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The interaction between cultural heritage and community resilience in disaster-affected volcanic regions

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ABSTRACT

Research on cultural heritage and disasters often focuses on the vulnerability of heritage and ways to disaster-proof it against geophysical, societal, and environmental hazards. However, heritage might in turn also increase the resilience of the communities in which it is present, for example by providing livelihood diversification, helping build social connections, and embedding local knowledge of past disasters. This study analysed how cultural heritage might contribute to multiple aspects of community disaster resilience. It builds on an analysis of resilience and disaster-related cultural heritage of four communities living around Besakih Temple located on Mount Agung volcano in Bali, Indonesia, using a mixed-methods MDSO (Most Different Same Outcome) multi-criteria analysis based on questionnaire-guided interviews with 114 respondents. While the variation of cultural heritage across sites is as predicted by theoretical literature, resilience varies considerably across the sites, depending on the type of resilience. Heritage had most positive effect on disaster preparedness and institutional aspects of community resilience. The results highlighted that connecting 'regular' disaster management and planning to local cultural heritage can provide valuable synergies for community resilience. Effects on other aspects of resilience were less clear and were likely mediated by existing socio-economic vulnerabilities and the geographical isolation of some of the communities. Further research could benefit from viewing cultural heritage through a 'community capital' lens, including matters of equitable access, capacity-building, community-based action, and interactions between cultural capital and other capitals, such as social, economic, political, human, physical, and natural.

1. Introduction

Cultural heritage, according to World Heritage Convention (1972), includes tangible (material) phenomena such as monuments, groups of buildings and (man-made and natural) sites "of outstanding universal value from the point of view of history, art or science." Barrère (2016) defines cultural heritage more broadly by highlighting its intangible dimensions such as cultural heritage originating human creativity and associated with the non-material aspects of life (Maniou, 2021).

Cultural heritage is vulnerable to a wide range of disturbances, including but not limited to biophysical and environmental ones such as earthquakes, acid rain or climate change as well as societal ones such as cultural shocks and wars. A sizable literature has developed to not only study such vulnerabilities but also to propose solutions that increase the resilience of heritage in the face of disturbances (e.g. Sabbioni et al., 2010; UNESCO, 2010; Wahlström, 2015; Jigyasu, 2016; Marrion, 2016; Ravankhah et al., 2017a; Stanton-Geddes and Soz, 2017; Maio et al., 2018). However, such framing risks portraying cultural heritage merely as a passive effect.

In contrast, several scholars (e.g. Fouseki and Nicolau, 2018; Almeida and David, 2019) have argued that heritage should be analysed as a more dynamic phenomenon that can serve as a handy resource to be exploited by communities in the face of shocks, stresses, and other disturbances. According to such scholars (see Graham, 2002), heritage is a

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potential source of knowledge, inspiration and meaning for communities. Heritage can therefore help local communities deal with future uncertainties (see Jigyasu et al., 2013; Fatorić and Egberts, 2020). This literature conceptualizes cultural heritage as 'embedded local knowledge'. Instances of cultural heritage as embedded local knowledge can be found across the world. For instance, consider examples from Asia: tsunami warning stones (both historical and modern), tsunami markers in local museums and music on tsunamis (e.g., Kimura, 2016; Barnes, 2017; Rowley, 2020; Sutton et al., 2021). Similarly, consider examples from Europe: flood stones indicating water heights of historical floods, water museums, 'flood walks', flood engineering heritage, and paintings portraying historical disasters (e.g., Krauß et al., 2018; Marschütz et al., 2020). Such artefacts and practices not only help preserve community knowledge of past events, but they also facilitate communities psychologically in local place-making & sense-making. In addition, such cultural artefacts and practices are often used for disaster risk communication. In other words, cultural heritage can be conceptualized as a dynamic source of resilience, at multiple levels: individual, community and societal.

Therefore, the association between cultural heritage and disaster resilience may be described as being bi-directional (or symbiotic) in nature: i.e., under certain circumstances, heritage may increase resilience and in other circumstances, resilience may increase heritage. This relationship is increasingly recognized by practitioners, policymakers, and the scientific community. For example, in 2021 the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Intergovernmental Panel on Climate Change (IPCC) and the International Council on Monuments and Sites (ICOMOS) convened a joint expert meeting for investigating the interactions between heritage and climate change (ICOMOS, 2021). The United Nations Office for Disaster Risk Reduction (UNDRR) too released several reports on such 'nexus'. These reports emphasize the consequent need to boost resilience through heritage (e.g., UNDRR, 2017, 2019, 2022). Better integration of such fields may therefore present valuable opportunities and synergies, assuming that a) researchers take into account local context, b) the complexities inherent in concepts such as heritage and resilience are rigorously analysed, and c) a solid evidence base is built on the interaction between heritage and resilience.

While several lines of argumentation from the heritage literature support the notion that cultural heritage might be a source of community resilience (see Section 2.1), only a handful of articles (Ravankhah et al., 2017b; Fabbricatti et al., 2020) have empirically investigated this. This article therefore presents a structured empirical investigation into the potential benefits of cultural heritage for resilience. We hypothesise that cultural heritage has a positive impact on community disaster resilience, but that this impact may vary across different aspects of resilience. We apply this analysis to a case study on volcano-related cultural heritage on Bali, Indonesia.

2. Theoretical background

2.1. Cultural heritage and resilience

In recent years, several scholars (e.g. Bui et al., 2020; Tavares et al., 2021) have argued that there appears to be limited scholarly research on how cultural heritage can serve as a source of resilience. There also appears to be limited research on the interaction between heritage and environmental management, the interaction between heritage and local governance, and on heritage in the Global South (e.g. Sowińska-Świerkosz, 2017). Such literature also presents several lines of argumentation on why, at least in principle, cultural heritage should benefit resilience. Such scholarly argumentation provides a nascent theoretical background to conduct more structured empirical research in this area. Several key arguments can be observed. Firstly, cultural heritage can provide economic opportunities for communities, for instance, through tourism. It can offer direct and indirect income to local residents, increase their financial buffers, and provide livelihood diversification (Ravankhah et al., 2017b; Allam and Jones, 2019; Fabbricatti et al., 2020; Ghahramani et al., 2020; Gómez-Ullate et al., 2020). These resources can help communities recover quickly after a disaster. Secondly, heritage has a socio-cultural function that can help build social capital and enable sense-making in the face of adversity. For instance, it can provide ways to strengthen community ties and networks, local identity, sense of belonging, and cultural diversity, offer wider community services, or help people make sense of past or recent disasters (Spennemann and Graham, 2007; Beel et al., 2017; Ravankhah et al., 2017b; Holtorf, 2018; Chakraborty and Gasparatos, 2019; Fabbricatti et al., 2020; Ghahramani et al., 2020; Gómez-Ullate et al., 2020). Thirdly, cultural heritage embeds local and/or traditional knowledge in associated communities via sense-making of hazards that a community has faced in the past or may face in the present or future. This can have varied applications: for instance, embedded hazard knowledge may be used by local communities to design physical infrastructure, such as buildings. that can often adapt better to a wider range of hazards and conditions, in contrast to 'modern' variants which may not be able to withstand the effect of 'extreme' hazards beyond the more limited range for which they are designed (Ravankhah et al., 2017b; Holtorf, 2018; Jigyasu, 2016, 2019; Nath et al., 2022). Embedded traditional knowledge on resilience can also lead to greater hazard awareness within communities, enable them to draw on embedded lessons and life-skills learnt from past disasters, facilitate faster detection of 'early warnings', provide guidance on adaption to sudden and unexpected shocks and help local communities tackle loss in order to recover from such shocks (Jigyasu et al., 2013; Ravankhah et al., 2017b; Holtorf, 2018; Kamran, 2020). Fourthly, lessons drawn by cultural heritage from past disasters can improve governance and disaster risk management. By better connecting risk management practises to the cultural dimensions of local hazards, one might reduce unintended effects of policies, reduce internal conflict, speed up economic as well as psycho-social recovery, and also provide the means to make disaster risk communication more locally meaningful by connecting such communication to pre-existing local knowledge and lifeworlds (Ravankhah et al., 2017b; Jigyasu et al., 2013; Fabbricatti et al., 2020; Marschütz et al., 2020).

Finally, in some cases, heritage may also adversely impact resilience. For instance, heritage may lead to fatalistic worldviews towards disasters (e.g., 'acts of God' for which proactive action can or should not be taken). Similarly, if tangible heritage is fragile, or if its focus on a specific historical hazard obscures analysis of other or future hazards, resilience may be inversely affected (cf. Jigyasu, 2019; Marschütz et al., 2020). These arguments set out in the heritage literature can be linked to similar themes and aspects discussed in the resilience literature and will provide the basis for our analysis of the interconnections between resilience and cultural heritage.

2.2. Analytical approach

Theoretical argumentation from the heritage literature, as discussed above, offers a broad palette of somewhat dissimilar ways in which cultural heritage may increase local resilience. Likewise, resilience is a multifaceted concept which lends itself well to multi-criteria analysis. These facets can be selected and analysed in multiple ways. We distinguish between two different ways to approach this analysis.

The first approach is a 'thematic' approach, which identifies overarching dimensions that characterise resilience. Such dimensions can be used to cluster more detailed sub-dimensions using bottom-up aggregation techniques (e.g., Cutter et al., 2010; da Silva and Morera, 2014; Sajjad et al., 2021). For example, one might select themes based on specific sectors or societal factors that may be impacted by a disaster. Such themes can be easily connected to policy goals or mission statements of relevant government departments. In the case of heritage and resilience, four themes can be identified: economic, social, institutional and infrastructure. Economic resilience is associated with the

availability of and access to financial and related resources. It is associated with the argument that heritage might offer job opportunities and income diversification. Social resilience is associated with education, health, and social capital. It is associated with the argument that heritage might encourage community cohesion and sensemaking. Infrastructural resilience is associated with various kinds of built environment, such as housing quality, roads, access to services such as hospitals, schools, et al. It is associated with the argument that the inclusion of disaster-related local/traditional knowledge in the design and planning of built environment may increase societal capabilities to bounce back from disaster. Institutional resilience is associated with the planning, implementation and communication of disaster risk management. It is associated with the argument that heritage can be used for tailoring institutional design to local needs.

The second approach is a mechanism-based approach: this approach analyses how heritage may contribute to different mechanisms by which a system or community can become more resilient (e.g. Sharifi and Yamagata, 2016; Wardekker et al., 2020). For example, does cultural heritage increase the immediate ability of communities to absorb the impacts of disaster, or does it help in speedy recovery afterwards? The mechanism-based approach can be linked to the different phases of the 'resilience cycle', or the disaster management cycle (see also e.g. Alexander, 2015). This phase-based or mechanistic approach is helpful in highlighting how disaster management is not just about the disaster-event itself; it is also associated with a broader process that covers the pre-event and the post-event phases of a disaster. We distinguish amongst three phases: preparedness, absorption, and recovery. Preparedness is about proactiveness before a disaster strikes: developing disaster management plans, hazard monitoring, training, and developing knowledge infrastructure. Absorption limits impacts during a disastrous event via measures such as increasing access to vehicles, disaster-resistant design of infrastructure, rapid access to healthcare, etc. Recovery facilitates quick and equitable bounce-back after a disaster in order to prevent the slow erosion of a disaster-stricken community via measures such as increasing access to resources for basic needs (Nath et al., 2021) or income diversification. Sometimes, research on climate and energy resilience, (see Sharifi and Yamagata, 2016 and Wardekker et al., 2020), which study stresses and slow-moving disturbances, also include adaptation as a fourth phase. Our article focusses only on shocks. Therefore, we have not included the adaptation phase explicitly for analysis. Nonetheless, several indicators related to literacy and education which also affect the adaptation phase have been included in the recovery phase.

This article analyses the association between cultural heritage and disaster resilience using both the thematic and phase-based approaches operationalised using a set of indicators. An important choice here is whether to focus on a) short-term or long-term resilience, and b) systemic characteristics or community capacities (e.g. Wardekker, 2021). As this article deals with a) disaster resilience, and b) community-level cultural heritage, the focus will be on short-term, community disaster resilience. Indicators were derived from the disaster management and community resilience literature (Hahn et al., 2009; Cutter et al., 2010; Cox and Hamlen, 2015), and categorized according to theme and phase. See Fig. 1. For indicators of cultural heritage, we draw on Sowińska-Świerkosz (2017). Together, these cover a range of potential interactions between cultural heritage and community disaster resilience.

3. Methodology

3.1. Research question, hypothesis, dependent and independent variables

The research questions that this article seeks to answer are: *How does resilience vary across communities characterized by different values of cultural heritage? What explains such variation?* These questions are answered using data collected on four communities in the volcanic area of Karangasem in the Indonesian island of Bali.

Mixed methods were used: data was collected using questionnaire-guided interviews; quantitative indices were then used to compare and contrast these four communities using a case-study approach.

Drawing on the research question discussed earlier, this article *hypothesizes* that communities living in disaster-prone regions which are characterized by high values of cultural heritage will also be characterized by high values of resilience. Accordingly, the *dependent* variable of interest is resilience and the corresponding *independent* variable analysed in this article is cultural heritage. Resilience and cultural heritage are both measured using composite indicator-based *indices*.

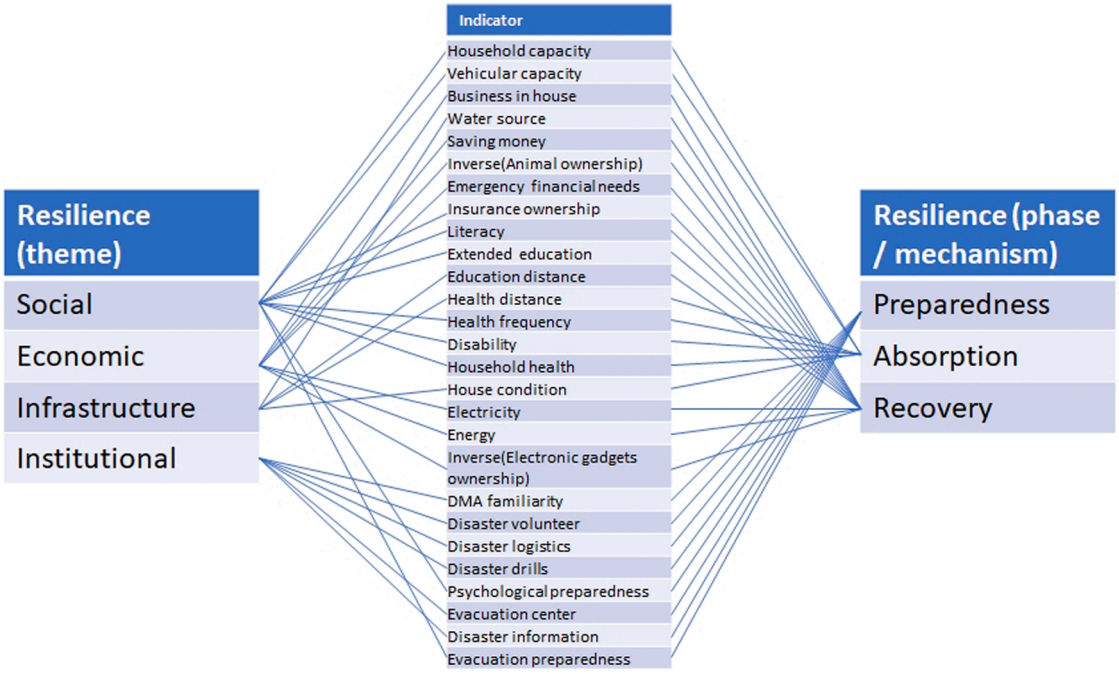


Fig. 1. Operationalising different aspects of Resilience into indicators.
Indicators adapted from Hahn et al. (2009); Cutter et al. (2010); Cox and Hamlen (2015).

Resilience and cultural heritage are both measured at the community-level. Therefore, the *level of analysis* is a community.

3.2. Calculating Indices

Composite indices represent aggregate measures of complex phenomena. They simplify complex measurements and enable comparison of multi-dimensional constructs (Booysen, 2002). Research on composite indices grew out of the belief that a single indicator cannot adequately measure a complex phenomenon "just as no single set of objectives can describe adequately the diversity of development conditions in the world" (Wilson and Woods, 1982; Booysen, 2002).

Accordingly, as outlined in the theory section, resilience has been measured using two different indices: a) Phase-based Resilience Index (*PRI*); and b) Theme-based Resilience Index (*TRI*). PRI is a composite measure consisting of three components: a) absorption, b) preparedness, and c) recovery (Hahn et al., 2009; Cutter et al., 2010; Cox and Hamlen, 2015). In contrast, TRI is a composite measure consisting of four components: a) economic resilience, b) infrastructural resilience, c) institutional resilience, and d) social resilience (Hahn et al., 2009; Cutter et al., 2010; Cox and Hamlen, 2015). Each of these components (for PRI as well as TRI) are measured using indicators drawn from widely used, well-cited, path-breaking sources such as Cutter et al. (2010), Cox and Hamlen (2015) and Hahn et al. (2009). See Table 1. Cultural heritage is measured using a single Index (*CHI*) consisting of four indicators (See Table 1) as outlined below. All four indicators are measures of intangible heritage: two of these indicators are state indicators and the other two are action indicators. This is because, a comprehensive review of 48 articles and 259 cultural heritage indicators by Sowińska-Świerkosz (2017) reveals that most research articles on cultural heritage use intangible (state and action) indicators of heritage. Action indicators are used to measure the governance aspects of cultural heritage (Sowińska-Świerkosz, 2017). Measures associated with the protection of resources (Xin and Chan, 2014) and decision-making (Grošelj et al., 2016) are examples of action indicators. In the context of this study, action indicators analyse how state indicators characterise heritage values such as "viewpoints", "identity" or "spirit" (Bruni, 2016; Sowińska-Świerkosz, 2017). Together, these indicators aim to capture: a) the presence of cultural heritage, b) how cultural heritage gets manifested in community life and, c) it's the association between cultural heritage and hazards.

While cultural heritage was analysed using an aggregated index, resilience wasn't analysed at the aggregated-Index level using PRI and TRI. Rather, resilience was analysed at the component level of these indices (see Fig. 1). In other words, 8 different forms of resilience were analysed: absorption, preparedness, recovery, economic resilience, infrastructural resilience, institutional resilience, and social resilience. This was done to develop a deeper and more nuanced understanding of the relationship between cultural heritage and resilience.

All variables have been calculated using the inverse variance method (Gupta et al., 2019; Xu et al., 2020; Moreira et al., 2021). First, all indicators were standardized using the following formula:

$$SI_i = \frac{(I_i - I_{min})}{(I_{max} - I_{min})} \quad (1)$$

where I_i is the value corresponding to a non-standardized indicator; I_{max} and I_{min} are the maximum and minimum values for the indicator in the dataset; SI_i is the standardized form of indicator I_i.

Second, for each of the components (see Table 1), values of c and w_i are calculated using:

$$c = \left[\sum_{1}^{n} \frac{1}{\sqrt{var(SI_i)}} \right]^{-1} \quad (2)$$

Table 1
Indicators and measures used in the phase-based resilience index (PRI), theme-based resilience index (TRI) and cultural heritage index (CHI).

Resilience

Indicator	PRI Component	TRI Component	Measure/ Interview question
Household capacity	Absorption	Social Resilience	How many people live in your house? *(quantitative)*
Vehicular capacity	Absorption	Social Resilience	How many people can be transported by you using all the vehicles you own? *(quantitative)*
Business in house	Recovery	Economic Resilience	Besides using your house for living, do you use your house for any business? *(qualitative)*
Water source	Recovery	Infrastructure Resilience	Where do you source water for meeting your household needs? *(qualitative)*
Saving money	Recovery	Economic Resilience	Do you save money to meet needs during emergency? *(qualitative)*
Animal ownership	Recovery	Economic Resilience	What kind of animals do you own? *(qualitative)*
Emergency financial needs	Recovery	Economic Resilience	If there is an emergency, how do you attain money to meet needs? *(qualitative)*
Insurance ownership	Recovery	Social Resilience	What kind of insurance have you procured for your family? *(qualitative)*
Literacy	Recovery	Social Resilience	How educated are you? *(qualitative)*
Extended education	Recovery	Social Resilience	Do you have any other education (training or course) outside formal education? *(qualitative)*
Education distance	Recovery	Infrastructure Resilience	How far is your house from the closest education center? *(quantitative)*
Health distance	Absorption	Infrastructure Resilience	How far is your house from the health facility you usually visit? *(quantitative)*
Health frequency	Absorption	Social Resilience	How often do you go to the health center? *(quantitative)*
Disability	Absorption	Social Resilience	How many members of your household suffer from disabilities or co-morbidities?? *(quantitative)*
Household health	Absorption	Social Resilience	Has anyone in your family been so sick in the past 2 weeks that they had to miss work or school? *(qualitative)*
House condition	Absorption	Infrastructure Resilience	Is your house permanent (made from brick) or semi-permanent (made from bamboo)? *(qualitative)*
Electricity	Recovery	Economic Resilience	How much money do you spend on electricity in a month? *(quantitative)*
Energy	Recovery	Economic Resilience	What type of energy do you use for cooking? *(qualitative)*
Electronic gadgets ownership	Recovery	Economic Resilience	What type of electronics do you have in your house? *(qualitative)*
DMA familiarity	Preparedness	Institutional Resilience	Do you know about BPBD or BNPB? Have you ever heard about it? *(qualitative)*
Disaster volunteer	Preparedness	Institutional Resilience	Is there any group of volunteers that deals with

(*continued on next page*)

Table 1 (*continued*)

Resilience			
Indicator	PRI Component	TRI Component	Measure/ Interview question
			disaster management in your village? *(qualitative)*
Disaster logistics	Preparedness	Institutional Resilience	How was disaster aid provided for disaster survivors during the volcanic eruption of 2017–2018? *(qualitative)*
Disaster drills	Preparedness	Institutional Resilience	What type of disaster preparedness drill is conducted in your village? *(qualitative)*
Psychological preparedness	Preparedness	Social Resilience	How prepared are you psychologically to tackle the next volcanic eruption?? *(qualitative)*
Evacuation center	Preparedness	Institutional Resilience	Do you know where the evacuation center is? *(qualitative)*
Disaster information	Preparedness	Institutional Resilience	Where do you obtain information about natural disasters in your area? *(qualitative)*
Evacuation preparedness	Preparedness	Social Resilience	How prepared are you to evacuate your family during natural disasters? *(qualitative)*
Cultural heritage			
Indicator	**Type of Indicator**	**Measure/ Interview question**	
Heritage protection	Action indicator	How familiar are you with the steps being taken to conserve Besakih temple? *(qualitative)*	
Heritage value	Action indicator	How much money do you spend daily for various religious rituals? *(quantitative)*	
Heritage type	State indicator	Do you perform specific religious rituals to prevent the occurrence of a disaster? *(qualitative)*	
Heritage effect	State indicator	Which natural hazard does the above ritual prevent? *(qualitative)*	

$$w_i = \frac{c}{\sqrt{\mathrm{var}(SI_i)}} \tag{3}$$

where c is the constant for each component after standardization; n = number of indicators in each component; w_i represents the non-standardized weight for indicator SI_i.

Third, for each of the components, values of w'_i are calculated using:

$$w'_i = \frac{w_i}{\sum_1^n w_i} \tag{4}$$

where n is the number of indicators in each component; w_i represents the non-standardized weight for indicator SI_i; w'_i represents the standardized weight for indicator SI_i.

Fourth, the final values for each of the components/index was then calculated using:

$$\text{Absorption} = \sum_1^7 (w'_i * SI_i) \tag{5a}$$

where the seven standardized indicators which constitute absorption are a) household capacity, b) vehicular capacity, c) health distance, d) health frequency, e) disability, f) household health and g) house condition (see Table 1).

Similarly,

$$\text{Preparedness} = \sum_1^8 (w'_i * SI_i) \tag{5b}$$

$$\text{Recovery} = \sum_1^{12} (w'_i * SI_i) \tag{5c}$$

$$\text{Economic Resilience} = \sum_1^7 (w'_i * SI_i) \tag{5d}$$

$$\text{Infrastructure Resilience} = \sum_1^4 (w'_i * SI_i) \tag{5e}$$

$$\text{Institutional Resilience} = \sum_1^6 (w'_i * SI_i) \tag{5f}$$

$$\text{Social Resilience} = \sum_1^{10} (w'_i * SI_i) \tag{5g}$$

$$\text{CHI} = \sum_1^4 (w'_i * SI_i) \tag{5h}$$

Finally, resilience and cultural heritage scores for each of the communities were calculated. Step four above calculates resilience and CHI scores at the household level. resilience and CHI scores at the community level were calculated by averaging the scores of all households associated with the concerned community. Note that all variables have been standardized to vary within the range 0–1. The higher the score on each component of resilience, the higher the resilience level/performance of the community. The higher the score on CHI, the higher the cultural heritage associated with that community.

3.3. Site Selection

Indonesia is a South-east Asian country of more than 17000 islands located between the Indian and the Pacific Ocean. Bali is one of these islands but what makes this island unique within Indonesia is that a majority of the population in Bali Province are followers of Hinduism. In contrast, a majority of the population in Indonesia are followers of Islam.

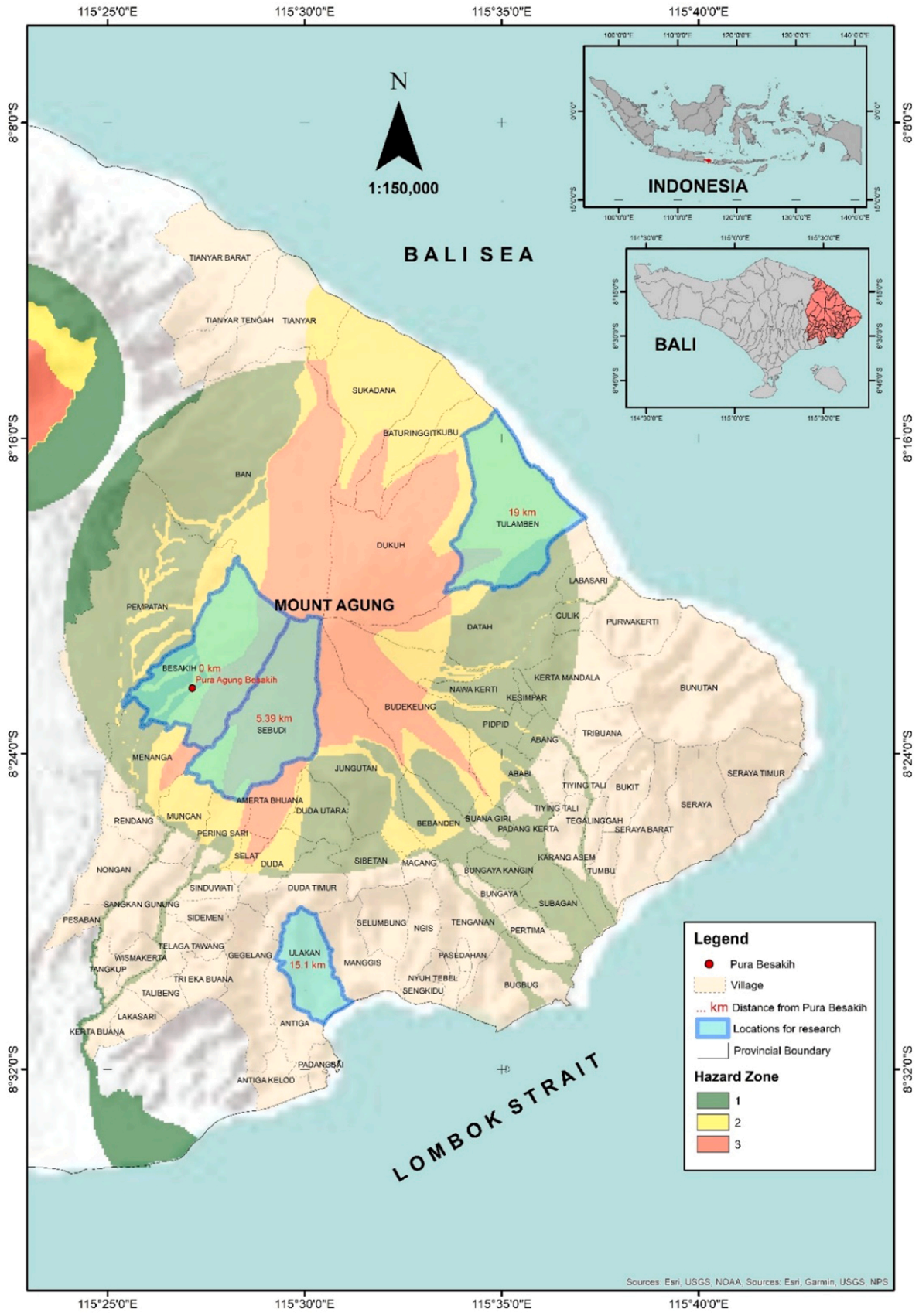
The north-eastern part of Bali is home to an active 3142 m high volcano named Mount Agung. One of the most recent eruptions of this volcano was in September 2017 when more than 150,000 local residents were evacuated to safety (see e.g. Matsumoto et al., 2018; Syahbana et al., 2019; Reliefweb, 2023). The disaster-proneness of such volcanic islands is further aggravated by tsunamis and sea-level rise along the coastline. The slopes of Mt. Agung are an important source of livelihood for local residents: agriculture, tourism, and sand-mining. Villages located near the coastline are associated with fishing and adventure sports. Nonetheless, Mt Agung is home to one of the holiest temples for Balinese Hinduism: The Besakih temple. It is one of the nine *Pura kayangan Jagat*[4] (Hindu temples for universal worship). Balinese people therefore deify Mt. Agung and such behavior shapes intangible cultural heritage of the local region.

Mt. Agung therefore represents a crucial case-study[5] for studying the interaction between cultural heritage and disaster resilience (Eckstein, 1975). This article analyses communities associated with 4 villages located on the slopes of Mt. Agung (see Map 1): a) Besakih, b) Sebudi, c) Tulamben, and d) Ulakan. Table 2 provides additional information on the 4 research sites.

These 4 village-based communities were chosen as study sites in

[4] For more information, see https://www.kintamani.id/mengenal-lebih-jauh-tentang-pura-kahyangan-jagat-pura-universal-di-bali/, accessed on 10th February 2023.

[5] A case is crucial "if the facts of that case are central to the confirmation or disconfirmation of a theory" (Eckstein, 1975).



Map 1. The study sites and their location compared to the Pura (Agung) Besakih temple and Mount Agung volcano.

Table 2
Basic data on the case study sites.

	Besakih	Sebudi	Tulamben	Ulakan	Source of Data
Landscape	Mountainous/hilly	Mountainous/hilly	Mountainous/hilly and coastal area	Mountainous/hilly and coastal area	Primary research
Altitude above sea level (m)	> 700 m	500–700 m	< 500 m	< 500 m	Public agency (Kecamatan Dalam Angka)
Hazard zone[a]	3 and 2	3 and 2	2 and 1	Outside hazard zone	Public agency (Kecamatan Dalam Angka)
Area (hectare)	3073.48	2735.06	2881.17	1044.93	Public agency (BPS)
Connectivity	Located far away from a provincial road	Located far away from a provincial road	Located next to a provincial road	Located next to a provincial road	Primary research
Distance from district capital in 2017	5–9 km	3–4 km	3–4 km	< 1 km	Public agency (Kecamatan Dalam Angka)
Distance from the crater	0–8 km	0–8 km	5–12 km	16–20 km	Public agency (PVMBG)
Distance from Besakih temple	0 km	5.39 km	19 km	15.1 km	Google Earth
Importance for tourism	High footfall	Medium footfall	High footfall	Low footfall	Primary research
Population in 2015	7682	6059	12067	6488	Public agency (BPS)

[a] Higher value indicates greater hazard.

order to implement a MDSO[6] (Most Different Same Outcome) research design (Mill, 1856; De Meur and Gottcheiner, 2009). The locations need to be similar enough (all connected to the same volcano and the same heritage) in order to study the impact of a specific case of cultural heritage, but also exhibit some variation, which might reveal the underlying connections between heritage and resilience. As is evident from Table 2, these communities are highly heterogeneous and are characterized by wide variation across a range of control variables (including but not limited to hazard-related variables such as exposure to disasters as well as social-economic ones such as impact of tourism). Since controls vary widely, the hypothesis outlined in Section 3.1 will be validated if both cultural heritage (independent variable) and resilience (dependent variable) demonstrate High-High or Low-Low relationship across the sites i.e., both cultural heritage and resilience are high for certain sites, and both cultural heritage and resilience are low for other sites.

3.4. Data collection, processing, and analysis

Primary data collection for this research was conducted in January 2020 and February 2020. A pilot study was first conducted to test a theoretically-derived questionnaire which was then updated to reflect ground realities. Next, data was collected in 2 stages: in the first stage, questionnaire-guided interviews were conducted with 114 respondents: 66 male and 48 female; ages ranged 14–75; covering a wide variety of backgrounds: businessmen, shop keepers, teachers, fishermen, farmers, government employees, and services industry workers. Respondents were located in: Besakih (27), Sebudi (27), Tulamben (34), and Ulakan (26). Each interview lasted for about 20 min. A purposeful convenience sampling strategy was used: we wanted to ensure that there was limited disparity in the number of male and female respondents while covering a wide variety of livelihood groups/local stakeholders. In the second stage, semi-structured in-depth interviews were conducted with 11 key actors.[7] For both rounds of data collection, interviewing was continued until saturation was reached in terms of generating new information. The data so generated was triangulated with secondary information (reports, newspapers articles). The information so generated was coded according to the variables listed in Table 1. Indices were then calculated according to the methodology outlined in Section 3.2. Resilience and cultural heritage were then compared and contrasted across the 4 research sites as detailed below.

4. Results and analysis

Amongst the four sites, Besakih (0.53) is associated with the highest value of cultural heritage, and Tulamben (0.27) the lowest. This is because Besakih is located closest to the Besakih temple (see Table 2 and Map 1) and Tulamben the farthest.

While the variation of cultural heritage across sites is as predicted by theoretical literature, resilience varies considerably across the sites, depending on the type of resilience. Three clusters can be observed. See Fig. 2. Cluster 1: institutional resilience and preparedness – Besakih is associated with the highest value of resilience (0.60 and 0.59) and Ulakan the lowest (0.37 and 0.41) while Tulamben is associated with the second lowest value of resilience (0.41 and 0.46). Cluster 2: social resilience and absorption – Besakih (0.65 and 0.83) is associated with the highest value of resilience and Sebudi (0.60 and 0.75) the lowest. Cluster 3: economic resilience, infrastructure resilience and recovery – Ulakan (0.68, 0.83 and 0.68) is associated with the highest value of resilience and Tulamben (0.57, 0.76 and 0.54) the lowest.

In other words, the relationship between resilience and cultural heritage is not as clear cut as was hypothesized in Section 3.1. Consider cluster 1: for certain types of resilience (institutional resilience and preparedness), the relationship between resilience and cultural heritage seems to be closest to the hypothesized relationship: communities living in disaster-prone regions but characterized by high values of cultural heritage will also be characterized by high values of resilience. However, the same does not hold for the other types of resilience in clusters 2 and 3: social resilience, economic resilience, infrastructure resilience, absorption, and recovery (Fig. 2).

5. Discussion

5.1. Interpreting the clusters

As discussed in the previous section: resilience varies considerably across the sites, depending on the type of resilience. These differences can be interpreted using qualitative answers obtained in the interviews and the characteristics of the case study sites. Three clusters can be observed - cluster 1: institutional resilience and preparedness; cluster 2: social resilience and absorption; cluster 3: economic resilience, infrastructure resilience and recovery. In other words, cluster 1 covers

[6] MDSO research design selects cases which are similar in outcome (dependent variable) but whose explanatory variables (independent variables) vary significantly from each other. “In other words, among cases with the same outcome, if one variable has the same value, this is the one to use for explanation”. (see De Meur and Gottcheiner, 2009).

[7] Key actor interviews included: a) Founder of Bali Cultural heritage Conservation; b) Secretary of Besakih Village; c) Head of Sebudi Village; d) Secretary of Ulakan Village; e) Head of Tulamben Village; f) Head of Planning Division, Ulakan Village; g) Head of regional farmers association; h) various public officials.

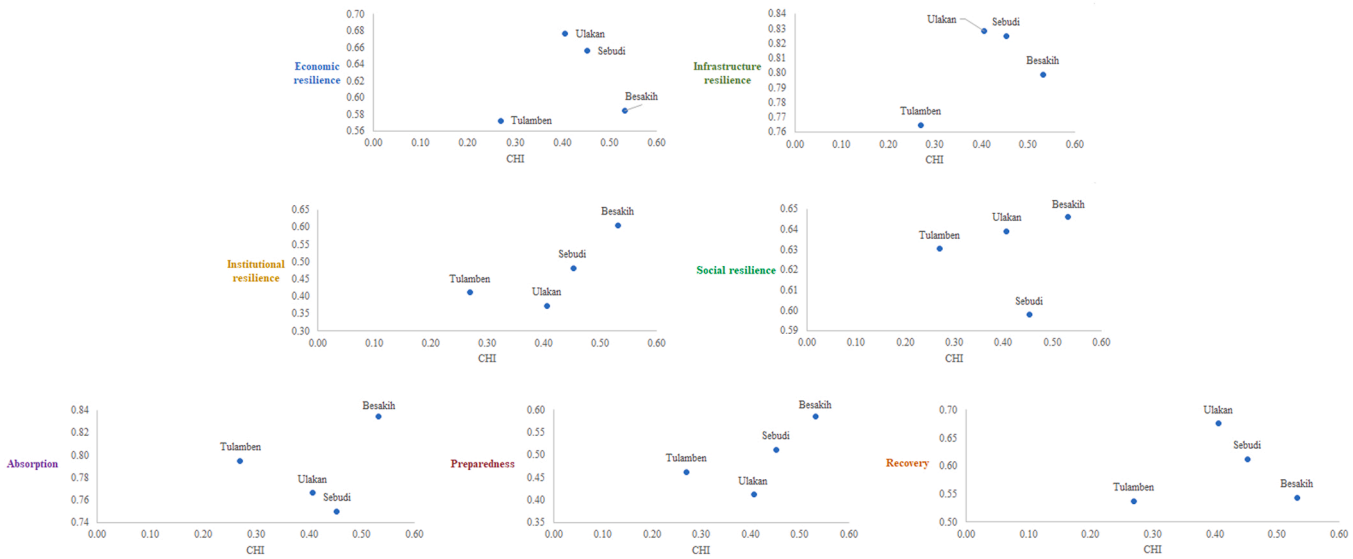


Fig. 2. Resilience versus cultural heritage. Plots show the scores of the four case study sites on our index for cultural heritage (CHI) and the indices for different aspects of resilience.

indicators that relate to disaster risk management in terms of a) organisation, information & communication, and b) social & psychological preparedness to deal with disasters. It seems that there are synergies at play between the 'regular' governmental disaster planning activities and the role of the cultural heritage in stimulating community awareness and preparation. Interview respondents indicated that the national disaster management agency uses local social and cultural infrastructure in the region to improve the impact of its organisation, training and local disaster response. Respondents indicated that the combination of science-based and heritage-based information provides much added value in local disaster risk management. As one respondent highlighted: "*Science without belief is death and belief without science is death*", referring to an incident where people practicing a ritual were caught unprepared by a sudden volcanic eruption. Integration of science-based and heritage-based disaster information improves connection with local life-worlds and enhances the acceptance of such communication by local communities.

In cluster 2, as hypothesized, both resilience (social resilience: 0.65, absorption: 0.83) and cultural heritage (0.53) are high for Besakih. But Tulamben (social resilience: 0.63, absorption: 0.80) is associated with higher value of resilience as compared to Sebudi (social resilience: 0.60, absorption: 0.75) whereas Sebudi (0.45) is associated with higher value of cultural heritage than Tulamben (0.27). Local observation and analysis of interview transcripts appears to suggest that this may be happening because Sebudi is located in a more mountainous region; therefore, it may be located further away from provincial roads and is therefore more isolated in comparison to other sites. Tulamben, in comparison, is located nearer to the coast: it garners more tourist footfalls as compared to Sebudi. As a result, indicators related to, in particular, the educational and health situation are worse in Sebudi. Furthermore, Sebudi is located in a more hazardous zone as compared to Tulamben (Table 1). Therefore, for social resilience and absorption in Cluster 2, the relationship between resilience and cultural heritage is probably mediated by variables such as disaster proneness and a lack of connectivity.

Similarly in cluster 3: as hypothesized, both resilience (economic resilience: 0.57, infrastructure resilience: 0.76, recovery: 0.54) and cultural heritage (0.27) are low for Tulamben. However, the resilience of Besakih (economic resilience: 0.58, infrastructure resilience: 0.80, recovery: 0.54) is considerably lower than that of Sebudi (economic resilience: 0.66, infrastructure resilience: 0.82, recovery: 0.61) and Ulakan (economic resilience: 0.68, infrastructure resilience: 0.83, recovery: 0.68) although it is associated with the highest cultural heritage (0.53) amongst all sites. This is probably because Besakih is economically the most vulnerable site. Although both Sebudi and Besakih are located in similar hazard zones, communities associated with Besakih appear to be performing significantly lower on the economic scale when analysed using factors such as electronic gadget ownership, access to electricity or ability to save money for tackling future stresses or shocks. While interview data indicates that the presence of heritage site in Besakih does indeed provide jobs, it does not seem to provide (sufficient) additional economic benefits that can improve the overall economic situation in this site compared to the other research sites. Therefore, for economic resilience and recovery in cluster 3, the relationship between resilience and cultural heritage is probably mediated by variables such as the overall economic prosperity.

5.2. Indicator overlap in phase-based and theme-based resilience indices

Sections 4 and 5.1 demonstrate that there is intersection between theme-based and phase-based composite indices. This is partly due to overlap amongst underlying indicators (see Fig. 1). Such intersection is particularly visible for preparedness and institutional resilience (Cluster 1): 6 out of 8 indicators used to calculate preparedness overlap with the 6 indicators used to calculate institutional resilience. For absorption and social resilience (Cluster 2): 5 out of 7 indicators used to calculate absorption overlap with 5 out of 10 indicators used to calculate social resilience. For recovery and economic and infrastructure resilience (Cluster 3): 7 out of 12 indicators used to calculate recovery overlap with 7 indicators used to calculate economic resilience.

Such overlap in indicators is partly an artifact of the methodological choices in this study: because we collected data using interviews, we were in a position to collect data on a limited number of indicators. Overlap in indicators is also a reflection of the on-the-ground realities. For instance, consider overlap between preparedness and institutional resilience in Cluster 1: preparedness often involves institutionalized proactive behaviour and foresight; it is also associated with intentional and organized activities by institutional entrepreneurs. Nonetheless, other non-matched indicators exist: indicators measuring the resilience of institutions themselves, or those measuring the role of informal networks in early warning and preparedness, etc. Furthermore, analysis of certain complex disasters may require including adaptation as a fourth phase (e.g., flood risk management, climate change resilience, urban disaster risks). This phase often includes many institutional variables as

well (see e.g., Wardekker et al., 2020). Inclusion of such indicators may reduce overlap between preparedness and institutional resilience. Analysis of disaster resilience using two sets of composite indices is important for understanding long-lasting risks; but such analysis may not be required for other kinds of risks. In any case, the conceptual approaches underlying different indices should be analysed reflexively during research design in order to avoid the exclusion of important aspects of resilience.

5.3. General limitations

Several other methodological trade-offs should be considered. This study used an indicator-based approach with both qualitative and quantitative criteria, and data collected using survey-guided interviews. Compared to qualitative approaches using semi-structured interviews, this results in less in-depth information, for example on the reasons why respondents give certain answers. However, it yields wider information: more sites, interviewees, backgrounds, and aspects of resilience and heritage analysed. This allowed us to test the early hypotheses already presented in qualitative and theoretical literature. Other limitations lie in the choice of indicators. Any indicator set zooms in on some but leaves out other aspects. We combined indicators from well-established literature into a broad set that was able to cover many aspects of resilience and heritage. However, it did not include long-term change and adaptability. These aspects are currently underdressed in the literature on community resilience (Wardekker, 2021). The case study instead focused on a 'shock'-based hazard (short-term events). However, in the context of sustainable development, further study of the long-term aspects of volcanic hazards and resilience will be important. Furthermore, respondent profiles can impact the ability to draw more general lessons. Due to the chosen method, we were able to cover a wide range of backgrounds (Section 3.4), with only marginal overrepresentation of men. This allowed for an accurate representation of the local population. Different historical experiences in the four sites can also play a role in the results. For example, Ulakan was not hit during the 1963 and 2017 eruptions, and is located outside the hazard zone, so disaster preparedness receives less priority. Finally, this paper focused on volcanic hazards, religious heritage, and Indonesia, but other factors may play a role for different hazards, types of heritage, and countries. Further research is required in other locations. Nonetheless, this study offers a first, rigorous empirical test of the links between heritage and resilience.

6. Reflection and conclusion

This study presents an analysis of how cultural heritage might impact the resilience of communities in disaster-affected volcanic regions. While previous research has argued that cultural heritage might benefit community resilience to disasters, this symbiotic relationship is likely more nuanced and depends on the local situation and context.

6.1. Potential lessons on the relation between cultural heritage and resilience

This investigation demonstrates that disaster preparedness and institutional resilience benefit the most from cultural heritage associated with the volcanic regions of Bali. Cultural heritage appears to improve local awareness of disaster risks. The combination of science-based and heritage-based disaster information and disaster preparedness seems to improve local acceptance, integration, and uptake of such information. This study confirms theoretical propositions on how cultural heritage can improve local disaster awareness (Jigyasu et al., 2013; Ravankhah et al., 2017b; Holtorf, 2018; Kamran, 2020) and enhance the effectiveness of government efforts in disaster risk management and communication (Ravankhah et al., 2017b; Jigyasu et al., 2013; Fabbricatti et al., 2020; Marschütz et al., 2020). The combination of science-based and heritage-based disaster information when supported by government efforts at disaster mitigation and local, social infrastructure may be particularly useful in delivering these benefits. If cultural heritage is not supported by government activities and appropriate infrastructure, heritage may not provide the same benefits, or worse may increase disaster risk. In the volcanic regions of Bali, disaster planners make active use of local social and cultural infrastructure in designing disaster-mitigation plans and providing disaster-recovery training. In other words, there is scope for active co-management of disaster planning, communication, and recovery. Furthermore, cultural heritage acts as a useful interface between government actors and local communities, thereby reducing power imbalances and creating a level playing field (at least to some degree) for disaster mitigation and recovery. We argue that this is an important factor that needs to be considered while designing plans for knowledge co-production regarding risks from local disasters because cultural heritage provides a ready-link to local knowledge and values (Nath et al., 2022). Knowledge co-production is an important topic in resilience research (e.g. Borquez et al., 2017; Bremer and Meisch, 2017; Aguilar-Barajas et al., 2019; Hill et al., 2020; Wardekker, 2021). It can provide benefits ranging from improved scientific knowledge to empowerment of local communities, if it is organised in collaboration with local communities for their benefit.

Heritage-related benefits for social, economic, & infrastructural resilience, and for the absorption & recovery phases of the resilience cycle appear to be less equivocal: such benefits appear to be visible only in certain sites under specific circumstances. In general, cultural heritage might provide income-generation opportunities, improve livelihood diversification or act as financial buffer (Ravankhah et al., 2017b; Allam and Jones, 2019; Fabbricatti et al., 2020; Ghahramani et al., 2020; Gómez-Ullate et al., 2020). It can also provide a platform for improving social capital and post-disaster sense-making (Beel et al., 2017; Ravankhah et al., 2017b; Holtorf, 2018; Chakraborty and Gasparatos, 2019; Fabbricatti et al., 2020; Ghahramani et al., 2020; Gómez-Ullate et al., 2020). For example, several respondents indicated that they receive primary or secondary income from working at the temple: selling religious items or working as tour guide. Some benefits related to improved social capital may also be available, but such benefits may be limited to preparedness. Nonetheless, social and sense-making benefits are difficult to capture using indicator-based resilience indices; they may get better captured via ethnographic data-collection methods. Therefore, mixed results may have emerged regarding social, economic, & infrastructural resilience: villages closest to the heritage site are quite remote (since they are located on the volcano's slopes, rather than on the coast). Such villages are not well-connected to provincial roads or to provincial towns. Also, they do not perform well on educational, healthcare, infrastructure and socio-economic parameters. They are therefore more prone to disasters and crisis because of their geographic location (Nath et al., 2021). While cultural heritage may increase the resilience of local communities under such trying circumstances, it is no 'silver bullet' for tackling all the challenges of living next to an active volcano. Therefore, we caution against being too optimistic in promoting heritage as a universal solution, particularly in developing countries. While cultural heritage does improve local resilience, the role of pre-existing vulnerabilities in the local communities should be considered.

6.2. An agenda for future research

6.2.1. Cultural heritage as community capital

In recent years, cultural heritage has been analysed as a form of capital (Rizzo and Throsby, 2006; Shockley, 2004; Throsby, 1999; Ulibarri, 2000). According to this school of thought, cultural heritage can be conceptualized as a set of assets or resources inherited from the past that provide specific benefits (services) to communities associated with it. Such assets can come into being via human creativity or nature's beneficence. Conceptualizing cultural heritage using the language of capital makes intuitive sense because cultural heritage often requires the

investment of physical, human, social, or economic resources for creation and/or maintenance. Cultural capital "reflects communities' ways of knowing the world, their values, and their assumptions about how things fit together. It is represented by symbols in language, art, and customs" (Magis, 2010). This includes heritage, among others (e.g., modern culture, art, language). What distinguishes cultural capital from physical or natural capital is that specific cultural services (architectonic quality, religious significance, spiritual value) can be derived from cultural capital which otherwise cannot be provided by any other form of physical or natural capital (Sowińska-Świerkosz, 2017; Rizzo and Throsby, 2006).

The language of capitals has been found useful for analysing resilience (Mayunga, 2007; Ungar, 2011; Tierney, 2006). This is true especially for community resilience since community resilience is associated with high social capital and increased access to (financial, physical, and information and knowledge) resources (Magis, 2010; Aldrich, 2017; Wardekker, 2021). For example, Magis (2010) drawing on Flora and Flora (2004) argues that community resilience depends on access to natural, human, cultural, financial/economic, built/physical, political, and social capital. Related concepts such as vulnerability (Metcalf et al., 2015; Nath et al., 2021) and adaptive capacity (Maldonado and del Pilar Moreno-Sánchez, 2014; del Pilar Moreno-Sánchez and Maldonado, 2013) have also been analysed using the language of capitals. This is because the capital-based approach focuses analytic attention on how concepts such as resilience and vulnerability are associated with community-level resource dependency (Adger, 2000; Mayunga, 2007; Nath et al., 2021). Whether the presence of capitals translates into resilience depends on whether communities have equitable access to those resources (e.g., physical, technical, legal), whether they have the capacities (e.g., skills, leadership) to harness them, and whether such communities proactively seek to access such resources (cf. Magis, 2010). The role of cultural heritage in resilience-building can be analysed in a similar manner.

An avenue for further research would be to investigate what specific resources heritage might provide for dealing with disasters. Current discussions in the literature (see Section 2.1) seem to be moving implicitly in this direction. Additional questions include: how to provide equitable access to heritage-based cultural capital for different groups in a community, which community capacities might be required to harness these capitals (and which capacities they might stimulate), and how heritage can be employed to stimulate practical action towards resilience-building. For example, for heritage to benefit resilience heritage access should extend beyond tourists or affluent groups in a community. It should also be inclusive towards the underprivileged and vulnerable members of society. Another interesting area of research is the investigation of the practical role of cultural actors (museums, libraries, artists, and schools) in capacity-building and stimulating action towards resilience. For instance, cultural actors may link 'remote' concerns such as potential disasters or environmental change to daily community life and other 'more mundane' concerns (cf. e.g., Baztan et al., 2020). Answering such questions are important not only for disaster research (short-term shocks), but also for researching resilience to long-term challenges such as climate change, transformations (ecological, economic, demographic or societal) and other gradual pressures. Long-term community resilience deals with concepts such as community self-determination, equity, deeper long-term socio-political determinants of vulnerability, community knowledge-building and community engagement (Wardekker, 2021). are strongly associated with resource challenges. Interpreting cultural heritage using a community-oriented capitals-based approach can therefore throw additional light on how heritage might benefit both short-term and long-term community resilience.

6.2.2. *Interactions between cultural heritage and other community capitals*

Using the language of capital to conceptualize the relation between cultural heritage and community resilience enables us to propose a theoretical framework of variables for analysing the interconnections between these two concepts. The relationship between cultural capital and resilience may not be straight-forward: it may be moderated or mediated by other forms of capital. As shown in this study, other factors may limit or increase the impact that heritage can have in practice. For example, the relative isolation of Sebudi from the provincial road (built capital) may have limited the impact of cultural heritage on resilience. In contrast, the willingness of policy-makers to link disaster-relief with conservation of local heritage may have increased resilience. Local leaders and village networks further reinforced the impact of heritage on resilience resulting in increased synergy amongst political, social, and cultural capital. Therefore, the interactions between cultural heritage (cultural capital) and other forms of community capital may be key to understanding the benefits that heritage can provide to resilience in practice. This is an important avenue for further research.

In general, causal relationships between independent variables (such as cultural capital) and dependent variables (resilience) can be analysed in three different ways: a) direct. b) moderated and, c) mediated. A mediator is a variable which "links" a cause to an effect. In contrast, a moderator "modifies" the causal relationship between a dependent and independent variable. It affects the strength of association between the dependent and independent variable (Wu and Zumbo, 2008). Different kinds of capital can moderate or mediate the relationship between cultural capital and resilience in different ways depending on the context. Drawing on scholarly literature about the association between cultural heritage and resilience and based on findings from this study, we hypothesize the following: (Fig. 3).

First, social capital (e.g., trust, norms, networks) influences community-level coordination and cooperation which in turns affects a communities ability to access resources for survival (Tierney, 2006). Social capital may therefore act as a mediator between cultural capital and resilience, for example, in communities which have a long history of community-led activism in heritage conservation. Second, economic capital (income, savings, investments) enables speedy recovery (Mayunga, 2007). Economic capital may therefore act as a moderator between cultural capital and resilience in communities where cultural capital is an important source of livelihood. Third, human capital (knowledge, information) can act as a repository of innovative solutions for increasing community resilience (Menéndez Blanco and Montes-Botella, 2017). Over the ages, communities in disaster-prone regions have often depended on traditional or indigenous forms of local knowledge for sailing through crisis (Nath et al., 2022). In such communities, knowledge may be associated with multiple sources of capital: human as well as cultural – some dimensions of such knowledge may be associated with cultural capital and the remaining dimensions of knowledge may be associated with human capital. Under such circumstances, cultural capital may sometimes mediate the association between human capital and resilience and sometimes human capital may mediate the relationship between cultural capital and resilience. Fourth, access to physical capital (roads, hospitals, materials) enables communities to absorb some of the harmful consequences of exposure to stresses and shocks by facilitating evacuation and recovery and therefore increases resilience (Mayunga, 2007). Higher physical capital also helps in conservation of cultural heritage. On the other hand, generation of economic capital via exploitation of cultural capital can generate resources for the construction and maintenance of physical capital (Ungar, 2011). Therefore, not only may physical capital mediate the association between cultural capital and resilience, the relationship between cultural capital and physical capital may actually be moderated by economic capital. Lastly, natural capital (ecosystem services) may provide solutions for nature-based community resilience (Bridges et al., 2015). Knowledge about nature-based community resilience may originate in local cultural capital. The ability to harness natural capital for increased resilience may therefore come from cultural capital i.e., the interaction between human capital and natural capital may moderate the relationship between cultural capital and resilience. Nonetheless,

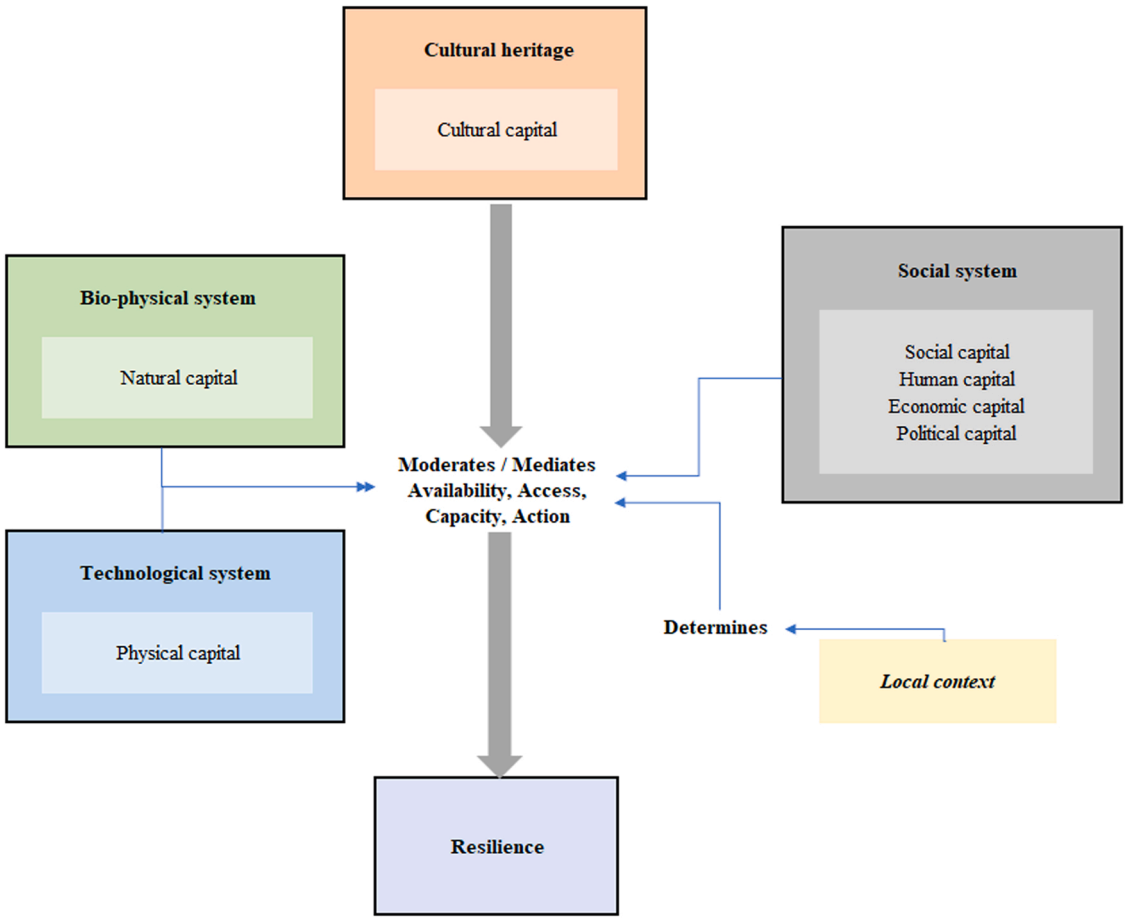


Fig. 3. Theoretical Framework for analysing the interactions between Resilience and Cultural heritage.

testing moderation and mediation effects requires that research design for data collection be conducted with sufficient care so that such effects can be properly captured (Wu and Zumbo, 2008). For quantitative methods: see Spencer et al. (2005) and Collins et al. (1998) for mediation; similarly see Cohen et al. (2014) and Frazier et al. (2004) for moderation. It should be noted that such interactions between capitals could be positive (reinforcing) or negative (resulting in barriers). This model of potential interactions provides an avenue to further investigate how cultural heritage and other community capitals and capacities may reinforce each other and stimulate community resilience in disaster-affected regions.

6.3. Conclusion

Our results confirm the hypothesis that cultural heritage has positive effects on community disaster resilience. We found most evidence for a positive impact on disaster preparedness and institutional aspects of resilience. Combining heritage-based and scientific information and risk communication, and developing preparedness that builds on existing local heritage and social infrastructure, was particularly useful. Impacts on other aspects of resilience (social, economic, infrastructural, absorption, recovery) were less clear-cut, likely due to existing socio-economic disadvantages and geographical isolation present in some sites. If combined with other community capitals – social, economic, political, human, physical, natural – cultural heritage presents a valuable resource that communities can draw on to build resilience in disaster-affected regions.

CRediT authorship contribution statement

Arjan Wardekker: Conceptualization, Methodology, Validation, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration. **Sanchayan Nath**: Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Supervision. **Tri Utami Handayaningsih**: Conceptualization, Methodology, Investigation, Formal analysis, Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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