Climate change and the challenges for cultural heritage preservation

Rohit Jigyasu | UNESCO Chair, Institute of Disaster Mitigation for Urban Cultural Heritage, Ritsumeikan University, Japan | rohit.jigyasu@gmail.com
Xavier Romão | Faculdade de Engenharia da Universidade do Porto, Portugal | xnr@fe.up.pt

Recent years have witnessed an increase in the frequency and consequences of extreme weather-related events. These events have been documented and examined by many and there is still an intense debate among scholars and in the media about the true source of the increasing socioeconomic impacts of such disasters (e.g. see Strader et al., 2017; and references therein). Still, one can easily accept that weather-related disasters depend on both climate and socioeconomic conditions. And both appear to be changing.

Climate change is defined by the Inter-governmental Panel on Climate Change (IPCC) as "*a change in the State of the climate that can be identified (*e.g. *using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer*" (IPCC, 2007). Nevertheless, climate change encompasses more than a worldwide trend of rising temperatures or "global warming". It includes changes in regional climate characteristics such as humidity, rainfall and wind, and with that comes the expectation of an increasing in the frequency of extreme weather events that may have physical, social and economic impacts (Archer van Garderen, 2010).

Climate change is therefore expected to affect disaster risk through complex interactions with its components: hazard and vulnerability. Our current level of knowledge indicates that the effect of climate change on hazards varies by hazard, by location, and by scale. Several studies refer that climate change can intensify or reduce some hazards, while having no effect on others (Hore *et al.*, 2018). As the result of a complex set of interactions, rising temperatures and changing rainfall patterns due to climate change can lead to an increase in temperature and a decrease in mean precipitation, which might then cause an increase in the frequency and severity of droughts and heat waves. Moreover, increasingly warm ocean surface temperature may generate more and stronger hurricanes, while facilitating the occurrence of floods in the aftermath. Sea level rise can cause coastal inundation while severe drought may lead to an increase in forest fires. As a result of these interactions, it can in fact be seen that many of these hazards can produce other secondary hazards.

As a whole, climate involves complex phenomena that make hydro-meteorological hazard projections challenging. Climate change increases these challenges by adding additional uncertainty: where will it happen and with what intensity? Indeed, the Swedish floods caused by intense snowmelt and the raging wildfires intensified by a long heatwave that occurred this year are unusual events in that country. In fact as unusual as this year's record-breaking rainfalls in South Africa, Kenya, Rwanda, Somalia, Japan and Nepal. In light of these uncertainand potentially extreme hydro-meteorological events induced by climate change, the inevitable conclusion should be to increase our level of disaster preparedness across all sectors of society. For the particular case of cultural heritage, apparently, much has still to be done towards fully grasping the impacts of climate change on cultural heritage and addressing short- and long-term challenges to enhance its preservation and/or adaptation (Fatorić and Seekamp, 2017).

Impacts of Climate Change on Cultural Heritage

Several initiatives connected to disaster risk management and sustainable development recognize the importance of cultural heritage, namely in shaping social capital, supporting education and learning, and contributing to growth and economic development. This recognition strengthens the need to assess the negative impacts that potential hazards may have on cultural heritage, namely those stemming from hazardous events induced by climate change.

1 | *View of the earthen structures of the World Heritage Site of Chan Chan, in Peru (WC, 2018a).*

Generally speaking, climate change-induced impacts typically include aspects such as sea level rise, floods, coastal erosion, changes in air and sea temperatures; changes in humidity, extreme weather events such as hurricanes, storms or droughts, and changes in soil and sediment conditions (*e.g.* see Fatorić and Seekamp, 2017; and references therein).

"As the result of a complex set of interactions, rising temperatures and changing rainfall patterns due to climate change can lead to an increase in temperature and a decrease in mean precipitation, which might then cause an increase in the frequency and severity of droughts and heat waves. Moreover, increasingly warm ocean surface temperature may generate more and stronger hurricanes, while facilitating the occurrence of floods in the aftermath."

2

2 | *View of the main portal of the Igreja Matriz de Vila do Conde damaged by erosion. © Esmeralda Paupério, 2009*

> **Among other steps needed to achieve these, both the development of realistic risk scenarios that use research-based adequate predictive modelling methods and the increase in the level of awareness about cultural heritage losses resulting from past disasters involving climate change related hazards are highlighted.**

These, of course, will have impacts on cultural heritage that depend on the type of heritage (archaeological, architectural, cultural landscape, objects, etc.) and on the specific attributes of that heritage that might be impacted (*e.g.* its tangible, intangible or social characteristics and values). For example, the physical impacts on built heritage assets might be related to the construction system or the nature of the construction materials (*e.g.* high winds or heavy rainfall can lead to a more severe erosion of earthen structures such as those of the Chan Chan archaeological zone in Peru (fig. 1), or of granite stonework such as that of the main portal of the Igreja Matriz de Vila do Conde (fig. 2)). These impacts may range from a more intense material degradation and weathering up to large levels of destruction, depending on the severity of the event.

The location of the heritage assets also plays a crucial role in defining their exposure to these events. For example, heritage located in low-lying areas along the coast or along rivers will be exposed to a substantially larger risk of sea level rise and flooding (*e.g.* the historical centre of Passau in Germany due to the 2013 floods of Central Europe) (fig. 3). Intense rainfalls may lead to more frequent floods, as referred before, but also to an increasing risk of landslides for heritage sites located along or close to mountain slopes. On the other hand, for heritage sites located in forest areas, the likelihood of a fire may increase significantly due to the occurrence of more intense and extended heat waves.

The increase in risk associated to these events can therefore be seen to depend on how the likelihood and the intensity of these events are changing due to climate change and on which attributes of the heritage are exposed. As mentioned before, the uncertainty in the likelihood and the intensity of these climate change-induced events calls for specific actions to mitigate their impacts.

The way forward: adaptation and planning

The influence of climate change in the shifting likelihood and intensity of certain hazards is inevitable. However, the importance of current vulnerability conditions on the overall disaster risks should not be overlooked. The effects of climate change on the potential increase of disaster-related losses cannot be ignored, but they should not downplay the role of other factors connected to how multiple sectors of society have been increasing their exposure to these threats. Acting on both sides of the disaster risk equation is therefore paramount. Still, actions on the side of vulnerability and exposure appear to be easier to accomplish since they can be implemented on a lower scale level. Generally speaking, these actions should facilitate a more effective adaptation to these changing conditions by developing efficient plans for disaster loss mitigation and emergency response.

To address the particular case of cultural heritage exposure and vulnerability, existing research has highlighted the need to use multidisciplinary approaches, as well as robust adaptation planning and decision-making tools (Fatorić and Seekamp, 2017; Fatorić and Seekamp, 2018). Among other steps needed to achieve

these, both the development of realistic risk scenarios that use research-based adequate predictive modelling methods and the increase in the level of awareness about cultural heritage losses resulting from past disasters involving climate change related hazards are highlighted. With respect to the latter, it should be noted that cultural heritage losses take on a multitude of forms, both tangible and intangible, as well as direct and indirect. Furthermore, since having an adequate knowledge about these losses is relevant for several disaster risk reduction tasks, namely for developing realistic risk scenarios (De Groeve *et al.*, 2014) and suitable heritage-focused disaster mitigation strategies, there is a need for comprehensive national and regional databases of cultural heritage loss and damage due to disasters.

Globally, adaptation planning related with hazards induced by climate change requires engaging in long-term risk management and taking actions to reduce risks and to capitalize on possible opportunities associated with these changes. For the cultural heritage sector, it involves analysing, selecting and prioritising measures in response to climate risks, targeting a reduction in the cost and extent of remedial actions, to preserve cultural heritage values (Perry and Falzon, 2014). However, there are no one-size-fits-all solutions. The level of priority given to each adaptation measure needs to account for the immediacy of the threat, the vulnerability of the site, but also for the financial constraints and the availability of other necessary resources. Adaptation is therefore an iterative process. Every measure needs to be monitored and reviewed as our understanding of climate risk changes or as priorities shift ■

REFERENCES

Archer van Garderen, E.R., Engelbrecht, F., Landman, W., Le Roux, A., Van Huyssteen, E., Fatti, C., Vogel, C., Akoon, I., Maserumule, R., Colvin, C. and Le Maitre, D.C. (2010) *South African risk and vulnerability atlas*. Department of Science and Technology, Republic of South Africa: Pretoria.

De Groeve, T., Corbane, C., Ehrlich, D., Poljansek, K. (2014) *Current status and Best Practices for Disaster Loss Data recording in EU Member States: A comprehensive overview of current practice in the EU Member States*. Scientific and Technical Research Reports. Report EUR 26879.

Fatorić, S., Seekamp, E. (2017) "Are cultural heritage and resources threatened by climate change? A systematic literature review". *Climatic change*, 142(1-2), 227-254.

Fatorić, S., Seekamp, E. (2018) "A measurement framework to increase transparency in historic preservation decision-making under changing climate conditions". *Journal of Cultural Heritage*, 30, 168-179.

Hore, K., Kelman, I., Mercer, J., Gaillard, J. C. (2018) "Climate Change and Disasters". In *Handbook of Disaster Research*. Springer.

IPCC (2007) *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC, Geneva, Switzerland.

Perry, J., Falzon, C. (2014) "Climate change adaptation for natural World Heritage sites: a practical guide". *World Heritage Paper Series* 37. UNESCO.

Strader, S. M., Ashley, W. S., Pingel, T. J., Krmenec, A. J. (2017) "Projected 21st century changes in tornado exposure, risk, and disaster potential". *Climatic change*, 141(2), 301-31.

WC (2018a) "Chan Chan, capital Chimu". *Wikimedia Commons*, https://commons.wikimedia.org/wiki/File:ChanChanCapitalChimu.jpg

WC (2018b) "Flooding of the historical centre of Passau, Germany, June 2013". *Wikimedia Commons*, https://commons.wikimedia.org/wiki/File:Hochwasser_Passau_2013-06-03.jpg

3 | *Flooding of the historical centre of Passau in Germany due to the 2013 floods of Central Europe (WC, 2018b).*