for this study involved obtaining, processing and interrogating climate model data. The climate model that was chosen for this project was the 'MIROC-ESM model'. This model was a collaborative development from a number of Japanese Universities and research institutions. It was chosen as it made use of the latest RCP emission scenarios and also because one of the individuals involved with the model was available for consultation if questions arose during the project, as they did on a number of occasions. Data was downloaded from the Coupled Model Intercomparison Project Phase 5 (CMIP5) online repository. Climate model data was downloaded for the four different RCP scenarios; RCP2.6, RCP4.5, RCP6 and RCP8.5. In addition, the output from a version of the climate model that had been run historically was downloaded in order to test the model's historical output against observed data.

The climate model is divided into different outputs; of interest to this case study were the sea level data. The relevant data were downloaded and processed using ArcGIS and Microsoft Excel. The output of the model took the form of point data. Based on these data the nearest point to Itsukushima Shrine was identified and the sea level values for that point formed the basis for the study. A more geographically accurate result could have been achieved if the points were interpolated into a raster. However, to do this for such a large of quantity of data was not feasible given the time constraints of the project. A 2004 paper noted that a sea level rise of just 10 cm at Itsukushima Shrine would lead to sustained frequent flooding of the Shrine, as the Shrine's corridor is constructed just 30 cm above normal high tide (Tokeshi and Yanagi 2004). In this light an important goal of the case study research was to understand when this would occur and to produce graph outputs displaying the information.

Current sea level data was acquired in order to understand how sea levels will change from their current heights in the coming years. For this purpose, tide gauge data was retrieved from an online repository of global tide level data, Permanent Service for Mean Sea Level (PSMSL, http://www.psmsl.org). The data itself for tide gauge stations in Japan is provided by JMA. PSMSL then takes these data and converts them into a common format, where data between different tide gauge stations can be directly compared. For the purposes of this study, tide gauge data were acquired for all recording stations in the Seto Inland Sea, where the majority of recording stations have data available from around 1960. Finally, global mapping data were acquired to allow visual outputs of both the climate model data and tide gauge data to be produced.

Observed Sea Level Change

Since 1963 the sea level in the vicinity of Itsukushima Shrine has been steadily rising. Tide gauge data is not available for Itsukushima Shrine or Miyajima Island; however, data is available for Hiroshima, which is located approximately 16 km away. It was assumed to be sufficiently close to inform the study.

Figure 7.3 demonstrates sea level rise at Hiroshima since 1963. The causes of sea level change at this location are complex and include land subsidence and complex natural processes, namely variations in seawater density and oceanic circulation. As a result, and as noted earlier, JMA has conceded that attributing sea level rise on Japan's coast to climate change is very difficult (JMA 2009). In order to better understand how sea levels changes over time in the vicinity of Itsukushima Shrine, tide gauge data were collected for all stations where they were available in the Seto Inland Sea.

The averaged data for all the stations show a rising trend at a faster rate than the global average (Table 7.1). The work of the IPCC has shown that global sea levels have been rising over the past century and there is conclusive evidence to suggest that this sea level rise is linked to increasing atmospheric temperatures due to

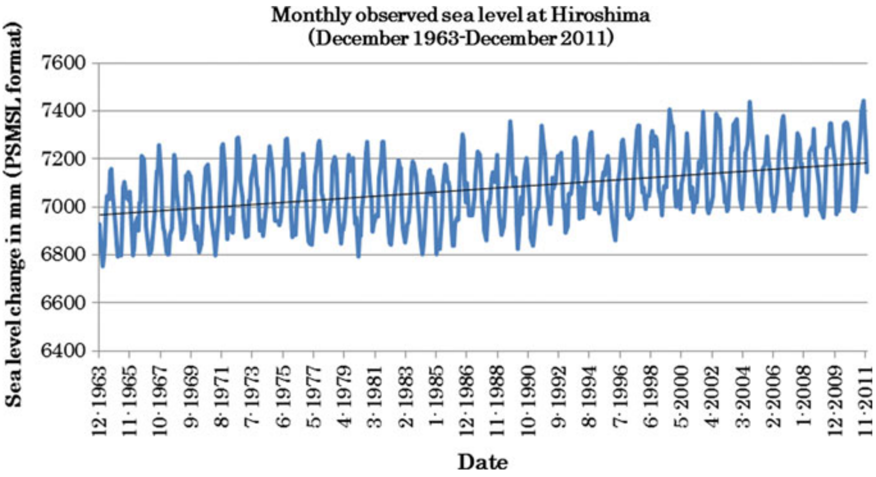

Fig. 7.3 Monthly observed sea level at Hiroshima December 1963–December 2011 (*Source* http://www.psmsl.org/)

Table 7.1 Rate of sea level rise for Seto Inland Sea and global average (*Source* http://www.psmsl.org/ and IPCC AR4, 2007)

Year	Annual seto inland sea level rise (mm)	IPCC Annual global sea level rise (mm)
1960–2010	2.1	–
1961–2003	2.8	1.8 [±0.6]
1993–2003	8.8	3.1 [±0.7]

anthropogenic warming of the earth as the result of the burning of fossil fuels (IPCC 2007).

It is not unreasonable to suppose that at least part of this rise in sea levels in the Seto Inland Sea is due to climate change. Because the Itsukushima shrine is so vulnerable to even small increases in the sea level it is prudent to acknowledge this change as a real threat. There is some question about what constitutes a flood event however, and while government data seem to indicate a rise in the number of floods in recent years, data produced by the shrine itself are slightly more flat (Fig. 7.4).

Projected Sea Level Change

In order to understand how sea levels around Japan's coasts are projected to change in the coming decades, data from the MIROC-ESM climate model were used. By assembling multiple time slices of future sea levels under the different emissions

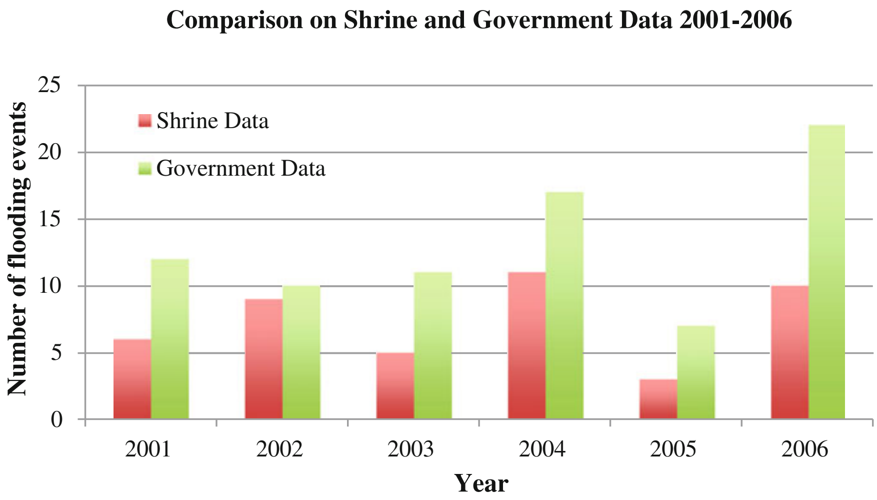

Fig. 7.4 Flooding event data from Itsukushima Shrine organization and the National Government

scenarios, it is possible to calculate the projected change in sea level between two different time slices. The climate model projects that Japan will see sea level rise along all of its coasts. The amount depends on the emissions scenario, with RCP2.6 showing significantly less sea level rise than RCP8.5 (Fig. 7.5). It is important to note that the climate model does not take into account factors such as land subsidence, which is important given the fact that land subsidence has been identified at a rate of 5 mm/year at Hiroshima.

As has been shown, the MIROC-ESM climate model shows sea levels in the study area increasing for all four emissions scenarios. Sea levels are projected to be between approximately 0.4 and 0.7 m higher by 2100 (Fig. 7.6) in the vicinity of the shrine. Until approximately 2075, all four emissions scenarios show a similar rate of increase. From this point onwards RCP2.6, RCP4.5 and RCP6 continue to see a similar rate of increase, whilst RCP8.5 shows sea levels rising by a significantly greater amount. This output is consistent with the idea of 'committed climate change' as detailed by the IPCC (2007), whereby even if anthropogenic CO_2 emissions were drastically reduced, global warming and associated climatic changes would continue to occur for the next several decades. It has been noted by Tokeshi and Yanagi (2004) that a 10 cm average sea level increase at Itsukushima Shrine would lead to sustained frequent flooding as a result of high tides. According to the climate model output data, this will occur before 2035, regardless of the emissions scenario. Again it is important to note that land subsidence has not been taken into account for the data presented in Fig. 7.6. This is corrected with Fig. 7.7, which show how sea levels could rise in the future if land subsidence continues at its current rate.

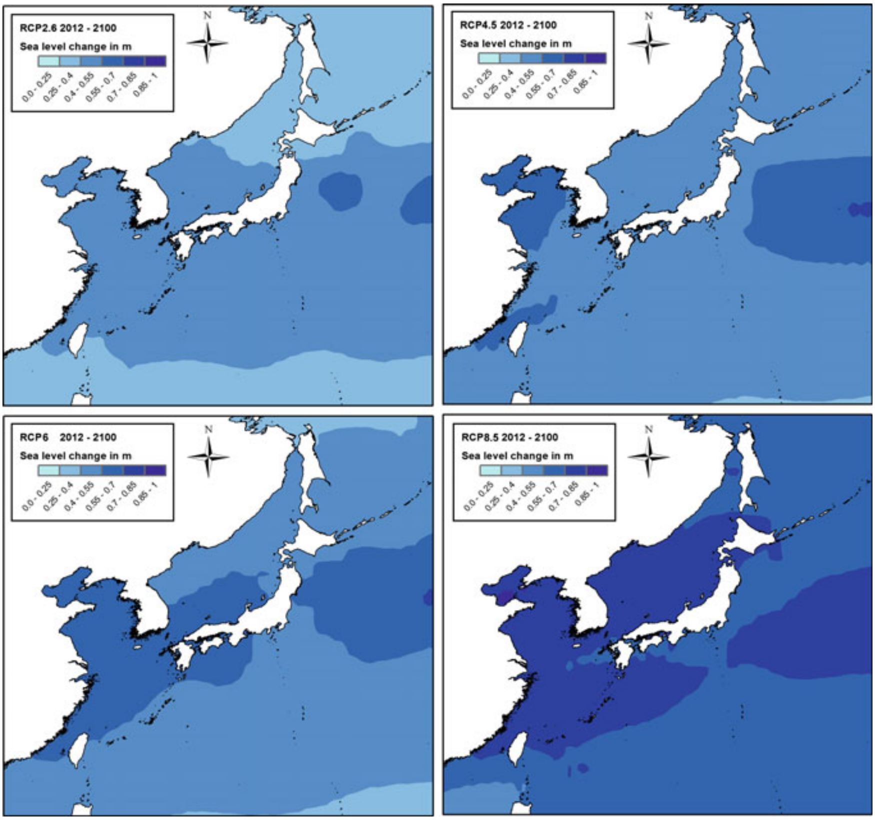

Fig. 7.5 GIS output showing projected sea level change in vicinity of Japan 2012–2100 under different emissions scenarios

When land subsidence is taken into account, an increase of 0.1 m will occur in the early 2020s regardless of emissions scenarios, with sea levels projected to increase in the region of Itsukushima Shrine between 0.89–1.14 m by 2100 depending on the emissions scenario. This compares to a projected rise of between 0.45–0.7 m when land subsidence is not included.

Other Potential Impacts of Climate Change

Sea level rise is the clearest example of how climate change is projected to impact Itsukushima Shrine in the future. However, analysis of climate model data as well as research into other potential impacts of climate change on Japan, shows that this may not be the only area in which the shrine could be impacted. Reports into how the future climate of Japan may impact typhoon activity have shown that whilst the

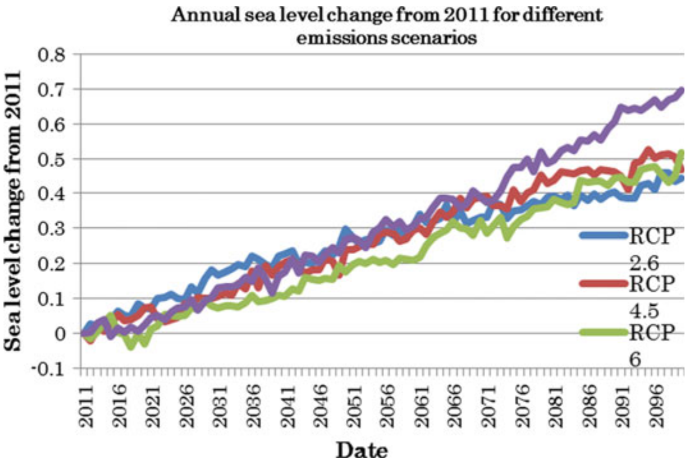

Fig. 7.6 Annual average sea level change in vicinity of Itsukushima under different emissions scenarios

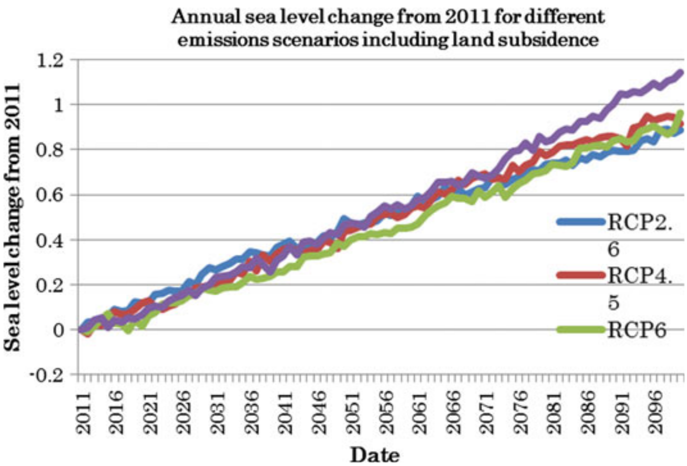

Fig. 7.7 Annual average sea level change in vicinity of Itsukushima under different emissions scenarios including 5 mm land subsidence

number of typhoons is projected to decrease, their intensity is predicted to increase (JMA 2011). This is a significant problem for the shrine as typhoons in the past have done major damage to shrine buildings.

Furthermore, based on published reports that make use of climate model data, other potential climatic changes in the region include:

- Surface temperature increases of between 2–3 °C, depending on emissions scenario (JME 2008).

- 10–20% increase in winter precipitation (JME 2008).
- 140% change in maximum daily precipitation in the next 100 years (JME 2008).

It is not known exactly how these climatic changes could impact cultural heritage sites like Itsukushima Shrine in Japan, as no studies have been undertaken that look into the possibility. However climatic changes of this sort were identified as having significant impacts on cultural heritage sites in Europe (Sabbioni et al. 2010), and it is not overreaching to imagine similar impacts in Japan.

Conclusions

The analysis completed and detailed in this paper shows that, regardless of the emissions scenario, the sea level in the Seto Inland Sea, and in the vicinity of Itsukushima Shrine, will continue to rise in the coming decades. The fact that humans have committed themselves to decades of global warming and associated climatic changes means that sea level rise in the study up to 2075 does not seem to be heavily impacted by future atmospheric CO_2 concentrations. It should also be noted that the results of this work suggest that sea levels in the vicinity of Itsukushima Shrine will, by 2100, increase by more than the IPCC predicted in their 2007 report.

The results are concerning as previous work has suggested that a 10 cm increase in sea level at Itsukushima Shrine would lead to frequent, sustained flooding (Tokeshi and Yanagi 2004). The results suggest this will occur before 2035 and it could occur even earlier if land subsidence continues at its current rate. Monitoring of the sea level at Itsukushima Shrine and the development of a management plan that takes future sea level rise as a result of climate change and subsidence into account is essential for the shrine's continuity. The lack of investigation into the impacts of climate change at the shrine and the fact that there is no provision in the local government's shrine management plan means a World Heritage site is currently at risk and unprepared for the future. This case study highlights the importance of climate change projection data and how they can be effectively used to understand potential impacts of climate change.

Part Two—Climate Change and Cultural Heritage in the UK

Climate Data Availability

In the UK, climate projection data is publicly accessible via the Government-funded UK Climate Projection (UKCP) program (last updated in 2009). This online data repository allows users to select their region of interest, the climate parameters of relevance to them, the emissions scenario, as well as the time-scale for the search and the degree of certainty based on current scientific understanding of climate change impact.[1] This information can be used directly to shape an organization's management strategy as well as allow organizations to prepare for any projected climatic changes that may threaten. The site provides a number of case studies showing how the data have been used to date. These range from local councils creating climate change information portals for their residents, to water companies planning to effectively manage future water supplies based on projected changes in precipitation patterns. Academics and researchers who may not have the technical knowledge to access and process raw climate model data can also use this online repository.

In the context of cultural heritage, this information has already been used by a number of researchers to understand how future climate change in the UK might threaten cultural heritage sites in the country. One such study analysed the output from UKCP to identify a list of 18 important changes (Cassar and Pender 2005), including temperature and precipitation, as well as humidity, soil and sea level changes. Visual outputs were then generated to show overlay projection data over cultural heritage sites. This kind of information is very useful for heritage bodies to understand which sites are under threat and to target resources accordingly. Following this data collection and analysis, questions were devised around the identified climatic and meteorological changes. The authors explained their methodology in the context of the questionnaires they developed as follows:

"The questionnaire was circulated widely to national, regional and local scientific and heritage experts, and local site managers requesting evidence of links between climate change and its impact on cultural heritage, the likely future effect on heritage of current climate change predictions and the planning and preparation that would be needed to ensure a timely management response" (Cassar and Pender 2005, p. 612).

The authors also organized regional workshops and a policy makers' workshop. Recommended policy outputs were centred on three themes: cooperation, funding, research and education.

Guidance and Publications in the UK

Publications and guidance in the UK have predominantly come from major heritage organizations; namely English Heritage and the National Trust. The National Trust's 'Shifting Shores: Living with a Changing Coastline' (National Trust 2008) publication made the following points with regard to effective adaptation to sea level rise and climate change:

[1]The UK climate projections online repository is available to all and can be found at http://ukclimateprojections.defra.gov.uk.

- There are serious shortcomings in baseline information
- The need for more coastal risk assessment studies
- The need for long-term planning at least at the time scale of 50–100 years
- To work with nature not against it
- Solutions need partnerships
- The need to raise awareness among the public of the impacts on coastal sites.

English Heritage is the UK Government's statutory advisor on cultural heritage and first published information on climate change and cultural heritage in 2006 entitled 'Climate Change and the Historic Environment' (English Heritage 2008a, b). This publication was updated in 2008. It provides information on climate change in the UK, as well as how this may impact cultural heritage in general in the UK through the use of specific case studies. English Heritage sees the purpose of its publication as a tool for the development of strategies and plans relating to climate change impacts. They also see it being useful for projects relating to risk assessment, adaptation and mitigation. Both English Heritage and the National Trust have sections of their websites that provide tools and further information on climate change that are available to all.

More recently other bodies and key stakeholders have begun to publish information relating directly to climate change and cultural heritage. In 2012, the Northern Ireland Environment Agency published a document entitled 'The Impacts of Climate Change on the Built Heritage of Northern Ireland' (Northern Ireland Environment Agency 2012). The report drew upon UKCP projection data to summarize projected climatic changes in Northern Ireland. It also explained how other countries in the union were addressing climate change and cultural heritage. Its main focus, however, was to see how climate change would impact cultural heritage in Northern Ireland, including coastal, wetland and general heritage sites. The report concludes with the following statement:

> In summary all predicted climate changes are likely to have negative consequences for the historic environment of Northern Ireland. While all built structures are likely to have to deal with this there are strong additional negative consequences for historic features near coasts or freshwater and wetlands plus those on/in clay soils which will need particular attention. NIEA Built Heritage is currently developing recommendations for managing the built heritage of Northern Ireland during this period of rapid environmental change. (NIEA: 2012).

This publication clearly outlines the position of the Northern Ireland Environment Agency. It raises awareness on the issue and also provides generalized information as a precursor to further work.

Historic Scotland have gone one step further and published 'A Climate Change Action Plan for Historic Scotland 2012–2017' (Historic Scotland 2012). This publication follows a 2009 joint statement produced by various Scottish institutions, including Historic Scotland, that acknowledged that,

> Climate change is the most serious threat to Scotland's environment, now and over coming decades. It will have far-reaching effects on Scotland's people and places, impacting on its economy, society and both natural and built environments. (Scottish Environment Protection Agency et al. 2009)

The 2012–2017 action plan document provides background information on climate change in Scotland as well as Historic Scotland's responsibilities on the issue, and sets out 7 'Strategic themes and actions'. These are:

- Reducing energy use in buildings
- Improving operations
- Improving energy efficiency in traditional buildings
- Building resilience: preparing the historic environment for climate change
- Improving sustainability of the historic environment
- Developing and promoting sustainable tourism
- Informing and influencing others.

These themes cover both mitigation and adaptation and clearly define Historic Scotland's commitment to preparing and combatting projected climatic changes. Of particular interest is the 'Building resilience' theme. Historic Scotland outlines their actions in regards to this theme as follows:

- "We will develop a methodology for assessing the impact of climate change on heritage assets including historic buildings and monuments, buried and submerged archaeology, historic landscapes, plantings and battlefields".
- Undertake a climate change risk assessment across the Historic Scotland estate to evaluate which sites are most at threat from issues such as coastal erosion, flooding, rainwater penetration etc.
- Work with a range of external partners to research and evaluate specific threats to buildings and monuments, such as increased biological growth and enhanced stone decay, and develop strategies to manage impacts.
- Review Historic Scotland's on-going maintenance and condition survey programs in the light of climate change predictions to modify conservation strategies and target priority sites where necessary.
- Input climate change factors into estate management strategies and business continuity planning, for example where threats to sites are likely to affect future visitor numbers and income.
- "Respond to current and emerging climate change threats by prioritizing our grant funding". (Historic Scotland 2012)

These actions are incredibly important if cultural heritage sites are to be protected from potential climatic and meteorological changes.

All of these publications are unequivocal in their view that climate change will have an impact on cultural heritage in the UK, and that the impact would be overwhelmingly negative. They aim to publicize the issue by clearly stating the organization's position on the issue, identifying areas that need attention, and providing details on actions they are taking. No such publications currently exist in Japan. Interestingly, all of the publications reference UKCP data and findings.

Compared to Japan

The information presented in this paper underlines the EU, and more specifically the UK, approach to the issue of climate change in the context of cultural heritage. It is multi-tiered, involving national and local governments, heritage bodies, academic researchers and individual cultural heritage sites. Their work is mutually beneficial and the information is disseminated between stakeholders. The situation in Japan is entirely different, and no sector is investigating the impact of climate change on cultural heritage. Government and heritage bodies have not produced any guidance or published statements relating to climate change and its impact, nor have academics investigated the potential impact of climate change on cultural heritage sites. It is perhaps not surprising that individual sites like the Itsukushima Shrine have not incorporated climate change into their management plans. The lack of information and easy access to climate model data, is a significant barrier to taking the needed steps in this regard.

The existence of the UKCP online repository and associated tools means that anybody in the UK is able to understand the impact of climate change in any area of the country. With this information in hand the cultural heritage sector has responded with guidance, mission statements and management plans targeting climate change and its impacts. Figure 7.8 shows a simple diagram of how UKCP data drives knowledge and guidance in this sector forward. This clearly shows that providing such an accessible resource for climate change information is highly beneficial for cultural heritage bodies.

Furthermore, academics studying cultural heritage, often without a natural scientific background, have been able to investigate the projected impacts of climate change on cultural heritage sites. If a similar repository were available in Japan, those with an interest in the conservation of cultural heritage sites would be able to understand the impacts of climate change and would be able to adapt accordingly.

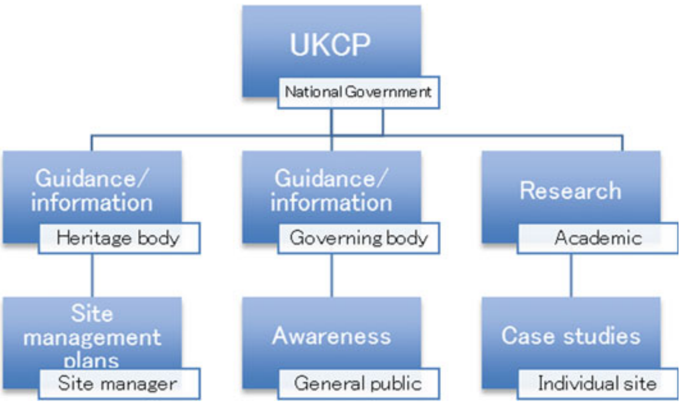

Fig. 7.8 Diagram showing UKCP and its relationship to the cultural heritage sector in the UK

UKCP Use Outside of the Cultural Heritage Sector

It is not just in the cultural heritage sector where organisations can benefit from easily accessible climate change data and up to date information. The widespread application of UKCP data and findings in the UK is a testament to this. In this section examples will be provided of how organisations from numerous different sectors have made use of climate change data to mitigate the impacts of projected climate change to their organisation and interests. It has allowed local governments to investigate the impacts of climate change within their geographic boundaries. Examples include Hampshire County Council, who have used the data to develop emergency planning scenarios; Kent County Council, who have used the data to visualise the impact of climate change on their county; Milton Keynes Council, who have undertaken a vulnerability assessment; and Oxford City Council, who present climate change information to local residents on their website. The final example of Oxford City Council is particularly important as it shows how organisations can easily repackage the information based on their requirements, in this instance presenting detailed information for a particular geographic area. Without the freely available UKCP portal, it is unlikely local governments would have the resources or expertise to undertake this kind of climate change related work. Indeed, in a paper introducing the 2009 UK climate projections, Street et al. noted that, "A recent survey of users of the UK Climate Impacts Programme's (UKCIP's) decision making tools showed that projections of climate change for the UK are the one UKCIP tool that stakeholders use most widely to plan adaptation strategies" (Street et al. 2009).

Projects within the building industry that have made direct use of UKCP information include PROMETHEUS, which aims to future proof design decisions in the building sector; and PROCLIMATION, which involves developing a simulation of a building's environmental performance in a changing climate. The water industry has also embraced UKCP data to understand how climate change will impact the water supply chain in the UK and to develop plans to mitigate these impacts. Severn Trent Water and Scottish Water have used the projections to undertake risk assessments to their business, whilst Thames Water has pioneered the use of UKCP data in water management planning. In regards to sewage, work has been undertaken by Atkins to understand how climate change may impact on the sewage network in the UK. Government bodies are particularly interested in how climate change will impact the environment and have made use of the data to investigate negative changes climate change may bring. The Environment Agency has undertaken analysis to estimate changes in flood damages as well as how climate change may affect pollution in the UK. The Department for Environment, Food and Rural Affairs (Defra) has completed a coastal flooding and erosion risk assessment, as well as investigating how climate change will impact crop yields and domestic food availability.

These examples show how organisations without the means to develop their own climate models to project future climatic changes have used UKCP to understand

and mitigate for potential climate change impacts. The academic sector has also used the information and a large number published papers rely on the availability of the data. These works are diverse and range from a study looking into how climate change will impact the railway industry (Baker et al. 2010) to a paper on winter road maintenance and traffic accidents in the West Midlands (Andersson and Chapman 2011). Other works have been published that are also directly relevant to business sectors in the UK. For instance a study on how solar radiation will change in the coming decades (Tham et al. 2010) is particularly relevant to the building industry and allows planning to be undertaken to make optimal use of solar energy power generation in building design. Environmental studies have also been taken and include a national estimate of changes in seasonal river flows (Prudhomme et al. 2012) as well as a paper assessing the impacts of climate change on flood frequency in Britain (Kay and Jones 2012).

Conclusions

With regards to cultural heritage and climate change in the academic sector in Japan, this study has shown that there is a complete absence of studies that investigate the topic. The methodology employed in the case study of Itsukushima Shrine shows that the site is under threat according to the latest climate model data and scientific understanding of climate change. The methodology can be used for other sites that are vulnerable to climatic changes and their associated impacts. Furthermore, the methodology presented here can be used as the basis for vulnerability assessments of other heritage sites in Japan. These assessments need not be limited to sites at risk from sea level change. The basic methodology of using sea level projection data is repeatable with other kinds of climate model output data—for example, temperature and precipitation. Indeed, work funded by the European Union has shown how climate model data can be used to assess the risk to cultural heritage properties (Sabbioni et al. 2010). Examples have also been provided for how organisations from other sectors can make use of the information to mitigate the impacts of climate change.

Recommendations

This report has shown that when organizations have easy access to up-to-date, unbiased, and easily understandable climate data they take action. This has been demonstrated through a study of the approach by the cultural heritage sector in the UK. With access to the Government funded UKCP data, heritage bodies have published statements, guidance, and plans relating to climate change and its impact on cultural heritage. Other organisations have also produced guidance and publications relevant to their interests. Without access to this information, it is unlikely these documents could have been produced, as the data and its implications are directly referenced by all. The lack of knowledge at all levels of the heritage sector in Japan is partly due to the lack of a comparable information resource in Japan. In an interview, management at Itsukushima Shrine admitted that they had no access to unbiased information and would not know where to turn if they wished to access climate model data themselves. They also expressed a willingness to use such information if it was available to them. Furthermore in a separate interview with the Hiroshima Prefectural Government, they said that they believed any such information should be provided by the national Government.

During the course of this research, the majority of information in regards to climate change in Japan has been in the form of reports from JMA. Some sectors, for example the agricultural sector, have dedicated information regarding climate change. However, no such information resource exists for cultural heritage sites. Furthermore, academic work is available regarding climate change in Japan but there is no chance to access that data directly without the technical skills and knowledge to download and process the raw data. Those working outside of the academic sphere are not expected to seek out this kind of information and there is a clear disconnect between what is known and being done in the academic sector and those working in the public and private sectors. This is clearly the case in regards to cultural heritage in Japan as knowledge and information that is abundant and accepted in the academic world is absent at the site level. By providing data to Japan in an easy to access format like that provided in the UK, other sectors and the general public would also benefit as any individual could investigate how climate change would impact their home, business or organization.

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