International Journal of Disaster Risk Reduction 19 (2016) 235–248

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

A proposed assessment index for climate change-related risk for cultural heritage protection in Newcastle (Australia)

Giuseppe Forino*, Jamie MacKee, Jason von Meding

School of Architecture and Built Environment, University of Newcastle, University Dr, Callaghan NSW 2308, Australia

ARTICLE INFO

Article history:
Received 14 March 2016
Received in revised form
9 September 2016
Accepted 10 September 2016
Available online 13 September 2016

Keywords:
Climate change
Cultural heritage
Australia
Disaster risk reduction
Risk assessment
Index

ABSTRACT

Worldwide, climate change is one of the main factors exacerbating the effects of hazards or generating additional risk. Investigation is required to understand climate change-related risks for all components of human systems, including cultural heritage. Accordingly, this paper aims to present a new risk assessment index for cultural heritage, referred to as the Cultural Heritage Risk Index (CHRI). The paper applies a desk-based review of the existing literature on climate change-related risks for cultural heritage and of multi-level policy and planning documents of cultural heritage management in Australia. The paper then presents the CHRI and describes its attributes based upon the formalisation of risk as a function of hazard, exposure and vulnerability. CHRI is applied to a unique asset of cultural heritage in Newcastle (Australia), the Burwood Beach Wastewater Treatment Works (BBWTW). The paper shows that this asset has a moderate risk related to climate change, and that some interventions can be applied to decrease its vulnerability. The use of a new index such as CHRI allows creating a baseline for the exploration of the relations between climate change-related risks and cultural heritage. It can be an effective part of tools assessing climate change-related risk on cultural heritage in Australia and might aid in prioritising specific interventions.

1. Introduction

Worldwide, climate change is perceived as a slow-onset process, dangerous for peoples and assets [54], which intensifies some of the hazards affecting social systems and weakens resilience in facing uncertainty and disasters [49]. While climate change and associated processes are fully embraced by disaster-related efforts, the United Nations Framework Convention for Climate Change (UNFCCC) and the United Nations Office for Disaster Risk Reduction (UNISDR) call for framing climate change within a disaster risk perspective [8,31]. The milestone document by IPCC 'Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation' [20] reports the likelihood of increased weather extremes in the future, suggesting that the number and the extent of weather- and climate-related hazards may increase [31]. The interaction of such hazards with vulnerable systems which have low adaptation capacity is expected to lead to severe and sometime irreversible impacts [50]. However, the extent for which damages and losses by disasters can be attributed to climate change is still debated and uncertain (e.g. [6,7,18,22,32,33,49,50,56]).

Among assets of social systems for which climate change poses a disaster risk, cultural heritage requires particular attention [10,25,31,39,41,48,59,60,69]. Cultural heritage represents the physical manifestation of past human activities and interactions with the environment, with different meanings for different individuals and communities [24,34,62]. According to Article 1 of the United Nations Educational, Scientific and Cultural Organisation Convention [67], cultural heritage includes moveable tangible heritage items such as paintings, sculptures, coins and manuscripts; immovable heritage such as monuments, archaeological sites and underwater cultural heritage such as shipwrecks, underwater ruins and cities; and intangible items such as oral traditions, performing arts and rituals ([67], see also [2]). These items indicate the 'valuable features of our environment which we seek to conserve from the ravages of development and decay' (Davidson, 1991, p. 1, cited in [34], p. 66). In this sense, cultural heritage enriches "people's lives, often providing a deep and inspirational sense of connection to community and landscape, to the past and to lived experience" ([29], p. 1). It has a historic, aesthetic, social, scientific or spiritual value for past, present, and future generations [39], and often represents the only remnants of people, historical processes or traditional events [62].

Therefore, decisions have to be made in some contexts about the degree of protection to be assigned to single or multiple cultural heritage assets [48]. While it can be argued that some assets

* Corresponding author.
E-mail addresses: g.forino@gmail.com (G. Forino), Jamie.mackee@newcastle.edu.au (J. MacKee), Jason.vonmeding@newcastle.edu.au (J. von Meding).

http://dx.doi.org/10.1016/j.ijdrr.2016.09.003
2212-4209/

need not be saved as they can be reproduced in other areas, or cannot be saved due to socioeconomic advantages, extremely dilapidated conditions, or limited interest by communities or governments, however there are examples of assets which cannot be reproduced or are highly significant in specific contexts [48]. Once destroyed, cultural heritage cannot be regenerated, duplicated, or reintroduced [24,34]. Therefore, protection of cultural heritage has to be promoted considering its intrinsic historic or artistic value, and the fundamental spiritual and psycho-social support and sense of belonging it provides to communities [31].

The fragile nature of some cultural heritage assets and the potential associated risk of damage, loss, collapse, or legal intervention mean that cultural heritage is exposed to climate change-related impacts [39,41]. A survey by the World Heritage Centre in 2005 among all States Parties to the World Heritage Convention found that 72% of the 110 received responses acknowledged that climate change had an impact on cultural heritage [31]. Climate change can affect cultural heritage through meteorology – (e.g., tornadoes, hurricanes and storms), hydrology – (e.g., sea level rise, inundation, floods, high tides, avalanches, and debris flow) and climatology – (e.g., extreme temperatures, wildfires, and droughts) related hazards [31,60,69]. These hazards can compromise the stability of buildings and monuments, alter or destroy the characteristics of materials, and modify the topography and vegetation of sites, settlements and landscapes [30,60]. Extensive analysis of pre-disaster circumstances and practices and of preparedness is therefore required to prevent climate change-related impacts on cultural heritage [30,39,48]. This analysis would allow the identification and assessment of such impacts and would be used as a baseline for specific strategies to be integrated into disaster risk reduction agenda [62,68,69], and for prioritising interventions on single or multiple cultural heritage assets.

The necessity of providing a risk perspective to climate variability and change in both the short and long term is a relatively recent topic within academia, policy, and practice related to cultural heritage [48]. In such perspective for cultural heritage, risk assessment methodology and tools can be considered as a helpful tool for establishing priorities and require more in depth investigation [31]. In fact, notwithstanding decades of experience, developing a risk assessment scientifically sound and flexible enough to be used by different users for single or multiple climate change-related hazards is still problematic for scholars, policy-makers and practitioners [50].

Against this background, this paper aims to present, to describe, and to discuss the framework and the attributes of the operational procedure for calculating the Cultural Heritage Risk Index (CHRI), a novel index that assesses climate change-related risk for cultural heritage. The paper builds CHRI using the formalisation of risk as a function of hazard, exposure and vulnerability [13,20,21]. The paper applies CHRI to the Burwood Beach Wastewater Treatment Works (BBWTW), a dilapidated cultural heritage asset in Newcastle, New South Wales, Australia. The paper is organised as follows. Section 2 contextualises climate change issues for cultural heritage in Australia. Section 3 defines risk assessment and its attributes, while Section 4 introduces and discusses the CHRI. Section 5 applies CHRI to BBWTW in Newcastle. Section 6 discusses the main findings from this application and concludes with some insights into future potential applications of CHRI in Australia.

2. Climate change and cultural heritage in Australia: is a stronger link between two scientific communities required?

Cultural heritage is an important physical manifestation of Australia's past [24] and an integral part of life today [16]. It underpins the Australian "sense of place and national identity and makes a positive contribution to the nation's wellbeing" ([16] p. 7), as well as reflects the large diversity of communities and landscapes [4,30]. Cultural heritage in Australia is among the assets of social systems which climate change poses at risk [41,51,57,58,63]. For example, bushfires of January 2016 have severely occurred on important Australian cultural heritage landscapes and related assets such as the Tasmanian World Heritage Wilderness, by burning trees and damaging bushwalking tracks [9]. Climate change has potentially serious implications for cultural heritage in Australia due to rising temperatures, changing rainfall, rising sea levels, altered fire regimes, and more frequent extreme weather events [63]. Table 1 reports the main potential climate change-related impacts to cultural heritage assets in Australia, ranging from water to extreme temperature related events. A discussion of potential climate change-related impacts on cultural heritage has slowly developed within both government and non-government research and policy [58], but a full understanding is still far from being reached.

Table 1
Climate change-related impacts to cultural heritage in Australia.Source: Adapted from ([51] p. 37 and [63] pp. 728–729).

- Physical damages, loss, and instability from sea-level rise and e.g. hail, floods, rainfall, storm, fire and wind events
- Soil instability, salinization, erosion, migration, subsidence, heaving and cracking
- Susceptibility to changing soil moisture in poorly damp-coursed structures
- Changes in hydrology, water tables and ground water levels
- Changes in humidity cycles, freeze/thaw cycles, wetting and drying cycles, and salt crystallisation and dissolution
- Changed in vegetation and habitat niches
- Migration of damaging pests with changes in environmental conditions
- Climatic zone movements impacting cultural landscapes, and gardens
- Changing economic and social patterns of settlements, with tension between the potential economic value of cultural heritage and conservation purposes

Important documents related to climate change issues in Australia do not mention cultural heritage as a specific target. For example, milestone documents such as the *National Climate Change Adaptation Framework* [17], the climate change study by CSIRO [14], and the *National Strategy for Disaster Resilience* [15] do not make mention of cultural heritage as a group of assets at risk of climate change-related impacts. The Garnaut Review [23] discussed a number of climate change-related challenges, including water scarcity, infrastructure and the resilience of ecosystems and biodiversity, but cultural heritage received no mention. In May 2016, the Australian government pressured UNESCO to remove all the mentions of important cultural heritage sites in Australia (such as the Great Barrier Reef and the Kakadu and Tasmanian forests) from the final version of the UNESCO report *World Heritage and Tourism in a Changing Climate* [40], claiming that it could have negatively impacted on tourism [61]. Additionally, the report on Australasia by the IPCC [55] does not mention cultural heritage as potentially threatened by climate change-related hazards. Therefore, climate change-related risks on cultural heritage appear as a politically sensitive issue.

Similarly, key documents produced by the scientific community of cultural heritage fail to address climate change. The joint work by the Department of Climate Change and the Department of the Environment, Water, Heritage and the Arts prepared a preliminary assessment of potential climate change-related impacts on biodiversity, geomorphic and aesthetic values, as well as on the cultural value of 17 World Heritage UNESCO properties in Australia [2]. However, the recent *Australia Heritage Strategy* [16] neither mentions climate change as an issue to be addressed, nor indicates it as a potential contributor of hazards impacting on cultural heritage. Among the three main Outcomes of this Strategy and the