A20: Scalable approaches to moisture risk assessment for historic buildings in a climate-changed era

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Abstract

In response to global warming, climate change risk assessments for cultural heritage should be applicable not only to iconic sites but to all historic buildings. Risk assessments should function at the material, site, and regional scale. Increasing days of heavy precipitation will have severe impacts for historic buildings, for example stressing rain-water goods. To evaluate this hazard, changing occurrences of extreme precipitation events have been calculated for the UK with 1.5 °C and 3 °C of warming using the National Severe Weather Warning Service thresholds. By integrating the materials of the over 380,000 listed buildings in England, this assessment explores how moisture damage processes can be translated to thousands of sites, informing regional prioritisation.

Keywords: historic environment; climate adaptation; moisture risk; climate mitigation; regional risk assessment

1. Introduction

Climate change will have drastic impacts on the historic environment from increasing risk of damage to complete loss. When considering moisture risk for the historic built environment there are multiple scales at which assessments can function: the molecular scale, for example when investigating the impacts of relative humidity fluctuations on salt mixtures [1]; the material scale, when looking at interstitial mould growth [2]; the building scale, for example when taking a whole building approach to retrofit [3]; and finally a multi-building scale where multiple sites are assessed together [4]. While each historic building is unique and regional assessments will always be limited by the quality and coverage of historic records, there is also a need to be able to identify areas and

heritage types that are particularly impacted by climate change, now and in future. The risk framework used here is that of the Intergovernmental Panel on Climate Change (IPCC) from the sixth assessment report, in which risk is represented by the combination of hazard, exposure, vulnerability, and response [5]. The hazard analysed is increasing heavy precipitation days communicated through changing occurrences of weather warning levels currently issued by the UK Met Office. The Met Office is the UK's national meteorological service and is responsible for the National Severe Weather Warning Service (NSWWS) which issues warnings – yellow, amber, or red – when weather thresholds are likely to be exceeded. These warnings are a combination of likely impact based on extreme hazard thresholds (very low to high) and likelihood (unlikely to very likely). These thresholds are used to determine future occurrence of high impact rain days, combined with the material composition of historic buildings (vulnerability), and the density of historic building locations (exposure).

2. Methodology

Days when precipitation (mm/day) exceeds the thresholds for low, medium, and high impact have been calculated for 1.5 °C and 3 °C of warning using the UK climate projections (UKCP18). Using nationally recognised weather thresholds aims to make the effects of climate change more easily communicable. The hazard of extreme precipitation events has then been linked to the materials present in the over 380,000 listed historic buildings in England to identify how vulnerable heritage buildings are to changing precipitation events. This material information is collated by Historic England from the description on the National Heritage List for England (NHLE) at the time of listing and uses a controlled vocabulary to standardise the terms.

3. Results & Discussion

The impact thresholds for rainfall in a 24 period are low (≥ 25mm), medium (≥ 50mm), and high impact (≥ 80 mm) [6]. In the baseline period (1980-2009), across the UK there are 1665 low impact days per year, increasing to 1705 days with 1.5 °C and 3 °C degrees of warming. Medium impact days also increases from 181 in the baseline period to 219 with 1.5 °C of warming, and 275 with 3 °C. High impact days occur 11 times in the historic period and with 1.5 °C, but increase to 31 days per year with 3 °C of warming. Primarily these days occur on the westerly side of the country with the highlands of Scotland, central Wales, Cumbria, and Cornwall in England as the most impacted regions. By examining the construction materials of listed buildings on the NHLE, the vulnerability of England's historic building stock to increasing heavy rain can be determined (the materials are not known for Wales, Northern Ireland, and Scotland).

There are 225 distinct materials across the 380,000 buildings on the NHLE; the most common are brick (15% of buildings), followed by tile (10%), stone (10%), slate (8%) and timber (7%). One example for how material classifications can determine vulnerability to water ingress is by identifying buildings with external coatings which act as protective barriers to multiple climate conditions but particularly wind-driven rain and extreme precipitation. By isolating buildings with 'render', 'plaster', 'roughcast', 'pebbledash', 'stucco', and 'lime' (if the others are also used) as listed materials, it can be determined that over one in four listed buildings (29%) have some sort of external coating. Furthermore, 78% of cob buildings – a traditional building material used in the south-west of England where precipitation is increasing – are rendered and by isolating earthen buildings which do not have renders, buildings most likely to be impacted can be isolated. The efficacy of the render does depend on its composition, its current condition, its age, and position on the building fabric, and this is unknown; however, knowing the material combinations for all English listed buildings can create a comprehensive assessment of building sensitivity to climatic hazards.

The increase of medium and high impact rainfall days is especially concerning for historically significant buildings where rainwater goods may be overwhelmed leading to increased water penetration. By using the thresholds of the NSWWS, the aim is to communicate more clearly the change caused by increasing global temperatures. Yellow, amber, and red weather warnings have been used since the 1980s to warn the public of high impact weather and are part of current decision-making processes [7]. Connecting this hazard to the material composition of all listed buildings in England expands current risk assessments to establish the overall vulnerability of historic building stocks meaning that research on single material types can be applied to all relevant listed buildings. By prioritising areas where high impact rain days are increasing with climate change, the profiles of building types can be established and buildings more exposed to precipitation can be isolated, with the aim of informing heritage policy and management.

4. Conclusion

Preparing for the impacts of climate change on the historic environment requires a flexible approach where both the opportunities and limitations of scalable assessments are recognised. There are hundreds of thousands of historic buildings in the UK with one fifth of English homes built pre-1919. While all buildings will have unique challenges, such as the current condition of the materials, single site assessments cannot account for the total impact of climate change on the historic environment. By looking at the building systems represented through the materials of the over 380,000 listed buildings in England, with a UK-wide assessment of how low, medium, and high impact rain days increase with 1.5 °C and 3 °C of warming, this paper explores both how to communicate climate change and the risks posed for the historic built environment on a national scale.

5. References

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