

## Impact of climate change on Immovable Monuments of Cultural Heritage

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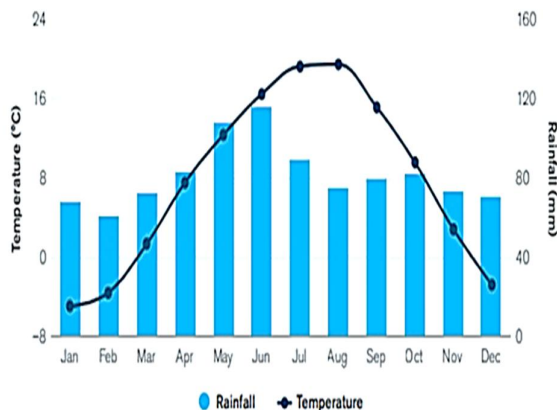
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**Abstract** Climate change represents a significant threat to immovable cultural heritage sites globally, impacting buildings in diverse ways. This article delves into the complex effects of climate change on structures, emphasizing the direct risks posed by extreme weather events such as hurricanes, floods, and heat waves. These events can lead to structural damage, water intrusion, mold growth, and other forms of both tangible and intangible harm. Additionally, climate change can severely compromise and, in some instances, destroy building materials and foundations.

Mitigating these challenges requires building climate-resilient buildings or adapting existing ones as much as possible, which is achieved by integrating robust materials and construction techniques that can withstand extreme weather, strengthening drainage infrastructure, and using energy-efficient designs to reduce environmental impact and reduce energy demand. By implementing proactive measures, buildings can better withstand the aggressive effects of climate change, ensuring the preservation and longevity of cultural heritage sites around the world.

**Key words:** climate change, cultural heritage sites, buildings, impacts, monument, temperature, precipitation, sea level rise, Vulnerability, map, immovable monument.

FIGURE 2. Average monthly temperature and rainfall in Georgia (1991-2020)<sup>19</sup>



Temperature extremes result in thermal expansion and contraction of building materials, causing cracks and structural weakening. Additionally, increased rainfall intensity or prolonged drought can lead to soil and foundation instability. Climate-induced erosion further destabilizes buildings situated on slopes or in landslide-prone areas. The concurrent vulnerability of various infrastructure components, including drainage and sewerage systems crucial to building sustainability, indirectly exacerbates these impacts.

### Introduction

Climate change presents a significant threat to immovable cultural heritage sites worldwide. The impacts on buildings are diverse and severe. Extreme weather events such as hurricanes, floods, and heat waves can inflict substantial damage. Hurricanes and storms can cause structural damage, floods can lead to water intrusion and mold growth, and heat waves can result in the deformation of building materials. Coastal buildings are particularly vulnerable to sea level rise, which can cause erosion, flooding, and saltwater intrusion, damaging both materials and foundations. Temperature extremes can cause thermal expansion and contraction of building materials, leading to cracks and structural weakening. Additionally, increased demand on cooling systems during high temperatures can significantly affect energy consumption.



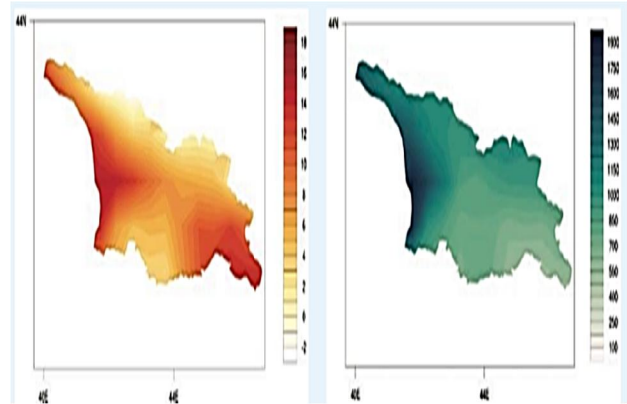
Changes in precipitation, such as increased rainfall intensity or longer periods of drought, can affect buildings. Drought can cause soil compaction and foundation compaction. Erosion and soil instability are also crucial factors. Climate change may increase erosion and soil instability, affecting the stability of buildings built on slopes or in landslide-prone regions and their structural sustainability.

Currently existing infrastructure is increasingly vulnerable to the effects of climate change induced by global warming. For instance, drainage and sewerage systems, which are crucial for the sustainability of buildings, are often not fully adapted to changing conditions, leading to indirect impacts on structural integrity. To mitigate these effects, buildings can be designed and constructed with climate resilience in mind. This includes using materials and construction techniques that withstand extreme weather, enhancing drainage systems, and adopting energy-efficient designs to minimize environmental impact buildings.

### Main Part

Assessing the impact of climate change on immovable cultural heritage requires a multidisciplinary approach that combines scientific research, cultural heritage expertise and community engagement. Here are some research methods that are commonly used for this purpose:

1. Climate Modeling: Climate models can be used to predict future climate scenarios, including changes in temperature, precipitation patterns, sea level rise, and extreme weather events. These models help predict potential climate-related threats to cultural heritage sites.



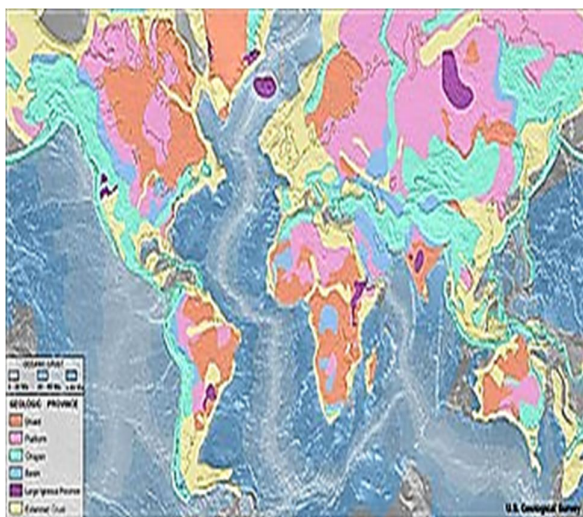
2. Historical Data Analysis: Examine historical climate data to determine trends in temperature, precipitation, storm frequency, and sea level rise. Historical records can provide information about past climate impacts on cultural heritage and predict future ones.
3. Site surveys and monitoring: Field surveys and monitoring programs should be carried out to assess the current condition of cultural heritage sites and to confirm any existing damage or vulnerability. Monitoring programs may include the use of sensors, remote sensing technologies, and visual inspections.
4. Risk assessment: Using all the factors at our disposal, we should conduct risk assessments to assess the sensitivity of cultural heritage sites to various climate-related hazards, such as floods, erosion, extreme temperatures and forest fires. Factors such as site location, building materials, structural

<sup>2</sup>NF P92-502 Building materials fire reaction tests  
<https://www.laboratoar.com/ka/testler/urun->

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integrity, and environmental conditions may be considered in the evaluation.

5. Vulnerability Mapping: This issue involves the creation of vulnerability maps in cultural heritage sites to identify high-risk areas and prioritize adaptation and mitigation efforts. Maps can include data on climate hazards, site characteristics, cultural significance, and causes of concern for stakeholders. Climate change vulnerability mapping involves assessing and understanding the factors that contribute to the vulnerability of a community or region to the impacts of climate change. Here are the basic steps and considerations for map security.



One of the primary issues is the identification of climate hazards. Specific climate hazards relevant to the study region need to be identified. Issues may include rising temperatures, changes in pre-existing precipitation patterns, rising sea levels, extreme weather events (hurricanes, floods, droughts), etc.

The next step in vulnerability mapping is exposure assessment, which involves determining how exposed a community or region is to these climate hazards. This involves mapping the geographic distribution and intensity of each hazard.

Depending on the content and purpose, they will distinguish:

- specifically geological,
- anthropogenic (Quaternary) sediments,
- tectonic,
- lithological,
- formative,
- paleogeographical,
- metamorphic facies,
- mineral,
- hydrogeological,

Pronozuli et al. Maps. By analyzing which maps of Mokvledonbi are obtained.

U. A map drawn by Smith

We are continuing our work with a sensitivity assessment report. It is necessary to assess the sensitivity of a community or region to identified climate hazards. This includes assessing how sensitive physical, social, economic and environmental factors are to climate change impacts. Factors such as infrastructure, ecosystems, health, economics and demographics need to be considered

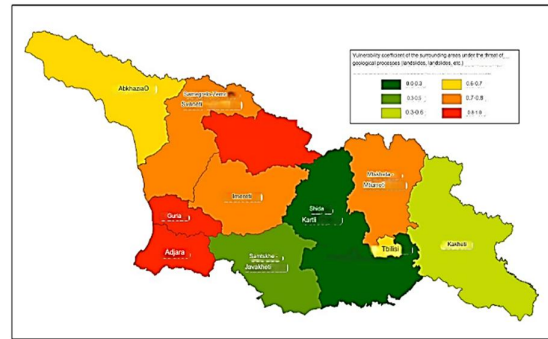


Assessment of adaptive capacity, which refers to the adaptive capacity of a community or region, which refers to its ability to cope with



and respond to the impacts of climate change. Factors such as governance, institutions, financial resources, technology, education, social networks and community cohesion play a critical role in determining adaptive capacity. Data collection and analysis Collect relevant data through field surveys, remote sensing, historical records, stakeholder interviews and other methods. Analyze data to identify patterns and trends related to vulnerabilities. It is recommended that preliminary maps be created that integrate the collected information on exposure, sensitivity and adaptability. Geographic Information Systems (GIS) can be particularly useful for visualizing spatial data and identifying areas of high vulnerability. Stakeholder Engagement Engage stakeholders throughout the process to ensure local knowledge and perspectives are integrated into the vulnerability assessment. This can help validate findings and ensure that adaptation strategies are contextually appropriate.

on the development agenda and ensure coordinated action.



Map 4.9.3: Vulnerability of settlements to geological hazards by country

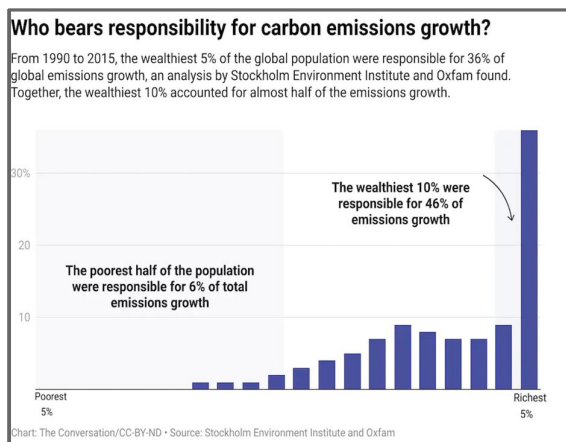
Mapping vulnerability to climate change is a dynamic process that requires constant monitoring and adaptation as new data become available and climate change continues. Effective vulnerability mapping can inform targeted interventions and policies that enhance resilience and reduce the impacts of climate change on vulnerable communities.

Hydrological and geotechnical studies: Conduct hydrological and geotechnical studies to assess the impact of climate change on soil stability, groundwater levels and drainage systems at cultural heritage sites. These studies help identify potential risks of erosion, landslides and water damage.

Cultural Landscape Analysis: Landscape analysis of cultural heritage sites to understand how climate change may alter their ecological, aesthetic and social value. Consider the interaction of natural and cultural elements within a landscape.

Community Engagement and Stakeholder Consultation: Local communities, subject matter experts, professionals, government agencies and other stakeholders should be involved in the research process from the outset. Their knowledge and experience are essential for understanding the cultural significance of heritage sites and for developing effective adaptation strategies.

Archaeological and Architectural Documentation: Conduct archaeological and architectural surveys to document the cultural heritage of vulnerable sites and assess the potential impacts of climate change on archaeological remains, historic buildings and

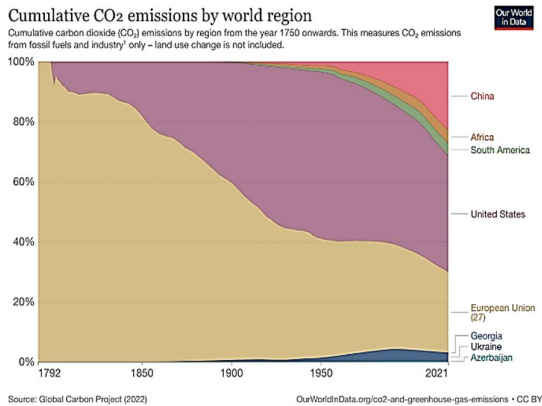


Risk assessment should be combined Vulnerability mapping with risk assessment to prioritize actions and interventions. Identify vulnerability hotspots where immediate action may be needed to reduce risks and improve resilience.

Scenario planning, which involves considering future climate scenarios to predict how vulnerability might evolve over time. It helps to plan adaptive strategies that are robust and flexible.

Integrating policy and planning Ensure that vulnerability mapping is integrated into local, regional and national policy and planning processes. This can help put climate adaptation

monuments.



Using a combination of these research methods, scientists, scholars and heritage practitioners can gain a comprehensive understanding of the impacts of climate change on immovable cultural heritage and develop strategies to protect and preserve these invaluable assets for future generations.

### Conclusions

In conclusion, assessing the impact of climate change on cultural heritage requires a comprehensive and interdisciplinary approach that integrates scientific research, cultural knowledge, and community engagement. By utilizing climate modeling, historical data analysis, site monitoring, risk assessment, vulnerability mapping, hydrological and geological analysis, cultural landscape assessment, stakeholder consultation, and archaeological documentation, experts can effectively evaluate the vulnerability of cultural heritage sites. This multifaceted approach not only enhances our understanding of climate change effects but also provides adaptive strategies crucial for preserving our diverse cultural heritage amidst environmental challenges. Bringing together scientists, scholars, and heritage practitioners, this collaborative effort aims to safeguard our shared cultural heritage for future generations.

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