

## Global Climate Change: Every Cultural Site at Risk?

Despite the 150,000-year pedigree of modern humans, the ice age that ended about 12,000 years ago forms a left parenthesis to virtually all of the major constructive activity of humankind. As much as we may cherish our surviving architectural and archaeological heritage, its destiny, like ours, is dust. Yet it is precisely this ephemerality that makes us appreciate the richness of human existence and the consequent value of preserving diverse exemplars of past cultural expressions. It is, therefore, with no trace of fatalism that we confront an environmental challenge beyond our collective experience, one rooted in divisive power politics, yet requiring unified action on a previously unimaginable scale.

Growing scientific consensus on the existence of global warming has led to a shift in public and scholarly discourse toward consideration of its likely effects. While it is clear that the impending challenges to heritage preservation posed by global climate change will pale next to the human and environmental costs, it is nevertheless incumbent upon heritage specialists to anticipate and adapt to these problems to the extent possible. In keeping with the theme of *Heritage at Risk*, my aim is to outline the major adverse impacts of global climate change on cultural heritage.

It is ironic that the combustion of carbonized life-forms - themselves victims of past environmental catastrophe - constitutes the principal threat to present-day life on earth. The accumulation of "greenhouse gases" - carbon dioxide, methane and nitrous oxide - caused by the burning of fossil fuels, and to a lesser extent, deforestation, trap heat within the earth's atmosphere. The ability of the earth to retain heat is critical to its long-term equilibrium, but too much heat retention leads to rising mean global temperatures, or global warming. Among the evidence for a recent warming trend is the observation that eleven of the last twelve years rank among the twelve years with highest average global surface temperature since 1850, when reliable records began (IPCC 2007a).

The scope and complexity of the probable effects of global warming defy precise estimation. The repercussions will cascade across time and space, varying with local conditions and future production or reduction of greenhouse gases. The Intergovernmental Panel on Climate Change (IPCC), the leading relevant international scientific research group, couches their projections in terms of competing scenarios. To provide such multi-track analyses specifically for cultural heritage is beyond the available data and the capabilities of the author. Here we simply consider direct, environmental and indirect, social impacts.

The main climate change parameters affecting cultural heritage are temperature change, atmospheric moisture change, sea level rise, wind, desertification, pollution and biological infestation (WHC 2006). Rising temperatures are melting polar and high altitude ice and snow and are causing the thermal expansion of seawater, resulting in an uneven global increase in moisture. This supercharging of the hydrologic cycle results generally in higher humidity, greater precipitation, higher sea levels, and more groundwater. Yet patterns of oceanic and atmospheric circulation cause some regions, particularly in the Tropics and Subtropics, to experience drier conditions accompanied by heat waves, drought and wildfires. A further outcome of higher temperatures and atmospheric moisture content is an increase in the frequency and severity of storm events. The resulting changes in seasonality, the availability of food and habitat, biodiversity, nutrient cycling, stress, disease vectors and other factors will have increasingly profound consequences for the composition, distribution and survival of biotic communities around the world.

According to the IPCC, global mean temperatures are expected to rise by 1.4 to 5.8° C by 2100 (WHC 2006). This increase will result in more extreme seasonal heating and cooling, altering the severity and periodicity of freeze/thaw and wet/dry cycles. This leads to problems for buildings such as biochemical deterioration, damage due to

water infiltration and freezing, and frost damage. Structures at the Indus Valley site of Moenjodaro, Pakistan, for example, are suffering damage due to thermal stress. The stratigraphy and integrity of archaeological sites are prone to deterioration caused by freeze/thaw-related ground movement and to decomposition due to the introduction of microbes to previously frozen environments. A recent 2° C temperature increase observed in mountainous southern Siberia, for instance, portends the thawing and destruction of the contents of 1,500-year old Scythian burial mounds (WHC 2007).

Atmospheric moisture change threatens cultural heritage in a multitude of ways. It is associated with increased humidity, rainfall and flooding; glacial lake outburst floods, changes in ground water and water tables; and altered soil chemistry. Resultant problems include rising damp, salinisation, erosion, subsidence, waterlogging, mold, ground heave, corrosion of metals, and deterioration of materials due to relative humidity shock. Increasingly heavy rainfall is implicated in subterranean erosion of Palatine Hill in Rome, and structural deterioration of earthen architecture at early Buddhist temple sites in Ladakh, India; the colonial town of Coro, Venezuela; and the archaeological sites of Chan Chan and Túcume in Peru (WMF 2007). Subsurface archaeological remains are also increasingly affected by erosion, chemical alteration, and the introduction of waterborne agents to previously desiccated or anaerobic environments. The melting of coastal sea ice is subjecting archaeological sites and historic structures in Arctic North America to high levels of storm surge and wave action, causing their loss due to erosion.

Climbing global temperatures are predicted to result in a sea level rise of .09 to .88m by 2100 (WHC 2006). Not only does this spell disaster for low-lying coastal areas and islands, but it also presents sites and structures with dangers due to storm surge, erosion by wave action and the incursion of salt water. Well-known examples of World Heritage Sites for which sea level rise is a looming menace include historic Venice and Westminster Palace, the Tower of London and the historic ensemble at Greenwich in London. Shoreline heritage properties in places such as Great Britain, western North America, Australia, New Zealand, Oceania, and western Africa are increasingly subject to damage by coastal erosion.

Changes in the frequency, severity and timing of extreme weather events associated with GCC will expose structures to potentially damaging wind and wind-driven salt, sand and rain. These can erode surfaces, penetrate porous materials, and cause static and dynamic loading (WHC 2006). In a 2005 survey of World Heritage States Parties, the most frequently cited threat to cultural properties was hurricanes, storms and lightning (WHC 2006). Recent severe storm episodes impacting immovable heritage include Hurricane Katrina, which damaged or destroyed thousands of historic buildings in southeastern USA, the 2006 flash flooding of the twelfth-century site of Sukhothai in Thailand, the 2002 inundation of the historic center of Prague, and the 1994 flooding of the Citadel of Alessandria in northwest Italy (ICOMOS 2005).

The chief danger to historic structures and archaeological resources in some areas will be the lack, rather than the surfeit, of water. Heat and drought cause evaporation and lowering of water tables, drying out structural materials and exposing them to salt weathering. Salt efflorescence is a major problem at Moenjodaro in the Indus Valley, Pakistan, for example. Notable examples of the desertification of heritage sites include the fifteenth/sixteenth century mosques of Timbuktu, Mali and the Chinguetti Mosque, Mauritania (WHC 2007).

According to the recent World Heritage Report on climate change and world heritage, the deleterious effects of global climate change

and airborne pollutants on stone and metal is mutually reinforcing. Increasing levels of atmospheric sulphur dioxide and nitrogen oxides (one of which is nitrous oxide, a greenhouse gas), caused by the burning of fossil fuels, are producing higher incidences of acid rain. While acid rain is not causally related to global warming, the effects of acid rain combine with the effects of climate change to hasten processes of decay. Airborne pollutants and acid rain are known to be damaging monuments at the Pre-Columbian site of El Tajin in Mexico, the petroglyphs of the Dampier Rock Art Complex in Australia, and grave markers at the Cimitero Acattolico in Rome, Italy (WMF 2007).

Global temperature increases lead to the spread of insects and other potentially damaging organisms into previously inhospitable areas, putting organic materials at risk. In addition to the spread of invasive pests, global warming will facilitate the proliferation of potentially harmful indigenous organisms, including fungi, mold and insects, as they expand their range and adapt to changing conditions. The wooden structures of Omo Hada in Indonesia and the woodwork of buildings in the Sonargon historic complex in Bangladesh are both included in the World Monuments Watch List of the 100 Most Endangered Sites due to biological/insect infestation. Although these cases cannot be attributed to climate change, they represent situations likely to be encountered at ever-higher latitudes in the future. It is likely that rising oceanic temperatures will permit expansion of the wood-eating teredo worm, whose intolerance of cold waters explains the remarkable preservation of shipwrecks such as the Swedish warship Vasa.

The effects of global climate change will inevitably extend to landscapes and their associations with heritage properties. Not only is there the potential to impair the settings and constitutive values of significant places, but there is also a risk of losing traditional building materials. The original relationship between the design, materials and use of historic buildings, on one hand, and local climatic conditions, on the other, is susceptible to environmental perturbations that may result in abandonment, demolition or unsympathetic alteration.

While the direct, environmental impacts of global climate change are profound, the human responses to these changes may pose the greatest threat to cultural heritage. The eventual loss of glacial meltwater, the incursion of salt water and increased evaporation of fresh water will expose hundreds of millions of people to shortages of potable water. Extensive changes in ecosystem functioning will differentially impact agriculture, fisheries, animal husbandry, forestry and other forms of food production. Ecological changes will result in the widespread movement, behavioral change and/or extinction of plant and animal species, with far-reaching consequences for human subsistence practices. Rising sea levels threaten millions of people living on low islands and in coastal areas, such as the mega-deltas of Asia and Africa. Increased incidence of environmental disasters, including floods, fires, droughts and hurricanes, as well as malnutrition, cardiovascular, respiratory and infectious diseases make up a sampling of the health hazards associated with global climate change.

It is sobering to reflect on the consequences of even one of these scenarios, let alone a combination of them. Economic destabilization, disinvestment, modified land use, local and regional conflict and mass migration are plausible outcomes. Current patterns of socio-cultural dislocation associated with rural-urban migration, industrialization and economic polarization will be exacerbated by these shifts, leading to increases in looting, the insensitive exploitation or ideologically-motivated vandalism of heritage sites, the redevelopment of urban cores and the relative devaluation of land for its intangible qualities.

Tragically, the negative consequences of global warming will be felt most strongly in the countries least equipped to deal with them: rainfall patterns are shifting precipitation away from the equator, toward the poles; one quarter of the African continent is already in the

process of desertification (WHC 2007). While wealthier nations are investing in water desalinization facilities, flood barriers and drought-resistant seeds, African countries - which collectively are responsible for just 3% of total greenhouse gas emissions - lack the resources for such protective measures (Revkin 2007).

There is growing appreciation among heritage professionals that the fates of tangible and intangible heritage are intertwined. Given the differential persistence of indigenous cultural groups in the remoter parts of less-developed countries, and the disproportionate impact of global climate change on many of those same countries, there is reason for alarm. Just as global warming puts already marginal ecosystems and species at greatest risk, so too does it especially imperil those cultures and sites with the least room for maneuver.

Everywhere, global environmental change will prompt new human adaptive strategies that may conflict with traditional beliefs regarding the social role of sacred sites, historic structures, cultural landscapes and archaeological remains. These new imperatives could undermine the viability of traditional lifeways, sacrificing long-held knowledge of crafts, industries, conservation methods, and much more along the way. In places such as Amazonia, much of which is destined to become savannah in the coming decades; the Arctic, where melting ice and rising sea levels are drastically altering subsistence regimes; or Oceania, where the homelands of some Pacific island societies are threatened with inundation by rising sea levels, the very survival of indigenous cultures is at stake.

It is easy to conceive of cultural heritage as a prostrate victim before the onslaught of relentless, inimical *Climate Change*. Yet I would argue that the regenerative power of heritage to unify, inspire and galvanize individuals will be a key to our success in confronting this challenge. The effects of global warming will alternately interrupt and reinforce the centrifugal and centripetal tendencies of globalization, elevating the importance of cross-cultural cooperation and understanding. The trial of climate change holds the challenge for heritage professionals to embrace the political nature of their work and the opportunity for them to meaningfully integrate the conservation of natural and cultural heritage. Heritage sites have the power to provoke public introspection, reawakening cultural memories of crises met, and by reminding us of our varied pasts, suggest the possibility of alternate futures.

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