Built Heritage

RESEARCH ARTICLE

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The impact of increased flooding caused by climate change on heritage in England and North Wales, and possible preventative measures: what could/should be done?

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Abstract

Despite 30 years of discussion, adaptation work is not routinely being carried out at heritage sites to minimise future impacts of climate change, particularly increased flooding risks. To understand barriers to essential work being carried out, interviews were carried out with six heritage sites that have already experienced river flooding to understand levels of preparation both before and after the flooding occurred. The results prove that despite funding, or lack of, being an important contributor, it is not the sole barrier to adaptation. Previously flooded sites still do not have a flood plan in place, outside agencies are preventing work being carried out, measures which have been put in place through listing status are prohibiting necessary work and delays in decision making about what is acceptable are all delaying adaptation while allowing more damage to be caused from weather impacts. While responsibility for adaptation lies locally this situation will not improve; responsibility needs to lie more centrally. While the principle of replacing like for like is a sound one with the best of intentions behind it, this is also contributing to losses in heritage and must be reconsidered when big decisions are finally made about what will be acceptable if impacts to heritage from future climate change are to be minimised.

Keywords climate change, adaptation, barriers, heritage, flooding, site interviews

1 Introduction

Climate change has become a growing concern since the 1990's (Editors 1991; Jamieson 1992; Rowland 1992; Orr et al. 2021). There are global agreements and legal treaties in place to mitigate the impact of continuing climate change (Maizland 2021; American Institute of Physics 2022). Many vulnerable areas of cultural heritage will face increasing pressure due to predicted changes in weather patterns in the 21st century and while there has been increasing discussion around what needs to be done, to date little proactive work is being undertaken. Responses to extreme weather emergencies at heritage sites make the news, yet less action is taken to prevent or reduce impacts in preparation of climate change progression. There is an increasing amount of research which focuses on what can be done (Cassar and Hawkings 2007; Sabbioni et. al. 2012; Sesana et al. 2018); recommendations have already been made for preventative measures heritage sites can take and some adaptation work has been undertaken. However it appears that the urgency of the situation is not yet understood.

Existing research focuses on expected weather changes, what parts of the UK they will happen in and what heritage sites can do to adapt. However there appears to be less research focussed on sites which have already experienced an extreme weather event,

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particularly flooding, and reviewing the situation before and after the event. This is an essential area to investigate: if sites who have experienced flooding are not taking preventative measures, will sites who have yet to face such extreme events be making preparations? If mitigation work at damaged sites is not being carried out, what have been the barriers? This is an area which requires appraising and will form the basis of this new research. Exploring what can be done is essential, and so is exploring what is, and what is not, being done, and why. While it is beyond the scope of this project to investigate all climate change weather predictions, the focus will be on the impact of precipitation and flooding potential in the areas the selected case studies lie: North West England, North Wales and the East and West Midlands.

This new research will focus on river flooding due to accessibility of relevant flooded sites for the researcher. However coastal and estuarine flooding also pose a considerable threat to heritage; English Heritage considers coastal flooding to be one of the biggest challenges they have ever faced (English Heritage 2022a, b) with estuarine flooding acknowledged to have devastating and long term effects (Lyddon et al. 2023). Due to the extreme threat posed, much work has already been carried out by leading heritage custodians: English Heritage (2016), Cadw (2019) and Historic Environment Scotland (2014) have all published works to help with understanding and adaption. Indeed, the National Trust's Shifting Shores project sets out very clearly that it is futile to attempt to stop damage from coastal and estuarine erosion: the key is to plan for it, work with it and to adapt. This ethos could also be applied to the projected issues associated with river flooding and will be the focus of this new study.

This new research is important because it is timely. Target dates of impacts from climate change are fast approaching. The aims of this new research are to appraise the root causes of flooding issues on heritage, and what mitigating and preventative efforts have been made by sites to combat future challenges. It will also seek to identify barriers that prevent adaptive work being carried out and what these might be. To achieve this aim, interviews will be conducted with heritage sites that have experienced flooding, as well as exploring the remedial work carried out, to identify if flood prevention work had been carried out prior to it happening. This will allow development of data to show not only can be done but also to document why preventative measures are not put into place, to allow changes to be made ahead of the climate change impacts that are drawing closer.

2 Literature review

The timeline of climate awareness emerged in 1824 when French physicist, Joseph Fourier, described the greenhouse effect (Bell 2016; American Institute of Physics 2022; UCAR 2022). Over the following century more links were made between the increase in CO2 emissions from fossil fuel burning and the potential future impacts, however it was not until the 1990's that a link began to be made between these impacts and what they could mean to cultural heritage (Editors 1991; Jamieson 1992; Rowland 1992). Despite developing scholarship, what climate change means to cultural heritage continues to produce more questions than answers. Academic consensus appears to be that more research is still required (Bertolin 2019; Fatorić and Egberts 2020; Sesana et al. 2020). Many climate change predictions regarding increases in CO2 levels and the impact it will have on weather – and thus, cultural heritage – describe impacts by mid 21st century, with 2050 specifically noted as a target date for action (Jamieson 1992; IUCN Marseille Manifesto 2021; National Trust 2021). However there are warnings of impacts as soon as 2030 (Climate Change Post 2022) and the UK climate is already experiencing the impacts of climate change through rising land temperatures, sea levels and more frequent episodes of extreme heat (The Climate Change Committee 2022). Prior to the 19th century Industrial revolution CO2 emissions were at 280 parts per million (ppm) (Borenstein 2022). In May 2022 this had risen to 420.8 ppm (Borenstein 2022), and is predicted to have risen further by 2050. Hambrecht and Rockman (2017) wrote that 'climate change-based threats to cultural heritage are not waiting on the horizon but are with us now' (p. 637). With rising CO2 levels and target dates fast approaching, it is timely to investigate existing research into what can be done to protect heritage from the impacts of predicted climate change and what barriers exist to stop proposed actions being implemented.

Climate change awareness has emerged slowly. Self-declared as the 'birth of the modern environmental movement' (Earth Day 2022), Earth Day, founded in 1970 (Bell 2016, Earth Day 2022) was established to promote environmental concerns and make them a priority in the United States. However it was not until 1972 that the first global conference on the environment was held, in Stockholm, hosted by the United Nations (Bell 2016; United Nations 2022). This was the first discussion of pollution of land, sea and air on the world stage, however it resulted in proposals, not legislation. In 1992 the United Nations Framework Convention on Climate Change was the first global conference explicitly to discuss growing climate change concerns and to attempt to tackle the issues raised (Bell 2016; Maizland 2021). However it was

not until the Kyoto Protocol entered into force in 2005, that the first legally binding treaty regarding climate change bound all members to reduce CO2 levels to 5% below 1990 levels (Maizland 2021; American Institute of Physics 2022). The Paris Agreement of 2015 went further, setting targets in an attempt to stop the average global temperature rising no more than 1.5˚C (Maizland 2021; American Institute of Physics 2022).

Despite a growing awareness of the impacts of climate change, archaeology and heritage experts were slower to begin to grasp the potential hazards to cultural heritage. The earliest reference found by the researcher to a link between climate change and its potential impact on cultural heritage was in an edition of Australian Archaeology, referencing a workshop held in 1991 to raise awareness of 'the likely adverse effects of climatic change upon cultural heritage' (Editors 1991, p. 68). Discussion increased in academia throughout the 1990's and 2000's, however Stefan Gruber (2011, p. 209) and Helen Phillips (2014) believed that the impacts of climate change on heritage was an area with attention already devoted to it. In 2008 the UK Government passed the Climate Change Act which committed the UK to cutting greenhouse emissions (Ashworth 2022) and was the first globally legally binding policy set in place by a country (LSE 2020). At time of writing, only five countries worldwide have made reducing carbon emissions to become net zero by 2050 law, and only two of these have as yet made a net zero carbon emission pledge (Fleming 2019). Given the slow route to adoption of legal measures to deal with climate change, it is not surprising that legislation to deal with its effects on cultural heritage has been even slower to follow suit.

Given the wealth of literature available, it could be supposed that climate change impacts are now better understood by heritage experts. However not everyone is ready. Historic England (2015) noted the increased probability of flooding due to climate change in 2015, with Cadw (2019) and the National Trust (2021) all following suit thereafter. English Heritage had first however reported on predicted impacts of climate change on cultural heritage in 2006 (English Heritage 2022a, b). While the impact of climate change on cultural heritage emerged as an area of increasing concern in the 1990's (Jamieson 1992; Rowland 1992), Phillips (2015) was still asserting that 'cultural heritage is not ready for climate change' (p. 118). Harrison et al. stated in 2020 that 'usually, people manage this uncertainty by simply not thinking about it' (p. 263). Brimblecombe et al. (2011) and Cassar and Hawkings (Cassar and Hawkings 2007) are in agreement that many historic buildings were built to withstand a different type of climate. Often they have already withstood the climate for hundreds of years and while we are aware that buildings will degrade over time, how they degrade is being accelerated in unpredictable ways. The projected increase in rainfall and its intensity will cause a number of different problems for cultural heritage. Buildings are put at risk of subsidence (Cassar and Pender 2005), flooding leads to ground saturation (Climate Change Committee 2022) heavy rainfall increases the load that roofs have to bear (Mintzer 1987; Brimblecombe et. al. 2011) and above all, many historic buildings have outdated drainage systems that will not withstand the predicted increases in rainwater that they will have to cope with (Sabbioni et al. 2009; Brimblecombe et al. 2011; Curtis 2016). Cassar and Pender's 2005 project collected questionnaires from 45 heritage experts to understand the challenges faced, and this confirmed that the biggest area of concern was damage to ruins, erosion caused by increased storminess and rainfall. Site vulnerabilities continues to be an area that is much discussed, with little action being taken to mitigate or adapt.

Historic England (2015) produced a definitive guide, Flooding and Historic Buildings, adapted and reused with permission by English Heritage (2016) and Cadw (2019). The publication acknowledges 'the risk of flooding is likely to increase as a result of a changing climate' (p. 2) and maintains that flood risk management is essential, with a need for each property to complete a flood risk assessment (p. 9). While there is a recognised need for short and long term strategies focusing on adaptation and monitoring of historic buildings (Cassar and Pender 2005; Sesana et al. 2018), the Climate Change Committee argued in 2022 that there is still a lack of planning when it comes to adaptation. Curtis (2016) noted that repair and maintenance are not always given the attention they require, despite this being an essential part of adaptation planning (Phillips 2015). There is a gap between research and actual work being done to start adaptation (Bertolin 2019; Curtis 2016; Fatorić and Egberts 2020). English Heritage (2022a, b, p. 9) stated that 'it is important to make every reasonable alteration to the existing building stock that can mitigate climate change'. However to date this has not resulted in widespread action. Cassar and Pender (2005, p. 614) made an important observation when they noted that 'planning time-scales in the heritage sector are often much longer than conventional planning cycles'. Consequently, given climate change target dates, the time is now to start the necessary work to protect cultural heritage. Fatorić and Egberts (2020) and Sesana et al. (2020, p. 212) are in agreement that there is limited knowledge about and limited research into vulnerabilities of heritage due to climate change. Sabbioni et. al. (2012, p. 100) are clear that adaption and mitigation are areas to be acted on, with responsibility for these lying locally.

There is no rule book for protecting cultural heritage from impacts of climate change. However, guidance is available and a critical contribution is Sabbioni, Brimblecombe, and Cassar's (2012) The Atlas of Climate Change, Impact on European Cultural Heritage. Drawing on these researchers' extensive experience in physics, environmental science and sustainable heritage, this followed the European Commission funded Noah's Ark project, the first international research project focussing on climate change and cultural heritage (2004–2007), which resulted in the publication of the atlas detailing the impacts of climate change on cultural heritage. Emerging risks to heritage are detailed and the research also provides strategies that can be put into place by heritage staff to prepare their sites for climate change impacts. A three year study funded by stakeholders including National Trust, English Heritage and Historic Scotland was also published (Cassar and Hawkings 2007). Presented as 'the first broad based research on the impact of climate change on historic buildings, buried archaeology, parks and gardens' (Cassar and Pender 2005, p. 610), it researched the effects of wetting and drying of historic masonry in a variety of conditions; the report provides solutions in the event of a weather event taking place and also advice regarding mitigation. In agreement with existing arguments from Historic England (2015), UK Climate Risk (2021), Bertolin (2019) and Curtis (2016), maintenance and regular monitoring are confirmed to be most critical (Cassar and Pender 2005 p. 615).

If adaptation is not routinely being carried out, we must understand the barriers. It appears that there is less interest in financing maintenance work than in being involved in a rescue operation post extreme weather event as Nigel Dann and Timothy Cantell (2007) noted: 'maintenance may be less exciting than a makeover and less glamorous than a heroic rescue…but maintenance is the most sustainable and suitable way to manage historic buildings' (p. 185). In his paper relating to water management and traditional buildings, Roger Curtis reflects that while there are detailed rules and policies in place with regard to the construction of new buildings, there is little in place when it comes to protection for historic buildings (Curtis 2016, p. 5). Regular repair and maintenance is a must but sadly often overlooked (Curtis 2016), with flood risk management in particular marked as an essential part of a heritage site's management programme (Historic England 2015). Expected heavier intensity of rainfall means that with increased surface water and loading on roofs (Mintzer 1987; Brimblecombe et. al. 2011) this must be an area for continued monitoring and assessment. The biggest area for consideration in site policies and management is the care of drainage systems which may not be able to cope with increased precipitation in the future (Cassar and Pender 2005; Sabbioni et al. 2009; Curtis 2016; Brimblecombe et. al. 2011). Helen Phillips (2015) wrote that there was a large gap in knowing how to prepare cultural heritage for climate change, with Fatorić and Egberts (2020) in agreement in 2020. In 2022 the Climate Change Committee wrote of adaption planning at heritage sites still lacking consideration of thresholds so it appears that whilst this is an area of concern and debate, little action is still taking place to prepare cultural heritage for the climate changes that are coming.

3 Methodology

To understand the impact of flooding on heritage sites and to be able to analyse preventative measures taken by sites which have experienced such impacts, it was decided to obtain qualitative data via interviews. Gaining qualitative data for research purposes allows the researcher to understand the lived experiences of the participants (Dworkin 2012), and to uncover the reasons that sit behind how and why that the events happened (Galvin 2015; Sutton and Austin 2015).

This research focused on heritage sites that have experienced flooding. This allowed the researcher to understand levels of preparation prior to the flooding happening and what preventative measures have been put into place post flooding event. If no additional preventative measures have been put into place, this would help the researcher to understand what barriers are in place preventing this. It is beyond the scope of this research to investigate the impacts of climate change on heritage sites across the whole of the UK, therefore sites were selected within a reasonable travel distance for the researcher. Dworkin (2012) acknowledged that the amount of funding budgeted for the study is a consideration for case study selection. This new research is unfunded and due to time and travel considerations, the researcher decided on six interviews to be held to generate sufficient date.

England and Wales have a listing system for heritage sites which includes Grade II, Grade II* and Grade I. The researcher contacted sites which had a listing status, apart from site three which was selected due to the severity of the flooding it had experienced. The sites selected were also within a reasonable travel distance from the researcher's base and had experienced flooding within the last 20 years. The researcher ensured that the sites selected for interview would provide a varied scope of size, background and management (Table 1).

It is important to get a sample of the population (Creswell and Guetterman 2020) and it was felt that the sites selected would give a good range of organisational backgrounds. The sites also had different levels of experience and funding available for flood prevention and

Table 1 Details of the sites visited and interview participants

Site Number	Site Descriptor	Date of Visit	Format of Visit	Number of Participants	Participant Length of Time at Site
1	Grade I listed, 12th century building. World Heritage Site.	Wednesday 20th July 2022, 12 pm	Face to face	1	35 years
2	Grade I listed building with Grade I listed gardens, dating to the 16th century. In private ownership.	Tuesday 26th July 2022, 2 pm	Face to face	1	28 years
3	Museum and Visitor attraction.	Wednesday 27th July 2022, 9.30am	Teams virtual meeting	1	18 years
4	19th century Grade II* listed building with Grade II* listed gardens.	Monday 1st August 2022, 12 pm	Face to face	1	4 years
5	19th century Grade II listed building on a site with 19th century Grade I listed house.	Wednesday 3rd August 2022, 1 pm	Face to face	3	14 years 9 years 3 years
6	18th and 19th century Grade I and Grade II listed buildings. World Heritage Site.	Tuesday 16th August 2022, 1 pm	Face to face	2	2 years 1 years

dealing with the aftermath of flooding taking place. After site selection and interview booking, an important consideration was that the person attending the interview would be in a position to provide the required data (Rowley 2012; Creswell and Guetterman 2020). All participants had worked at their site at the time of the flooding.

4 Results

4.1 The sites

All sites visited are based on or near a river and are threatened by flooding. The face to face meetings allowed the researcher to explore the site to increase familiarity and knowledge. The meeting with Site 3 was held via Teams, however the site is one that the researcher has visited on several occasions and is very familiar with.

The results below are sectioned according to the question format of the interview. The images in each section detail each question asked and the answers provided by the sites.

4.2 The weather event

- The sites were asked how flooding has changed since 2002. Two participants confirmed it has stayed the same, with four confirming it has become worse.
- Four sites were unsure of any flooding happening at their site prior to 2002, while two sites were able to confirm that flooding had happened prior to that date (Fig. 1).
- Most sites had seen the regularity of flooding increase since the participants began working there. A variety of causes were confirmed for the flooding that took place. The varying causes of flooding were reflected in the damage caused to each site. The resulting repairs are also therefore accordingly varied (Figs. 2, 3 and 4).
- Four sites confirmed they did not have a flood prevention plan in place prior to the flooding. One site confirmed that there was a plan in place, with one site being unsure.
- This was followed by querying whether the site had a flood prevention plan in place now that they had experienced flooding. Three sites said no, two said yes and one was unsure (Fig. 5).
- The next question was whether any flood prevention plan related solely to the specific site or, if applicable, to the organisation that ran the site. Two sites said the plan was specifically for their site, the remaining four sites were wither unsure or there was no plan in place.

The majority of sites had no prevention plan in place prior to the flooding, with half having no plan in place now. Where there is a plan in place, where relevant, it is specific to the site in question. More than half the sites confirmed that despite a lack of prevention plans being available they were prepared to handle the flooding that occurred.

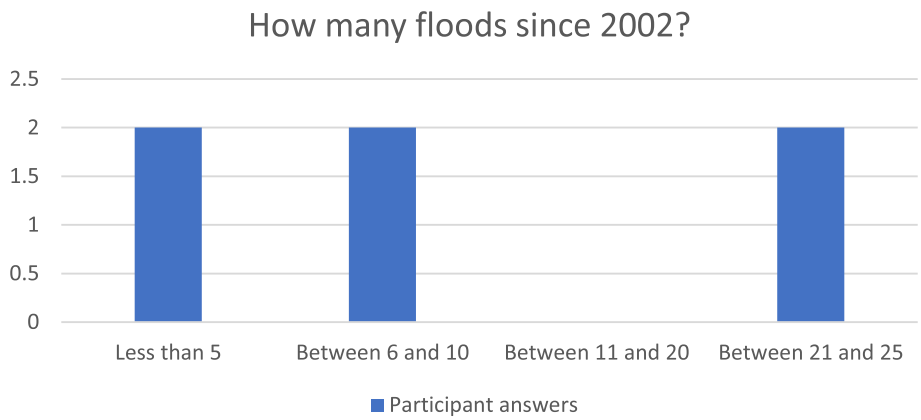

Fig. 1 How many floods since 2002

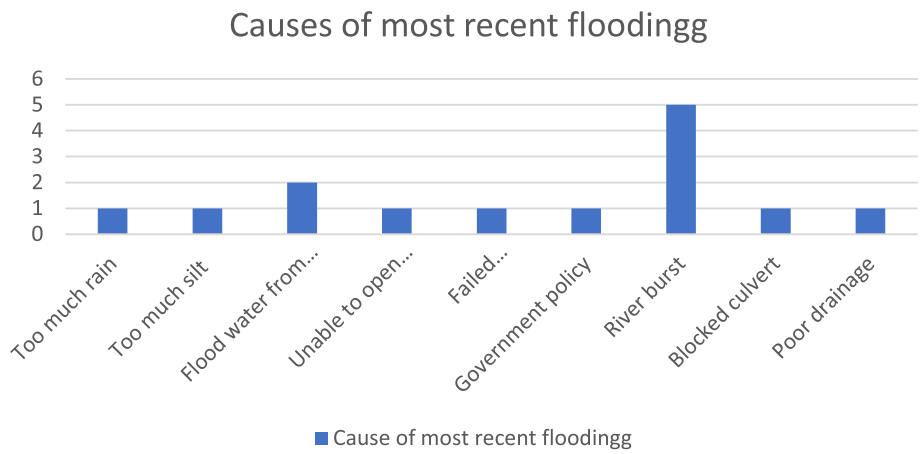

Fig. 2 Causes of most recent flooding

4.3 Planning ahead

- The sites were asked if they had a preference for green or grey infrastructure. Two sites preferred green, two preferred grey and the remaining two had no preference. (Green infrastructure = working with nature to combat climate change, using an ecological framework. Grey infrastructure = human engineered infrastructure.

- Each site was asked whether they currently had a climate change policy in place; four sites confirmed that they did not, with only two confirming that they did. Of the two that did, one confirmed that the policy was solely for their site and not the organisation that ran them, while the second site confirmed that the policy was for both their site and their organisation.

There was no clear preference for the type of infrastructure to prepare sites for future flooding events. There were a variety of opinions of how best to mitigate against future floods, with no common recurring theme. The majority of sites have no climate change policy in place; where there is such a policy, and where relevant, the majority of them were for the managing organisation and not for the specific site. All sites believed

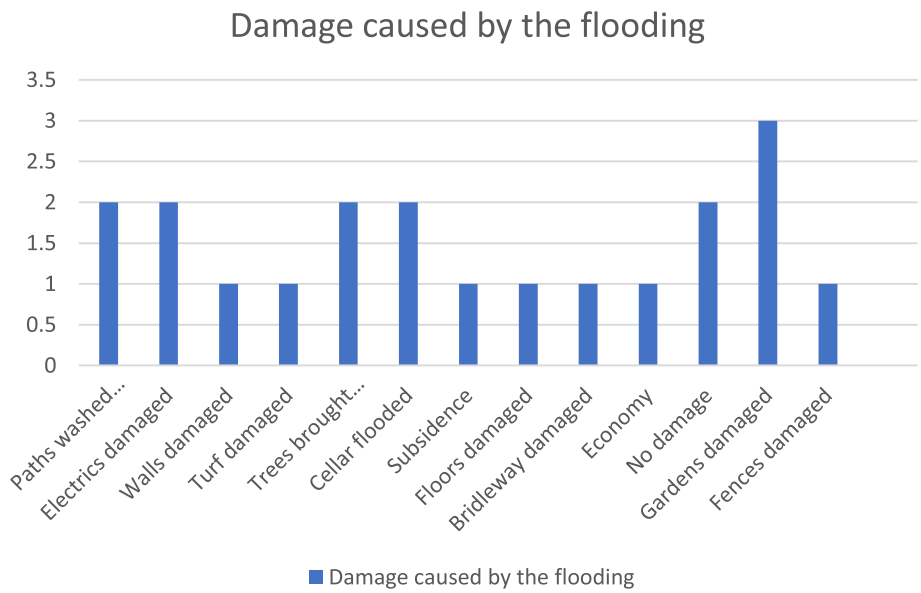

Fig. 3 Damage cause by the flooding

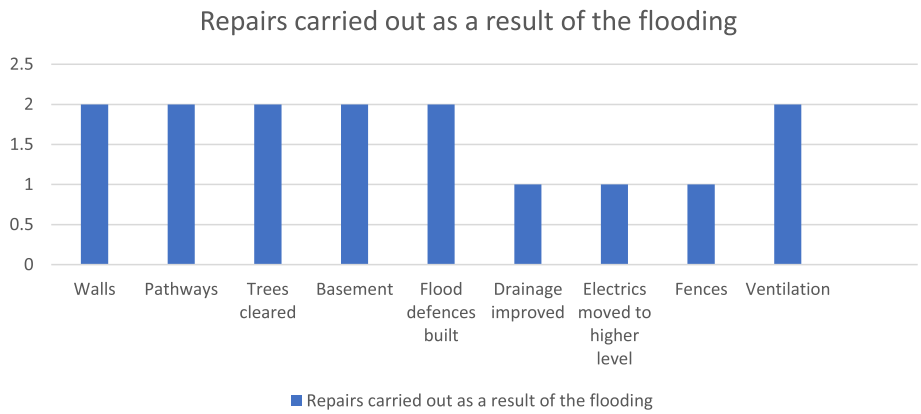

Fig. 4 Repairs carried out as a result of the flooding

flooding to be the greatest future risk to their site from climate change, with half having concerns about the impact of heatwaves. None of the participants believed that their site was ready for the future impacts of climate change (Figs. 6, 7 and 8).

4.4 Costs

When asked about the amount of revenue lost from the site closure, one site confirmed it was less that £5,000 with a second site confirming they suffered no revenue loss. The remaining four sites did not know how much revenue had been lose (Figs. 9 and 10).

As can be seen, some sites received funding from more than one source (Fig. 11).

- Asked whether a public contribution fund has been set up, 50% of the sites confirmed yes, with 50% confirming no.
- Asked whether site insurance had paid for any flood related costs, two sites confirmed yes with the remaining four confirming no.
- The final question related to whether site insurance would pay out in the event of any future flooding. Four sites confirmed it would not. One site was unsure with the remaining site not having insurance in place, thus an insurance pay out not being a possibility.

There were varied costs for cleaning up and repair work after flooding at each site. Most commonly, the sites were

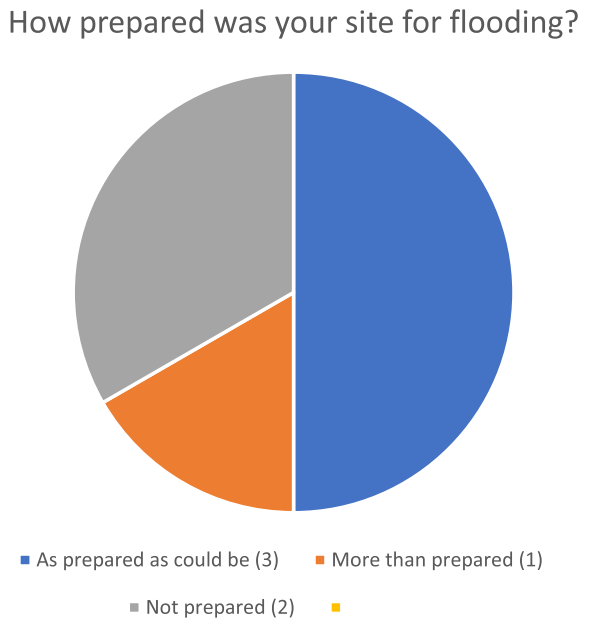

Fig. 5 How prepared was your site for flooding?

closed for less than a week. The majority of participants were unsure about how much money their site had lost through being closed. There were various sources of funding available to the sites. All sites except one currently have insurance in place. Most sites had not had an insurance pay-out for flood related costs and none of the sites were able to state that their insurer would pay for future flood defences.

5 Discussion

The data produced from this new research both complements and challenges existing ideas about the impacts of climate change on heritage sites. This new study confirms the prevailing view that more research is still required (Sesana et al. 2020; Fatorić and Egberts 2020). Analysis here demonstrates that much of the existing advice that sites can work with has not yet been followed through despite public weather warnings being increasingly used and the advances in forecasting of river flooding in recent years (Parker 2017). This new data supports predicted problems that increased rainfall will bring, and provides deeper understanding of the continuing lack of adaptation of heritage sites. While it has been acknowledged that work to prepare sites for climate change is underfunded and under resourced (Sesana et al. 2018), the participant perceptions indicate that these are not the sole barriers to adaptation.

Historic England's (2015) Flooding and Historic Buildings, warned of the likely increase in flooding due to climate change and stressed the importance of sites preparing themselves. Each site interviewed for this research flooded after the preparation of this guide, nonetheless it was confirmed that of the six sites, only one had a plan in place prior to flooding of their site and only two

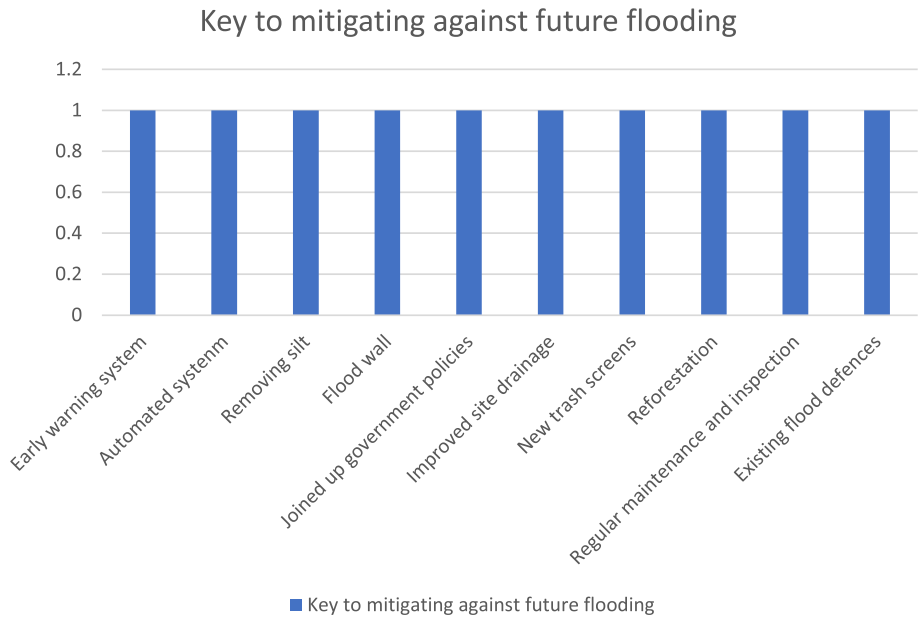

Fig. 6 Key to mitigating against future flooding

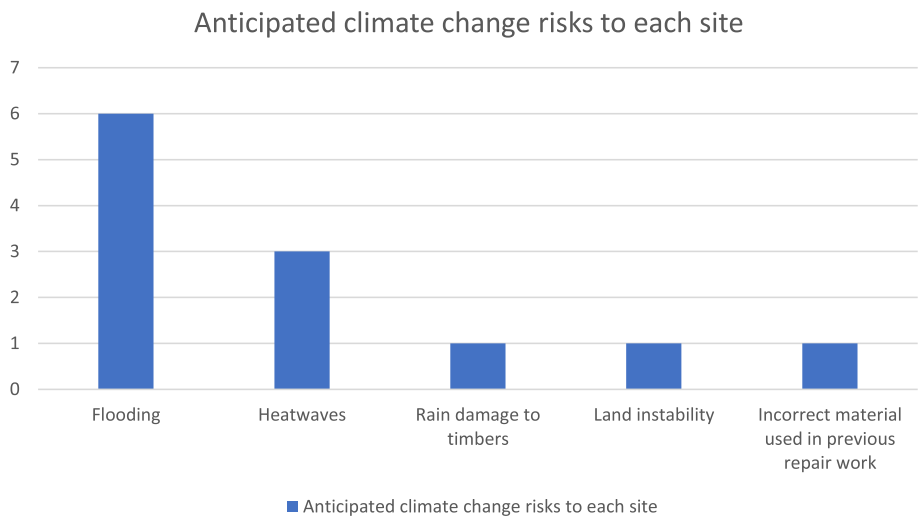

Fig. 7 Anticipated climate change risks to each site

have a flood plan in place now. The National Heritage List for England currently holds over 400,000 properties (Historic England 2022). Given the small sample of case studies in this new research, extrapolating the results to include all properties on the list must be taken with a degree of caution, however, it could suggest that 332,000 historic sites have no flood plan in place. Most of the sites (five out of six) reported the cause of their flooding to be the nearby river bursting its banks. Many sites on the National Heritage List for England may not be situated near rivers. However the potential for flash flooding and surface water runoff will increase as a result of increased temperatures (Broecker 1975; Bertolin 2019) and more intense rainfall (Jamieson 1992). Few sites should consider themselves immune to future flood impacts and the sites selected for this research have provided important insights into the potential large volume of properties unprepared for the flooding that climate change may bring in the future.

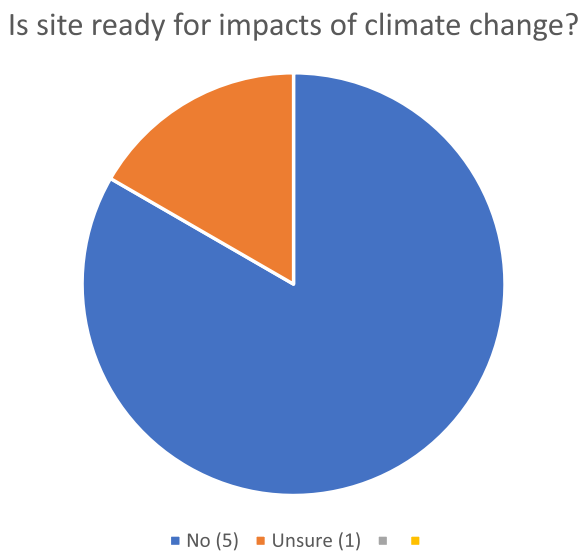

Fig. 8 Is site ready for impacts of climate change?

This new data adds new evidence that historic sites which were created for climate at the time are now showing damage due to changes in the climate that have already taken place. Sites Two and Four reported that trees, up to 250 years old, originally thrived but are now starting to die. Site Two confirmed that 'We've got 15 mature trees we have to take out as they're dying….. which shows this is a modern phenomenon'. Referring to 'the historic trees in the listed garden', planted two hundred years ago, Site Four reported that these once healthy trees are also now starting to die. Until such time as climate change effects are mitigated, this damage will continue and heritage which is being weakened as a result may ultimately have to be permanently removed.

Constraints imposed by English Heritage were perceived to be excessive, with Site One commenting 'By rights they're [English Heritage] only supposed to be in charge of the walls but they have so much say over the precinct itself' and reflected that when it came to proposed preventative measures, 'big permissions' needed to be obtained. The site also reported that 'you've got to jump through too many hurdles', making some suggestions an impossibility. With respect to improving the drainage of the site, Site Four commented that 'We would be very limited to putting in more drainage here as you would have to dig parts of the site which

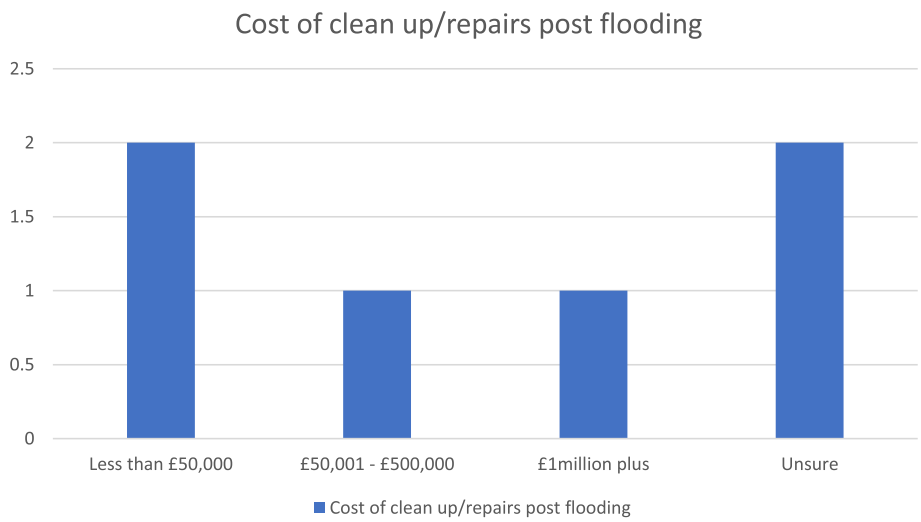

Fig. 9 Cost of clean up/repairs post flooding

we wouldn't want to do for heritage reasons'. Site Five referred to 'constraints from Historic England' when it came to replacing historic single glazed windows with newer double glazing for energy efficiency reasons: the suggestion was 'just dismissed as we're Grade I listed and it has to be replaced like for like'. At Site Six, evidence of restrictions on climate change mitigation measures was also reported when the participant discussed sourcing solar panels designed as clay tiles to fit with the aesthetic of the buildings. However 'Talking to Historic England we could only use that on new builds, we couldn't use it on existing historical fabrics'. Five of the six sites interviewed reported restrictions on what they can do to prepare their site for climate change due to the influence of outside agencies. The European Commission (2012) and UK Climate Risk (2021) have both called for more collaboration between parties however this emerging trends from this research suggest that the rules and regulations are now too stringent to allow capacity for adaptation in the face of the looming climate change impacts.

The principles applied when selecting heritage sites for listing 'plays a vital part in safeguarding this [architectural and historic] legacy' (UK Government 2018), however they appear to be at odds with climate change mitigation which is necessary for such safeguarding to be effective. Site Two is a Grade I listed building in North Wales. Currently, Grade I buildings make up less than 2% of listed

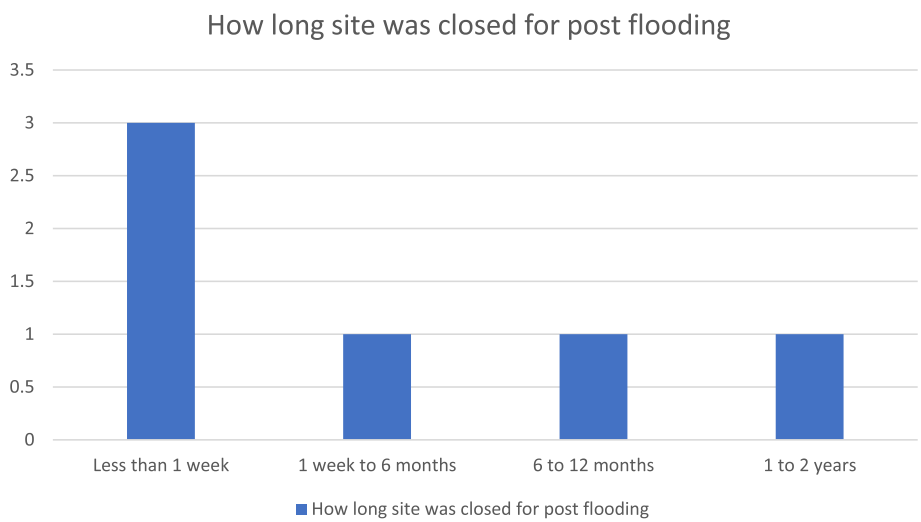

Fig. 10 How long site was closed for post flooding

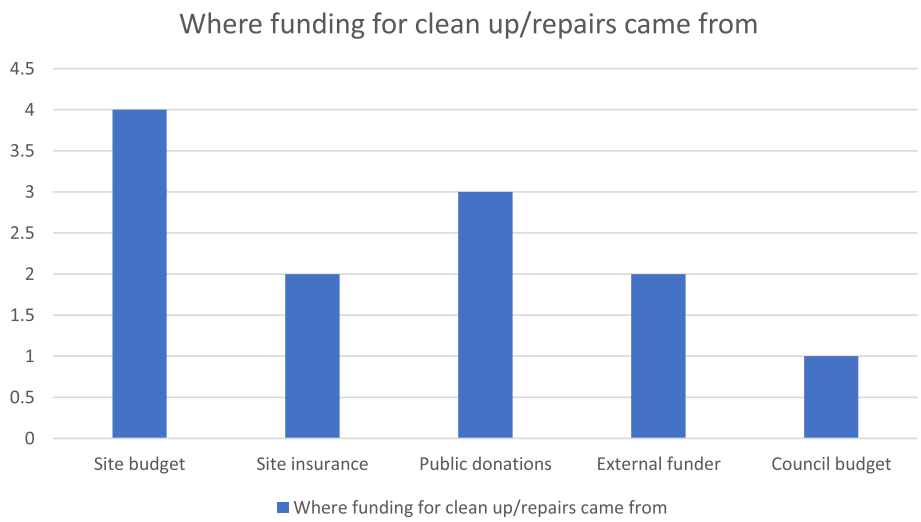

Fig. 11 Where funding for clean up/repairs came from

buildings in Wales (Cadw 2018, p. 6). One of the general principles applied for listing selection is that of age and rarity. With heritage of its nature a rarity in Wales, and with the listing status having been applied to safeguard this material fabric, more should be being done to prevent the flooding and future damage. Another general principle is that of aesthetic merit. Site Four is a Grade II* listed garden landscape where 250 year old trees are dying due to climate change, along with their modern replacements. For both heritage and aesthetic reasons, no alternative trees are allowed to be planted. The original trees, Cedars, are not thriving in the landscape of the 21st century due to climate change impacts on the ground they were planted in and as more die, the aesthetic value of the garden will diminish. If the historic gardens were not listed then whatever the managers chose could be planted in them; replacing like for like is resulting in trees that do not thrive. Listing is in place to safeguard heritage. Heritage is demonstrably under threat from climate change, both now and in the future. Modifications are being suggested by the sites to allow adaptation yet being declined due to being listed. The UK Secretary of State is responsible for applying the guidelines and principles as found in Principles of Selection for Listed Buildings (UK Government 2018, p. 3). The publication currently has no reference to climate change. Listing heritage is important to afford protection; the inclusion of a site is a reflection of its significance and importance. And yet, conversely, when it comes to affording the protection these sites need to mitigate against the known impacts of climate change, a concerning trend from the case studies is the very fact of their listing is what appears, to be prohibiting much of the suggested adaptation works.

Site Six reflected on the delays in being provided with up to date details of what will be acceptable when it comes to preparing heritage sites for the impacts of climate change: 'UNESCO and ICOMOS are still discussing what's going to be acceptable at World Heritage Sites as far as changes, for example the flood doors' and also that 'Historic England are still figuring out what they'll accept on a heritage site.' Damage caused by delays in decision making was highlighted in the 1980's (Sinclair 1987; Schneider 1989) and yet decisions are still to be made as to what is permitted. Cassar and Pendar (2005) made the observation that planning in the heritage sector takes longer that elsewhere, a sentiment echoed by Site Six who noted 'I'm sure you'll appreciate nothing moves fast in heritage.' The policy collisions between organisations and heritage professionals working at heritage sites must be addressed. If the impact of climate change on heritage sites is to be tackled then this research suggests a starting point should be to speed up the discussion and communication of what adaptation infrastructure is allowable. With the impacts of climate change on heritage being known for over thirty years (Editors 1991), and target action dates moving closer, decisions to allow site adaptation must be made now.

This new research confirms the concern that previous repair work is contributing to damage to cultural heritage (Forsyth 2007). Site Five is already experiencing problems caused by the use of incorrect building materials forty years ago, with gypsum and concrete used instead of the more appropriate lime mortar. They reported that these incorrect materials do not allow rainwater to evaporate; instead the water seeps into the timber fabric which is causing the timbers to age at an accelerated pace. When planning ahead for adaptation purposes to minimise

damage from future flooding at other sites, these resulting damages should be taken into account when creating a flood awareness plan. A focus for future study needs to be an appraisal of inappropriate use of materials in historic repair work to understand the extent of the problem. With its experiences of repeated cycles of flooding and drying out, site five suggests a particular direction for future research: that of the specific effects of this in the wider research in the area of the impacts of flooding on the 20th century repair work on built heritage.

With lack of funding a recognised problem in preparing heritage for climate change (Otero 2021), this research demonstrates that where funding comes from is a concern for heritage sites. Cassar and Hawkings (Cassar and Hawkings 2007) reported that insurers may amend or even withdraw cover altogether as climate change impacts worsen (p. 147). Analysis of this new data confirms insurance is unlikely to fund adaptation. None of the sites could confirm that their existing insurance would cover the cost of adaptation to prevent future flooding; four knew it would not, one was unsure and with one site having no insurance it is clearly not an option for them. Only two sites confirmed that they had received funding from their insurers towards the cost of clean-up and repair work. Thus four of the sites had to produce the funding themselves and/or ask the public to contribute towards the cost. Many sites that will experience flooding in the future due to climate change will not be in a position to fund repair work themselves which leads to the important question of where the money will come from. It is already recognised that the cost of adaptation will be less that the cost of repair (Clark 2003). It is beyond the scope of this research to implement suggestions as to where funding for flood prevention measures should come from, however this is clearly an area requiring further study.

This new research argues that responsibility for preparedness of individual sites for climate change needs to lie elsewhere and not solely with the site itself. Among the contributing causes of delay in site adaptation are slow planning timescales (Cassar and Pender 2005) and heritage not having sufficient funds or manpower to implement what is required (UNESCO 2006; ICOMOS 2022). This research confirms these existing theories however it also contributes new information which adds a further insight into why the work is not being carried out. Outside restrictions and influences have been highlighted through this research as contributing factor to the delay. With influences from English Heritage and Historic England, many proposed mitigation works cannot be implemented. This research suggests that individual sites themselves are failing to take responsibility for certainly some of the initial planning work that needs to take place. Four of the sites interviewed do not have a climate change policy and it was discovered that only two of the sites, despite having experienced flooding, currently have a flood prevention plan in place. If responsibility for working to prevent future flood impacts does indeed lie locally, it is not being acted upon. Phillips (2015) wrote that cultural heritage was not prepared for the impacts of climate change and this new research confirms that this is still the case today. With potentially thousands of other heritage sites on the National Heritage List for England not having an existing plan in place, if responsibility is not being taken locally then the challenge remains of who should ensure heritage sites are putting plans into place to protect themselves.

There are several scales of responsibility for heritage that need to be taken into consideration. There are heritage sites in private ownership, maintained by local authorities and also those run by archaeological and conservation charities. The National Heritage List for England is maintained by Historic England (Historic England 2022). Ultimate listing decisions come from the UK government (UK Government, 2018). Historic England confirmed that mitigation and adaptation work is approved by local planning authorities (B. Bishop, personal communication, 25th August 2022); as evidenced by this study, while some local authorities are focusing on tackling climate change, others do not currently have it on their agenda despite the National Planning Policy Framework advocating for green infrastructure to reduce impacts of flooding. Some local authorities do not even have conservation officers. This research demonstrates participants' desire to protect heritage from the future impacts of climate change. However, there are no central decisions yet made about what is acceptable. There is no one body ultimately responsible for ensuring heritage sites are preparing for climate change, and with these scales and layers of responsibility, climate change impacts which are already happening will continue to affect heritage sites.

6 Conclusion

Existing research into climate change impacts is already available documenting future challenges, and providing recommendations to enable sites to carry out adaptation in readiness for climate change (Cassar and Hawkings 2007; Sabbioni et. al. 2012; Sesana et al. 2018). This new research has demonstrated that heritage which has already experienced flooding and its after effects is still not ready for climate change. This new research has approached the situation from a new and innovative perspective, by focusing on flooded sites to understand the problems they and others will face. In doing so, new contributions to the issue of climate change and heritage have been made. From this new data, predictions can

be made about what will happen to heritage sites and to understand what challenges they face, allowing changes to be made now.

This research has confirmed that few heritage sites have a flood prevention plan in place with a wider implication of this being the scale of heritage properties that will be in a similar situation. Many sites will not be in a landscape where they consider flooding from rivers or coastal areas a future problem. However with the potential for flash flooding and surface water runoff increasing, few sites should consider themselves immune to future flood impacts. With individual sites not necessarily being able to take responsibility a focus needs to be on where such responsibility should ultimately lie.

An important area to emerge from this study is clear evidence of existing climate change damage to heritage, with historic structures built for the climate at the time (Cassar and Hawkings 2007; Brimblecombe et. al. 2011) and of predicted future areas of damage for sites. This contributes new data to concerns that changes have already happened to the climate. Predictions of future damage to heritage from flooding have also been confirmed from this research. Phillips (2015) stated that adaptation will be best be managed by understanding the vulnerabilities of each site. This is confirmed by this new research, providing a clear focus for sites to pay attention to when they are implementing regular maintenance checks and their own flood plans. It has also highlighted an existing concern about damage that historic repair work is causing in the face of increased rainfall (Forsyth 2007). Future research should explore the extent of the problems that this will cause so appropriate and relevant mitigation work can be carried out.

This research has shown that with damage already being caused to heritage, and preparation for climate change still to become a focus, the inevitable acceptance of loss may need to be a reality. Funding restrictions, insurance policies not providing for mitigation works and restrictions from management agencies are suggested by this research to be combining to stop adaptation being carried out. It is already recognised that loss will happen (Sabbioni et. al. 2012; Harrison et al. 2020; UK Climate Risk 2021) and perhaps this could be turned into an opportunity. The process of Adaptive Release (Desilvay et al. 2021) accepts some decline may be necessary and allows for curated management of the process. The authors' recognise the need for a trial period of the process and given the data from the case studies, there would appear to be many heritage sites where such a trial may be welcomed. Allowing management to make informed decisions and to be able to manage decline where adaptation does not appear to be an option may be the best solution for that site.

Data produced by this research has provided new evidence that site insurance and external factors are key barriers to adaptation. External factors were identified with sites being restricted in what they can do to mitigate by, for example, Historic England and English Heritage. While discussion continues to centre around what sites may or may not be able to do, limited solutions can be implemented. There is no time left for deliberation and inactivity.

The future potential for the results of this study are twofold. The first area of focus from this new research is the damage that is being caused while waiting for heritage management to make decisions about what can be done as adaptation and mitigation. While those in charge of heritage management continue to deliberate over what is allowable with regards to preventative works, more damage will be caused. With clear evidence that damage has already occurred, sites are proposing appropriate mitigation which is thus far being denied on the grounds of not appropriate for heritage sites. This new evidence shows that people are thinking about it, but limitations and barriers around mitigating infrastructure must be overcome to allow sites to rise to the challenges they face. It can be argued that the listing status of heritage is contributing to lack of adaptation. Alternatives must be allowed to be considered.

The second focus area to emerge from this research is the question of where the necessary funding for adaptation should come from. Many smaller sites will not have the funds to pay for mitigation work. The size of public contributions when online donations were requested is generous; if visitors are made more aware of the future impacts through climate change there may be even more willingness to contribute to the sites they have been demonstrated to be very sympathetic to. However given the high costs of repair work, despite being more expensive than mitigation work this may not be sustainable long term (Clark 2003; Naylor 2022). If prevention is unaffordable – if adaptation cannot be carried out—then the resulting damage from climate change may be unavoidable.

Abbreviations

ICOMOS	International Council on Monuments and Sites
UCAR	University Corporation for Atmospheric Research
UNESCO	United Nations Educational, Scientific and Cultural Organisation

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University of Chester Ethics Committee approved the research. All participants were provided with appropriate documentation and confirmed their willingness to participate.

Consent for publication

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Competing interests

There are no competing interests.

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