

Assessment of the factors affecting the physical resilience of Bamiyan cultural heritage against climate change

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Keywords: *Bamiyan — Climate change — Natural hazards — Cultural heritage — Physical resilience*

CHNT Reference: Heidari, A. and Salehi, M.M. (2021). 'Assessment of the factors affecting the physical resilience of Bamiyan cultural heritage against climate change', in CHNT – ICOMOS Editorial board. *Proceedings of the 26th International Conference on Cultural Heritage and New Technologies*. Heidelberg: Propylaeum.

DOI: xxxxxxx.

Introduction

Climate change is one of the greatest challenges which the planet earth is facing in 21st Century. The reason for this change is global warming which is positively growing in recent decades and have had numerous direct and indirect effects on the urban and non-urban areas especially on historical cities. Attention to the historical cities and cultural heritage due to their vulnerability and cultural values has special importance. In the meantime, Afghanistan is categorized as a vulnerable country against natural disasters and climate change. In spite of valuable historical monuments and cultural heritage with a long history in Afghanistan, there is not still a great number of researches done in this regard. In addition, the four decades of war and mismanagement have led to a destroyed environment and significantly decreased the resistance of urban and rural societies against climate change driven natural disasters. Hence, climate resilience is one of the critical solutions which states the abilities and capacity of a city for responding to the damages originated from climate change driven natural hazards and severe weather conditions (UN-DESA, 2017). In this regard, the fundamental reasons for this vulnerability against climate change and natural disasters should be recognized so that solutions for improvement of resistance and climate resilience can be suggested.

Research objectives

- Recognizing the climate change effects in Bamiyan
- Studying the effects of climate change on the resilience of Bamiyan's cultural heritage
- Recognizing solutions for decreasing the vulnerability and increasing physical resilience of the monuments as parts of Bamiyan's cultural heritage against climate change driven natural hazards

Methodology

The methodology used for this research is qualitative-analytical by an emphasis on library-based research and can also be categorized as a functional research. The historical city of Bamiyan has a high importance due to its historical and geographical situation, as well as the situation of this city against natural disasters and damages like flood, raised temperature, avalanche and draught. Consequently, studying the mentioned natural hazards and solutions for increasing the climate resilience against climate change driven natural risks in Bamiyan is of high importance. So, after studying the climate change driven factors impacting the physical resilience of Bamiyan's monuments and by considering the available maps and the damages which might be arisen from the mentioned risks, and their effects on the studied monuments including remains of two Buddha's statues (Shamama and Salsal), Kakrak valley, Kafari fort, Ghulghola city, and Zohhak city, some solutions for enhancing climate resilience in these areas were suggested.

Case study

Afghanistan is the 11th most vulnerable country impacted by the climate change effects (Andre and Laubin, 2017) and Bamiyan as one of its ancient cities is located in Afghanistan's central highlands. Competition over and mismanagement of the province's limited arable land has resulted in widespread soil erosion, the denuding of natural vegetation, and degradation of rangelands. Coupled with these environmental issues is an increased risk of natural disasters such as flood and drought, particularly as a result of climate change (UNEP, 2017) (Figure 1).

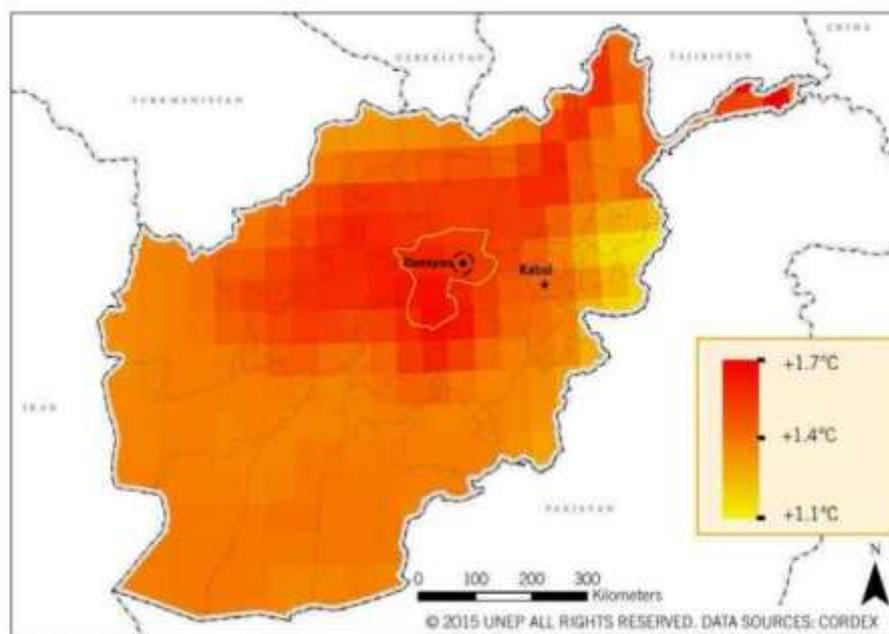


Fig. 1. Map of areas under drought caused by temperature hike (© 2015 UNEP, Data sources: CORDEX)

Results and discussion

The new forecasts of climate change show that Afghanistan's raining level will remain relatively constant till year 2100, however, the general temperature's hike in all over the country leads into rising evaporation which cannot be compensated by inadequate raining (NEPA, 2017). Therefore, it will

have a negative effect on water resources access and cycle, which increase the risks of vegetation degradation, desertification, erosion, floods, avalanche, and landslide. In addition, temperature's hike begins glacial melting in Hindukush area which negatively affects underwater resources (NEPA, 2017).

The library research and international institutes' reports confirm that the most important consequences of climate change in Bamiyan City are intensified level of climate disasters (temperature's hike, draught, raining degradation, landslides and avalanches) which will adversely affect this historical and valuable area. Thus, the factors which are caused by climate change are recognized and studied based on the aerial photography, satellite images, Bamiyan topographical maps, and location of monuments and historical places and the results are included in the Table 1.

Table 1. Climate change effects on Bamiyan's historical monuments

Climate change effect			
Temperature hike	Drought	Natural hazards due to climate change	<p>According to forecasts, the heights of Afghanistan, such as Bamiyan, will face a 1.6 ° C increase in temperature in the next few decades (UNEP, 2017).</p> <p>Drought: One of the effects of climate change in Afghanistan is the increase in droughts due to increased heat and changes in rainfall. In addition, poor water resources management, lack of proper planning and preparation, lack of water storage and lack of awareness of drought-resistant farming methods and ultimately increasing poverty are some of the factors that greatly increase the drought effects. Moreover, very dry lands have less water absorption capacity during heavy rains, leading to increased risk of soil erosion, desertification, and floods.</p>
		Impacts on Bamiyan's historical monuments	<p>Drought and loss of plants and green areas will have a great negative impact on the urban landscape of Bamiyan and the historical sites of Bamiyan. The presence of elements such as water and plants are inseparable parts of architecture, however, by the increase in drought, important features of the landscape will be taken from historical buildings and will reduce the targeted use of ecotourism capacities.</p>
		Mitigation plan	<ol style="list-style-type: none"> 1. Preservation and maintenance, revival, and improvement of canals 2. Management of catchments, including grasslands, forests, and reforestation
Fluctuation in Atmospheric precipitation	Landslides	Natural hazards due to climate change	<p>The effects of landslides, like the effects of floods, are often very serious due to the high risk. Five factors of lithology, slope, fault, road, and rainfall are effective factors in landslides. In addition, environmental degradation is a key factor in landslides, because deforestation, soil erosion and land degradation cause instability on hillsides and mountains and increase the risk of landslides.</p>
		Impacts on Bamiyan's historical monuments	<p>The landslide is causing more and more destruction of worn-out texture and physical damage to Buddha statues and areas around Bamiyan historical monuments.</p>
		Mitigation plan	<ol style="list-style-type: none"> 1. Strengthening slopes and controlling erosion and soil drainage by methods like nailing system of stabilization or resistant synthetic carpets 2. Planning improvement to prevent and limit the construction of houses in danger zones
	Flood	Natural hazards due to climate change	<p>Flood: Following global warming and global climate change, rainfall in Bamiyan will also change. But it is important to note that with the average annual temperature rise in Bamiyan, anticipated to be around 1.6° C by 2050 compared to 2021 (UNEP, 2017), precipitations which used to be snowfalls will turn into rain, or snow will melt sooner than in the past, which could result in unpredictable and devastating floods. Environmental degradation (deforestation and grassland degradation) increases the severity of floods, and</p>

Avalanche		lack of planning and insufficient infrastructure to reduce the effects of floods can lead to disaster.
	Impacts on Bamiyan's historical monuments	According to the location of the studied monuments against the rivers (Figure 2), in case of a flood, the remains of Buddha statues are not in great danger because their distance and height from the Bamiyan River is high; The distance from Bamiyan river is about 700 meters and their height difference with Bamiyan river is about 50 meters. Kakrak valley, Zohhak city, Gholghulah city and Kafari fort are also located at a relatively high altitude of the Bamiyan river, so they are less likely to be destroyed in the floods. Floods will have devastating effects on residential buildings located at lower altitudes, and measures can be taken to reduce damage in the unforeseen floods.
	Mitigation plan	<ol style="list-style-type: none"> 1. Systems for monitoring, forecasting and warning of heavy rains and floods. 2. To divert the flood route from historical monuments, in suitable places, obstacles such as stone fences, tunnels, and diversion dams are some of the measures that can be considered.
	Natural hazards due to climate change	Avalanche: Increased winter precipitation in the form of snow and rise in air temperature increases the probability of avalanche. Factors influencing the occurrence of avalanche include geology, faults and earthquakes, lack of vegetation, slope amount, slope direction, altitude, precipitation, and temperature. Among the topographic factors, slope plays an important role in the occurrence of avalanche. Most avalanches occur on slopes of 30 to 45 degrees (Qanavati and Karimi, 2009). Regarding the slope of hillsides near the studied monuments (the remains of Buddha statues, Kakark valley, Ghulgholah city, Kafari fort and Zohhak city), none of them are seriously exposed to avalanche.
	Mitigation plan	<ol style="list-style-type: none"> 1. Rehabilitation of grasslands, forests and tree fields 2. Warning systems for risky areas 3. Structures to divert and prevent the entry of avalanche, snow walls, or snow barriers

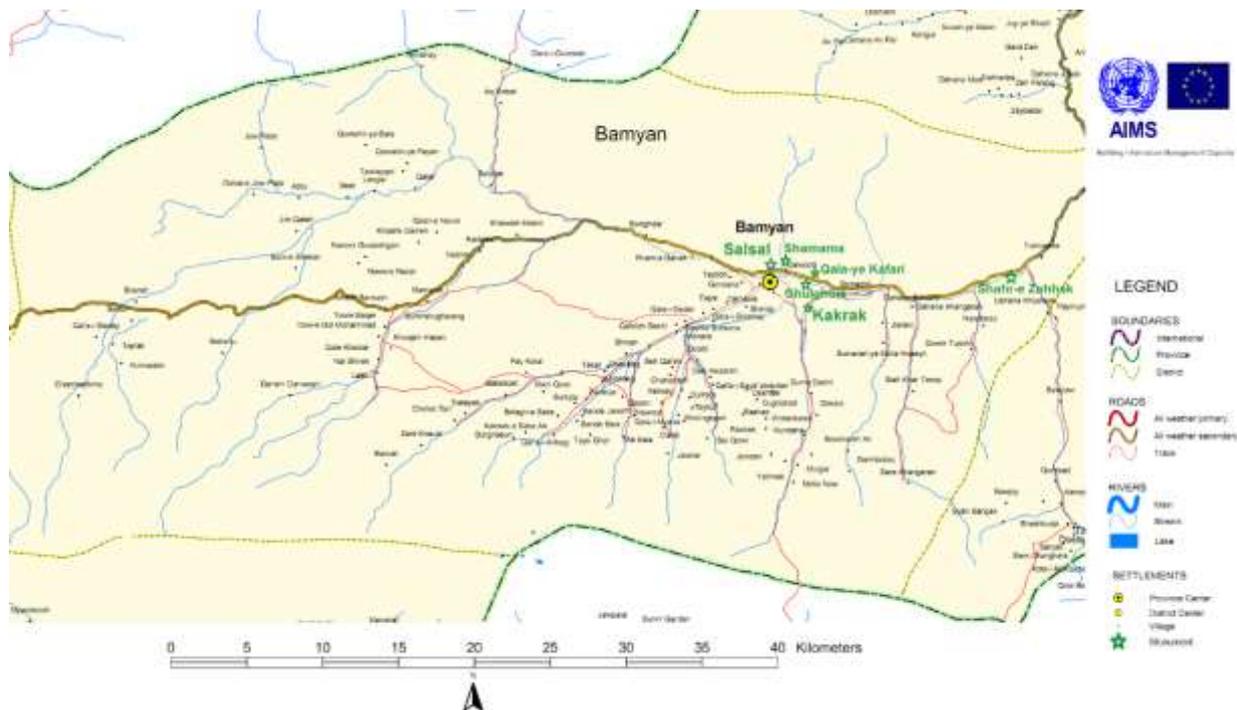


Fig. 2. Map of rivers and the studied historical monuments

Conclusion

The climate change has several effects on the historical places and cultural heritage. Bamiyan as one of the oldest historical cities of Afghanistan with several ancient places is being affected and will be affected more in the future by the climate change driven natural hazards. In this study, the condition of six ancient monuments were studied against the effects of natural hazards caused by climate change including drought, landslide, flood, and avalanche. Then plans were proposed to mitigate the adverse effects of the hazards (Table 1).

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