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Vulnerability Assessment and Conservation of Heritage Sites in A Changing Climate

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ABSTRACT

Climate change and its related natural hazards have emerged as a significant threat to the conservation of heritage sites. Identifying the level of vulnerability to climate change at historic sites plays a vital role in the long term effectiveness of adaptation policies. This study discusses a set of factors that are involved in vulnerability assessment to improve adaptation policies at heritage sites. For this purpose, data were gathered through a systematic literature review and then analyzed using descriptive analysis method. The findings highlight that regional institutions should be informed about how notions of vulnerability are framed, recognizing specific cultural, social, and political contexts. Furthermore, the vulnerability assessments at heritage sites require education and knowledge exchange across a wide range of stakeholders, transdisciplinary research, and climate science.

Keywords: Climate Change, Cultural Heritage, Vulnerability Assessment, Sustainability.

INTRODUCTION

Conservation of cultural heritage sites has been accompanied by various challenges, including the pressure of globalization on historic cities [1], damaged as a result of major escalations of armed conflict [2], transformation of the historic landscape as a result of religious differences [3,4], methods of identifying cultural values [5], the measuring tools for authenticity and integrity [6,7], the efficiency of management plan [8], the quality of place image [9,10], and consequently the tourists perceptions and satisfaction of a heritage site [11].

Climate change has emerged as a new challenge to the long-term conservation of cultural heritage sites. Historic sites can be vulnerable to changes in weather patterns [12], not only limited to direct impacts on the built structure [13], but also having very indirect consequences like fragmentations of local community, loss of intangible characteristics [14], declining in tourists numbers, and disruption of socio-economic activities [15].

The World Heritage Committee at its 29th session in 2005 recognized that the impacts of climate change are affecting many cultural and natural heritage sites, and those impacts are likely to affect many more in the years ahead [16]. However, Climate change itself is a new challenge for international heritage organizations, and the solutions for the conservation of heritage sites are under development [17]. The effectiveness of adaptation policy is not visible in the short term and is dependent on the used methods for assessing climate vulnerability at historic sites. [18]. Therefore, this study discusses a set of factors that are involved in vulnerability assessment at cultural heritage sites.

Climate change and natural hazards

Observations show that the climate is changing fast, about ten times more quickly than natural changes in climate based on pale climatic observations of the changes that occurred since the end of the last ice age. Moreover, the evidence points to climate changes over the last half-century as being fundamentally due to human activities, notably the burning of fossil fuels and also land-use change, primarily through

deforestation. It is not surprising that many national and world leaders have concluded that climate change, often referred to as global warming in the media, has become one of the most significant issues facing humanity [19].

Climate change is transforming the likelihood and magnitude of natural hazards around the world and creating new vulnerabilities [20]. These hazards include heatwaves and their impacts on droughts and wildfires, severe precipitation and its effects on floods and significant snowfall events, and hurricanes.

It has become increasingly clear that our future depends on how we act to limit climate change [21]. For this purpose, science is the basis for improving responses to climate change by providing:
• Seeking to develop a cost-effective plan to diminish those impacts; motivation for acting so now rather than waiting;
• Awareness that such a plan must include both mitigation and adaptation;
• Knowledge of the sources of the offending emissions and the character of society's vulnerabilities that allows appropriate specificity in designing a plan.

In this way, we basically have three choices:
• Mitigation, referring to measures to reduce the pace and magnitude of the changes in the global climate being caused by human activities.
• Adaptation, meaning measures to limit the adverse impacts on human well-being resulting from the changes in climate that do occur.
• Suffering the adverse impacts and societal disruption that are not avoided by either mitigation or adaptation.

Impacts of climate change on cultural heritage sites

The vulnerability assessment of climate change on heritage sites must account for the complex interactions within and between natural, cultural and societal aspects. In this sense, climate change has direct and indirect impacts on natural and cultural heritage sites.

According to Colette et al. [17], the direct impacts of climate change on cultural sites mainly affect the structures of ancient buildings in different ways (Table 1). For instance:
• Archaeological evidence is preserved in the ground because it has reached a balance with the hydrological, chemical, and biological processes of the soil. Short and long cycles of change to these parameters may result in a more average level of durability of some sensitive classes of material.
• Historic buildings have greater intimacy with the ground than modern ones. They are more porous and draw water from the ground into their structure and lose it to the environment by surface evaporation. Their wall surfaces and floors are the points of exchange for these reactions. Increases in soil moisture might happen in more significant salt mobilization and consequent damaging crystallization on decorated surfaces through drying.
• Timber and other organic building materials may be subject to biological infestation, such as migration of pests in latitudes and altitudes that may not have been before concerned.

Potential threats would take many forms and would affect different types of heritage in different ways. Therefore we think of heritage sites in an integrated manner, including landscapes, buildings, and objects and collections. Consequently, heritage sites should be envisaged in a broader environment and link with landscape planning. There is a necessity for more research on the impacts of climate change on both the tangible heritage and the social and cultural processes that they are a part of it. In this sense, the Intergovernmental Panel on Climate Change (IPCC) has been provided objective information on climate change for policymakers. Their assessment reports have provided the technical, scientific, and socio-economic information on climate change, possible impacts, and responses.

A more complicated issue that will need underpinning by scientific research is that of documenting cumulative processes to complement events based data. Information needs to be disseminated on the

following specific areas of need:

- Climate change modeling and monitoring geared to heritage sites;
- Prediction of subsidence and heave caused by extreme weather events;
- Understanding of decay and damage mechanisms and remediation due to extreme weather;
- Understanding the effect of wind-driven rain at a local level which leads to severe damp penetration;
- Understanding the effect of wind-driven dust and pollutants at a local level leading to erosion and weathering;
- Understanding the effect of new pest migration and infestations, e.g., termites;
- Understanding the water-resistance of building materials and techniques;
- Assessment of the availability of stocks of renewable materials and the development of old technologies such as lime technology;
- Environmental performance of historic buildings under extreme weather;
- The interface between fragile and very robust materials.

Table 1. Climate change impacts on cultural heritage [17]

Climate indicator	Climate change risk	Impacts on cultural heritage
Moisture	• Intense rainfall • Flooding • Groundwater changes • Changes in soil chemistry • Changes in humidity cycles	• Damage due to faulty or inadequate water disposal systems • Physical changes to porous building materials and finishes due to rising damp
Temperature	• Extreme events, like heat waves, snow loading • Changes in freeze-thaw	Deterioration of facades due to thermal stress Damage inside brick, stone, ceramics that have got wet and frozen within material before drying
Sea-level rises	• Coastal flooding • Sea-water incursion	Coastal erosion Population migration Disruption of communities
Wind	• Wind-driven rain • Wind-transported salt • Wind-driven sand	Penetrative moisture into porous cultural heritage materials Static and dynamic loading of historical or archaeological structures
Desertification	• Drought • Heatwaves • Fall in the water table	Erosion Salt weathering Impact on health of the population Abandonment and collapse Loss of cultural memory
Biological effects	• The spread of existing and new species of insects • Changes to lichen colonies on buildings	The collapse of structural timber and timber finishes Changes in the appearance of landscapes
Pollution	• Changes in the	Stone recession by the

	deposition of pollutants	dissolution of carbonates Blackening of materials

Vulnerability assessment

A vulnerability assessment includes an analysis of the scope and severity of the potential impacts of climate change. The study of risk reduction requires a perception of the hazards, and a representation of the system's response when subjected to the hazards [22]. Vulnerability is an emerging concept for climate science and policy. Over the past decade, efforts to assess vulnerability to climate change triggered a process of theory development and assessment practice, which is also reflected in the reports of the Intergovernmental Panel on climate change (IPCC) [23].

Figure 1 presents a framework in which climate dynamics is viewed as a critical driver of change in social and biogeophysical environments. The frequency and magnitude of climate hazards are altered by changes in the climate state and have measurable impacts on cultural landscapes. The outcomes can be complicated, resulting from the direct and indirect effects of several climate and non-climate factors. Furthermore, the level of impact is altered by the system vulnerability to climate variability and change, and the risk involved is determined by the probability of the hazard occurring. Societal and environmental vulnerability to climate change is a function of the degree of exposure, the sensitivity of the system, and the capacity for adaptation.

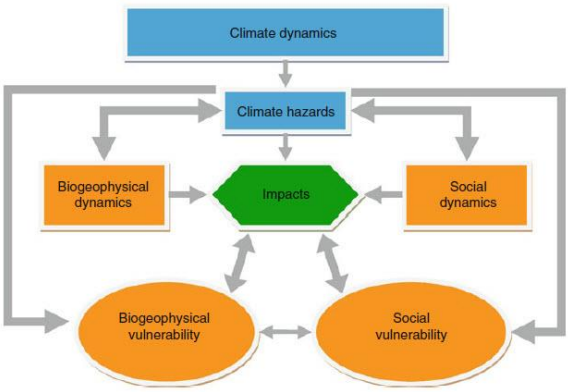

Figure 1. A conceptual framework for identifying and selecting indicators [24].

Besides, in some heritage sites, where vulnerability assessment and adaptation to climate change are more likely to be implemented because of available resources, there are few local solutions that can reduce the impacts of climate change [25]. For instance, managing coral reefs is complicated from a social and ecological perspective and requires holistic and practical systems dynamics planning [25,26]. In this case, local strategies could include understanding local regulations and laws surrounding the reefs and helping enforce these rules to ensure coral reef management [27].

At the cultural landscape, the first step to assess vulnerability is to define the scope of the proposed assessment, including the issues of interest and the assessment process to be used. The objective of this scoping effort is to focus on significant questions and issues and to use limited resources efficiently. The IPCC has outlined a general approach for scoping and problem definition [28]. The IPCC outline and Carter and de Rozan [29] make it possible to describe the steps that can be taken to determine the proper scope of an assessment. The steps are consisted of:

- Identify assessment goals, Define sectors to be studied,
- Select the study region,
- Select the time frame,
- Determine data needs,

- Develop the context for assessment, and;
- Develop a schedule.

Identify assessment goals

The overall objectives of a climate change vulnerability and adaptation assessment, as stated by the IPCC, are to

(1) Evaluate how climate affects human activities and natural systems and estimate uncertainties of these effects;

(2) Evaluate sensitivities, thresholds, and vulnerabilities of natural systems to likely scenarios of climate; and

(3) Identify possible adaptation and policy options.

These goals define broad objectives for an assessment. More detailed, country-specific goals also need to be identified. The following issues need to be considered:

- Identify who will use the outcomes of the assessment. For instance, heritage managers could use the work to evaluate policies for adapting to climate change. The scientific community could use the results to develop research plans. Results could also provide information for international cooperative efforts in climate change. Each of these goals could require different studies about cultural landscapes and analyses.
- Determine what information should be generated from the assessment. It is essential to consider what type of information would be the most useful to the site managers. This information will help to guide the type of analysis and the scope of detail.
- Determine what level of detail is necessary for vulnerability assessment. The type of results desired from the assessment should be determined. If the object is to develop a first-order estimate of the magnitude of climate change impacts and to develop conservation plans for more detailed studies, a relatively simple analysis process can be used. If the work is a follow-up study to other work, more detailed work needs to be organized, and a more rigorous analysis should be conduct.

It is crucial to identify the territory objectives early in the process to ensure the efficient allocation of limited resources.

Define sectors to be studied

The second step in the scoping process is to recognize sectors in the region that are most vulnerable to climate change and will have the most significant impact on the population and the economy.

When endeavoring to decide whether a region should include a particular sector in a vulnerability and adaptation assessment, the following questions can be asked:

- Is the sector a significant part of the cultural landscape and regional system? Examples include agriculture as a major (or minor) component of GNP, extensive (or limited) low-lying coastline areas, and extensive (or limited) natural forests.
- Do any current conditions indicate that the sector is especially sensitive to changes in climate? Examples include crops that are sensitive to changes in rainfall, coastal areas that flood regularly, and water supplies that are currently marginal or sporadic.
- Would a disruption in the sector because of climate change have a significant impact on human populations or economic activity?
- Is there a foreseeable benefit to taking some action to deal with climate change impacts on the sector in the short or medium time horizon?

If these questions can be answered affirmatively for a conservation sector, the issue should be considered for inclusion in a vulnerability and adaptation assessment. It would also be useful to rank the sectors in terms of importance to the vulnerability and adaptation issue to allow work to focus on high-priority sectors.

Select the study region

The selection of the study region is guided by the goals of the assessment and by sectors chosen for the study. The primary consideration for cultural landscapes are:

- Administrative units (e.g., district, town, province, state, and nation). These units are useful for dealing with social and economic issues. They are also convenient because boundaries are clearly defined.
- Geographic units (e.g., river basin, plain, mountain range, and lake regions). These units focus the assessment on areas closely related to a physical and biological perspective. The same type of impacts can be seen in the entire unit.
- Ecological zone (e.g., wetland, forest, moorland, and savannah). These units are useful for investigating impacts on a specific biological community.
- Climatic zone (e.g., desert, monsoon zone, and rain shadow area). These areas are likely to have similar climate change patterns.
- Sensitive regions (e.g., tree lines, ecotones, coastal zones, ecological niches, and marginal communities). These regions are likely to be especially sensitive to climate change. The first indications of impacts may show up in these areas because of their sensitivity.

In terms of climate change, the study of the cultural landscape can be selected by careful consideration of available data, including both physical information and socioeconomic data.

Select the time frame

The time frame used for vulnerability and adaptation assessments is generally long (20-100 years) because many of the impacts are not expected to become evident or significant in the short term. However, it is also vital to consider short-term issues (5-10 years). Consideration must be given to adaptation strategies that need to be implemented in the relatively short term in order to be effective in dealing with longterm problems. For example, if an analysis shows that sea-level rise in coastal sites will inundate large areas, and it is decided to construct seawalls to deal with the problem (like Venice), the planning and implementation of these measures must be started early.

Determine data needs

All of the determinations of scope addressed so far must be tempered with consideration of data availability. If sufficient data of reasonable quality are not available to use as a basis for an assessment, it is not necessary to carry out sophisticated quantitative analyses.

Countries are urged to review these data requirements and to determine the availability of the necessary information before committing to a vulnerability assessment in any of the sectors. Furthermore, the analytical methodology to be used in a vulnerability assessment in any sector should be selected based on whether the quality of the available data justifies the use of the approach. In the case of natural heritage sites, for example, the agricultural crop computer simulation models should not be used if sufficient information on soil classification, historical weather data, and current plant populations is not known. The alternative nonsimulation approaches might be more appropriate in areas with serious data deficiencies.

Develop the context for assessment

The next step in the scoping process is to develop the broader context of the assessment. Included in this activity is identifying other work (either completed or in progress) that might support the assessment, developing a coordinated and well-managed project, and determining the extent to which the results will be integrated with other work, once completed. These factors help establish the role that the assessment will play in the regional decision-making process.

Of particular importance is identifying "stakeholders" in the outcome of the assessment. Some members

of the community are either directly or indirectly involved in the assessment process. Included in this group are policymakers, climate researchers, government officials, educational leaders, nongovernment organizations, and the general public. Each of these groups may have a different interest in the result of the work. To the extent practicable, the interests of stakeholders should be considered when designing the scope of the assessment.

Important considerations in addressing the interests of the stakeholders are:
(1) Their input to the assessment will be obtained and
(2) The results of the assessment will be conveyed to them.
Of necessity, these issues will need to be addressed in different ways in each country and region.

In some instances, a region may wish to convene a formal advisory committee with representatives from each of the interested groups. This committee can be briefed on the type of assessment to be done, the methodologies to be used, and the expected results. The committee can meet regularly during the assessment to review intermediate results and to provide feedback to the analysts. An alternative would be to approach each stakeholder group separately to solicit input to the assessment and obtain a reaction to the results.

Whatever technique is used, it is important that the analysis receive exposure to a wide range of stakeholder and decision-making groups. The development of a broad base of input will enhance the ability of a cultural landscape to implement the recommendations resulting from the vulnerability assessment.

Develop a schedule

Table 2 presents a sample schedule for completing the assessment in a cultural landscape. This schedule should be considered as a general guide and should be modified to suit the specifications required by individual countries.

Table 2. Sample Schedule for a Vulnerability and Adaptation Assessment in a Cultural Landscape

Step	Action
1	Define the scope of problem and assessment process and methods
2	Select and develop scenarios
3	Conduct vulnerability and adaptation assessment for each conservation sector
4	Present workshop in the region on preliminary vulnerability results and discuss integration and adaptation options
5	Integrate results across heritage sectors and analyze the adaptation policy, including presenting an adaptation workshop
6	Draft vulnerability and adaptation report; present results for review
7	Present workshop in the territory on results
8	Finalize results and report

In this model, the communication between planning institutions, stakeholders, and researchers would be essential in developing the adaptation policies at natural and cultural heritage sites. Such communication not only protects the heritage sites against climate change, in a broader vision, it also enhances the preparedness of cultural landscape to natural disasters [30].

SCOPE

This article addresses the vulnerability of heritage sites on a regional scale. We explain how different heritage sectors should be identified and involved in this process. Finally, this study presents a guideline

for vulnerability assessment at heritage sites.

METHOD

This study explains a set of factors that are involved in vulnerability assessment to improve adaptation policies at heritage sites. For this purpose, data were gathered through a systematic literature review and then analyzed using descriptive analysis method.

CONCLUSION

Responding adequately to climate change requires a collective effort of stakeholders and community. It requires integrating and synthesizing the scientific understanding of climate change, models to predict the impact of climate change on the natural and cultural heritage sites, an understanding of the implications of climate change for risk reduction. As discussed in this paper, interdisciplinary research and discussions among the different heritage sectors and stakeholders should aim to develop successful strategies that are technically sound and that promote the sustainability of cultural landscapes. In this sense, heritage adaptation policies should focus on landscape and territorial scales to inform natural and cultural resources and facility management. The key factor in redefining the protection policies include the synthesis of existing information, research, inventory and monitoring, and delivery of relevant information to managers and stakeholders to support decision-making. This approach encompasses four-step: connecting impacts and information; understanding scope, integrating practice; and learning and sharing. This study also points to the areas at the regional scale where further research is needed for our collective success in vulnerability assessment at heritage sites.

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