Indian J.Sci.Res. 13 (1): 54-60, 2017 ISSN: 0976-2876 (Print)
ISSN: 2250-0138 (Online)

CLIMATE CHANGE: ISSUES OF BUILT HERITAGE STRUCTURES IN THE COASTAL REGION OF EASTERN INDIA

NAGARAJU KAJA[a1] AND MEGHANA MALLIC[b]

[ab]School of Planning and Architecture, Vijayawada, Maharashtra, India

ABSTRACT

The essence of human life is qualitatively and quantitatively affected by climate change issues like rise in sea level, increase in surface air temperature, abnormal monsoon, severe storm incidence, changes in precipitation and humidity etc. The coastal zones would be the first to be affected, which are highly populated because of fertile soil, opportunities for the development of the fishing and shipping industries and ease of transportation. The cultural heritage sites of the world are also exposed to the threat of changing climatic factors. The ancient structures were designed for a specific local climate but the migration of pests, increasing sea levels, increased acidity and salinity of sea-water, etc. threatens many coastal heritage sites today(Climate change and World Heritage,2006). Climate change will either cause direct physical damage to the built heritage, or will affect the society associated with it which will lead to their migration. This paper aims to study and discuss the effects of climate change in coastal regions & their impact on the built heritage sites in India, especially of the Eastern Coastal areas. Climate change is studied in general, followed by its impacts on heritage buildings of coastal regions in Eastern India.

KEYWORDS: Built Heritage, Conservation, Climate Change, Coastal Regions, Vulnerability

Built Heritage

Built heritage is a cultural asset inherited through generations which defines the origin and identity of a place (ICOMOS Cultural Tourism committee, 2002). The sense of belongingness, attachment to community, ethnic pride and appreciation of our past are the various contributions of the built heritage to the society, attributed to the timelessness and memories through various layers of history. The present concern is to preserve important structures and sites that promote identity and continuity of place, without compromising on development that is essential for the present times. Evolution of surrounding locations and natural aging of the historical structures is inevitable but it is essential to check both for sustained development.

As per UNESCO adopted in the general Conference of it on 16 November 1972, built Cultural Heritage comprises Architectural works which are of outstanding universal value. It was found that the built heritage across the globe is increasingly threatened with defects being caused not only by the natural causes of decay like gradual weathering and bio-chemical factors, but also by the variations in Climatic, social and economic conditions. The World Heritage Committee at its 29th session at Durban, South Africa during 10-17 July 2005 directed the World Heritage Centre, the Advisory Bodies, interested State Parties and petitioners to summon a broad working group of experts on the impacts of Climate Change on the World Heritage.

Climate Change and its Impact on Coastal Regions: Global Concerns

Climate change is a substantial and inevitable threat to the built heritage of our coasts and the way of life which co-exist with these environments, and the overall wellbeing. The major indicators of climate change anticipated by the Heritage Council of Ireland are:

- Increased mean annual temperatures
- Increased mean annual rainfall, but with the likely drier summers
- More extreme weather including heavy downpours and more intense storms
- Higher sea levels due to melting of ice and thermal expansion

The direct impacts of these climate change phenomena would be:

- Higher evaporation leading to regular summer drought conditions, combined with heavy downpours
- Alluvial flooding and sudden flash floods
- Increased coastal erosion
- Coastal flooding and the gradual inundation of low lying areas, especially following tidal rushes due to the combined effect of sea level rise and occurrences of storms.

These impacts present serious consequences on heritage structures and socio-economic activity that is directly or indirectly associated with it, including tourism (Kelly and Stack, 2009). Coastal areas are easily

[1]Corresponding author

accessible, rich in resources and attract investors. Ancient civilizations have developed near coastal plains and towns were developed near ports for ease of trade and communication. However, these are the very regions affected by extreme disasters like cyclones and tsunamis. Study by Intergovernmental Panel on Climate Change (IPCC), links vulnerability with climatic change, and point out that the vulnerability of a region depends to a great extent on its wealth, and that poverty limits adaptive capabilities (IPCC, 2000)

Protection of Built heritage

The following are the outcomes of ICOMOS & ICCROM international meetings concerning the issue of protection of built heritage from climate change effects:

i) ICOMOS International Workshop On Impact Of Climate Change On Cultural Heritage- New Delhi (India), 22 May 2007

The Recommendations of the ICOMOS International Committee on Risk Preparedness (ICORP) & Workshop on Risk Management of Heritage Sites are acknowledged as means to promote further collaboration between professional, scientific and institutional networks.

ii) ICOMOS Thematic Workshop On Cultural Heritage And Climate Change –16th General Assembly and Scientific Symposium, Quebec (Canada), 1October 2008

The recommendations concluded from discussions on the effect of (GCC) Global Climate Change on built heritage are:

• Materials or components which withstand prevailing environmental conditions are often likely to fail when those conditions changed

• Extreme weather and rising sea levels are more likely to cause catastrophic damage and destruction to cultural heritage

• As losses occur in the physical environment, intangible heritage values associated with the environment will also be lost, and hard choices will need to be made about what to try to preserve and what to compromise on, based on context specific issues

• Adjusting to Global Climate Change will require improved monitoring so that changes can be identified in time for immediate response, and improved maintenance to make cultural heritage more resilient to changing environments and disasters.

iii) ICCROM) International Centre For The Study Of The Preservation And Restoration Of Cultural Property 29th General Assembly- Rome (Italy), 18 – 20 November 2015

At this meeting, a thematic discussion on "Climate Change, natural disasters and cultural heritage: Culture cannot wait" emphasized the need to integrate cultural heritage in the global risk agenda as a vital resource for building back resilient communities. Contributions from speakers showed how working closely with communities and grassroots initiatives can raise awareness with younger generations. An example can be stated from the Philippines, where climate change and disaster risk reduction are included in the secondary school syllabus and this enables the citizens to be aware of the current conditions of the issue from a very young age so that the protection of cultural built heritage is inculcated in their lifestyles which saves the efforts of raising awareness at later stages. The broad dialogue also emphasized the need for concentrated actions to defend cultural and natural heritage in disaster-prone countries from extreme weather conditions in disaster-prone regions like India and Japan.

THE COASTAL REGIONS OF INDIA

India has an impressive length of coastline of 8118 km surrounded by Arabian Sea in the West, Bay of Bengal in the East and Indian Ocean in the South with around 30% of the population living in these coastal areas. Indian coastal areas are also famous for their rich built heritage like the Colonial-era structures in west, Odishan temples in East and Dravidian Temples in the South. Some of the best examples are Jagannath temple in Puri, Odisha and shore temple in Mahabalipuram, Tamilnadu.

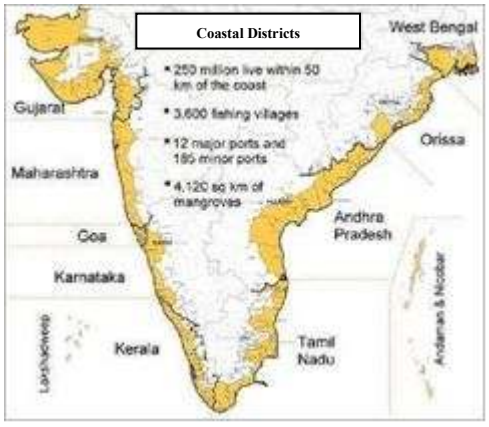

Figure 1: Map showing coastal areas of India (Source: earthzine.org)

- It has been observed that the sea level has risen at a rate of 2.5 mm per year along the Indian coastline since 1950. A mean SLR of between 15 and 38 cm is projected by the mid-21st century along India's coast (Aggarwal PK., 2008).
- Added to this, a 15% projected increase in intensity of tropical cyclones (Aggarwal PK., 2008) would cause great losses of life & property and disrupt the population living in cyclone prone coastal regions of India. Such disasters cause economic pressures by the loss of farmlands & destruction of beaches.
- The average temperature increase is predicted to be in the range of 2.33° C to 4.78° C with a doubling in CO2 concentrations (Watson et.al, 1998)

According to Census 2011, nearly 48% of India's population from coastal regions is currently living in urban areas. More than fifty percent of towns i.e. 2661 out of 3827 villages are situated in the coastal regions of India. Coastal states receive more than 60% of investment, 68% of total factories in India are located in coastal states. The recurrent incidences of coastal disasters as a result of climate change have many impacts on the economy and biodiversity of the region. The vulnerability of the coastal regions is measured by the frequency of occurrence of extreme events like cyclones, storms and depressions. The Eastern coasts have higher vulnerability than the Western coasts (Source: ncrmp@ndma.gov.in).

Figure 2: Map showing the cyclone-prone areas of India

Between 1877-2005 total 283 cyclones (among those 106 severe cyclones) occurred in a 50 km wide strip on the East coast whereas comparatively less severe cyclones occurred on West coast

From the data on the frequency of occurrence of extreme events it is clear that the districts in the states of Orissa and Andhra Pradesh are highly vulnerable than the other states (Senapati & Gupta, 2014). Apart from the frequency and intensity of disasters, the total population & population density also contributes to the vulnerability of the region.

EFFECTS OF CLIMATE CHANGE ON BUILT HERITAGE

i. Organic building materials are subjected to increased biological infestation such as migration of pests in altitudes and latitudes that may not have been previously troubled by threats of climate change.

ii. Historic buildings are more porous as compared to newer ones and draw water from the ground into their structure and lose it to the environment by surface evaporation. Their wall, floor & ceiling surfaces are the points of exchange for these interactions. Increase in soil moisture results in greater "salt mobilization" and consequent damaging through "crystallization", which means that the structures draw huge amounts of salt along with water and after the water is evaporated, the salt which remains cause a lot of damage to the structure.

iii. Flooding damages building materials not designed to withstand prolonged immersion, and the flood conditions boost the growth of damaging micro-organisms such as moulds and fungi.

iv. Increased occurrences of storms and wind gusts leads to structural weakening of buildings & subsequent damage.

v. Moisture penetrates into porous materials by wind-driven rain. Wind transported salt and sand are another factors which damages the built structures.

vi. Numerous pollutants interact with surfaces of buildings and structures and causes undesirable alterations which are irreversible in nature. When the processes are linked to pollutants resulting from human activities, these measures could include reduction of emissions and vibrations from vehicles and industries.

vii. Common pollutants like Nitrogen & Sulphur react with building materials to originate secondary compounds which cause decay. Some other common

gaseous, dissolved and particulate pollutants are carbon oxides, dust, organic compounds etc. are crucial components involved in the deterioration of building materials.

viii. Another concern related to conservation & restoration of cultural heritage is the substitution of decayed materials with new materials which leads to consumption of new substances with the associated financial and environmental costs, and environmental risks associated with its extraction operations.

ix. The increased emissions of CFCs into the atmosphere have led to the depletion of ozone layer. Now the ultraviolet or UV-rays of the Solar spectrum can easily penetrate into the atmosphere and cause great damage to life and property. Wood is one of the most common materials which have been used for centuries. It undergoes auto-oxidation in the presence of UV radiation leading to bleaching of the surface and weakening the material. Paints and varnishes 'polymerize' to a semi-solid state & bleached by uv-light. They tend to increase in transparency over time and auto-oxidation leads to cracking, hazing, loss of gloss and yellowing.

x. Metals are damaged due to corrosion, rust and factors like acid-rain which affect the structural integrity of buildings.

BUILT HERITAGE IN THE INDIAN COASTAL REGION

Jagannath Temple, Puri (Odisha)

Odisha boasts of its temple architecture and one of the magnificent monuments is the Jagannath Temple in Puri located near the sea shore. The Temple was constructed in 12th century A.D during Ananta Varman Chodaganga Deva's, Ganga Dynasty. Presently, this temple is a centrally protected monument under Archaeological Survey of India (ASI), Bhubaneswar Circle, since 1975. The edifice is not only the grandest but also a soaring surviving shrine of Orissa (Approximately 66m height). Heavy plastering was applied to the monument with the purpose of protecting it from saline breeze or salt-laden wind of the sea, but this made the structure vulnerable to damage. The Temple complex being in the proximity of sea, had suffered extensive erosion and corrosion. The plaster of lime coat has become spongy and porous, developing profuse leakage. During rains, water penetration occurs and this accelerates the rusting of iron clamps and dowels, increasing their volumes resulting in cracks and structural damage to the stones.

Decay in stone is caused by the migration and crystallization of soluble salts. Archaeological Survey of India undertook its conservation in 1975 with the main objective to strengthen and consolidate the grandest edifice by adopting conservation measures. The works of conservation is an on-going process since some of the problems are perpetual in nature, like changing rainfall patterns & human intervention factors like pollution.

Figure 3: Repair of the Jagamohana (audience hall) of the temple (Source: Odisha Sun Times)

Shore Temple, Mahabalipuram (Tamil Nadu)

It is an 8th century Hindu temple, which is an UNESCO World Heritage Monument. It is five-storied and has a pyramidal structure 60 ft high and is 50 ft square at the base. It is under constant threat of damages caused due to sea-level rise, coastal erosion, salinity and corrosive action of the sand bearing winds.

Micro-climate of the temple complex is affected by encroachments of the surrounding area, including the road leading to the Shore Temple. Vehicles of tourists parked around the temple spew numerous pollutants to damage the structure. The major concern however, is the receding coastline which will submerge the structure eventually. This has been happening since centuries and has presently under risk of being accelerated due to rising sea levels and increased storm incidences.

Figure 4: Renovation work at Shore temple by ASI (Source: Author)

Archaeological survey of India is taking various measures to protect this priceless monument which is described below:

- Chemical treatment to the monument to stop water from entering into the rock allows the stone to breathe and prevents it from becoming weak.
- Paper-pulp method is carried out periodically for the removal of salts.
- Vegetation is grown to act as buffers to the wind. A total of 11.70 acres of land has been landscaped where 5 Coconut *(Cocs nucifera)*, 4 Portia (*Thespesia populnea)*, 5 Neem *(Azadirachta indica)*, 30 Karanja *(Pongamia glabra)*, 15 Palmyrah *(Borassus flabellifer)* and numerous oak trees have been planted.
- Vehicles are mandatorily parked 100 m away from the fence surrounding the temple (200 m from the monument).
- The exposed joints are being pointed to match with the original.
- A boundary wall was constructed in 1970 by the Archaeological Survey of India, with big blue metal boulders. This was damaged and rebuilt after the tsunami of December 2004. The huge waves smashed the wall, ripped down the fence, and flooded the lawns of the temple. The foundation of the sacrificial altar was damaged and the flight of steps to the miniature shrine at the basement was flooded.

LOSS OF CULTURAL BUILT HERITAGE AND ITS IMPACT ON SOCIETY

Not only the above described monuments, there are hundreds of built heritage structures in Indian coastal areas which at present are being used by local communities to live, work, worship and socialize. They depend on their communities to be sustained and maintained and in turn provide livelihood, shelter and identity to them. Climate change will either cause direct physical damage to the built heritage, or will affect the society associated with it which will lead to their migration. In any case, the social damage to the local residents amounts to a huge loss. The very fabric of the indigenous settlement will be disturbed, leading to loss of character, attachment to the site, history and cultural richness. People economically dependent on cultural property either as direct employment (e.g.: flower sellers at Lingraj Temple, Odisha) or through tourism (e.g.: restaurant owners around Golconda Fort, Telangana) or as a site for their handicrafts or business (e.g.: silk weavers of Chanderi, Madhya Pradesh) will be affected deeply as their source of income will be threatened. The socio-cultural & economic aspects of societies are under threat along with the physical characters of the built Environment.

RISK PREPAREDNESS

Risk preparedness is concerned not only with sudden disasters, but also gradual changes in the landscape. Global Climate Change results in slow but equally destructive changes. Desertion of significant places and heritage sites is one example of a sneaking disaster, since the very care takers of the cultural site would be absent from the duty of maintaining the sites and in turn, lose their sense of belongingness & traditional history. ICOMOS International Committee on Risk Preparedness (ICORP) has been researching on the preparation for protection against disasters arising from Climate Change. It has identified the conservation of vernacular skill sets and traditional construction knowledge as part of risk preparedness. It has been observed that the first phase of disaster response causes irreparable damage to cultural built heritage than the disaster itself, as the cleaning processes often remove physical evidence and strictly limit any capability for reconstruction. However, traditional vernacular construction methods permits precise reconstruction methods, which lead to better maintenance over a long period of time through numerous generations of the regions.

A cultural heritage protection strategy is needed

not only for training for natural disaster relief, but also for military training to deal with protection of cultural heritage in armed conflict, in accordance with The Hague Convention. Post disaster, the challenge for conservation consultants is often how to preserve and revive the spirit of a devastated place. Various countries have well-established programs for disaster response that includes a cultural heritage component.

- Museums in the Netherlands have disaster plans that include the safe removal of valuable items in the collections, & training programs to rehearse it.
- In Japan, there is regular training for response to earthquakes.

There is a three-stage recovery process:

1. Providing water, food, hygiene solutions, and instantaneous protection from disaster.
2. Providing temporary accommodation.
3. Fixing and reconstruction or restoration of permanent accommodation.

Conservation experts in Cuba had various suggestions for amendment of existing action plans:

- Preparation of a new inventory
- Planning of new interventions to improve security in the forthcoming events
- Development of new typologies for buildings that reflect new knowledge about previous mistakes in planning and designing.

CONCLUSION

There is adequate evidence to prove the ill-effects of climatic change on built heritage in coastal areas. These climate change issues are being brought about in an unprecedented rate by the human activities in the name of development. Human intervention has already caused immense harm to ecosystems and physical forms of life, buildings and infrastructure. In the process of adopting remedial measures to right the damages already caused, we should keep in mind not to aggravate the issue otherwise, they hit back with intensities more than we can imagine. Involvement of local communities, understanding the local knowledge systems is essential to adapt to changes in climate. Communities need to be a part of the overall process of understanding and dealing with the conservation and restoration processes. Local influential sectors should also be part of this process such as tourism or industry and the participation would include management planning and implementation, monitoring, etc. A landscape-based approach would help to address the issue in an integrated manner, including natural ecosystems, settlements (urban and rural), buildings and objects. Prevention, adaption and mitigation strategies have to be made in a bottom-up approach for best results, starting at grassroots levels.

REFERENCES

Aggrwal P.K., 2008. Global Climate Change and Indian Agriculture; Impact, adaptation and Mitigation. Indian J. agric Sci., **78**(11):911-919.

Alves C. and Sanjurjo-Sánchez J., 2011. Geosciences of the Built Environment: Pollutants and Materials Surfaces. Geosciences, **1**: 26-43.

Guhathakurta P., Sreejith O.P. and Menon P.A., 2011. Impact of climate change on extreme rainfall events and flood risk in India. India Meteorological Department, **120**(3): 359-373.

ICOMOS, International Cultural Tourism Charter. Principles and Guidelines for Managing Tourism at Places of Cultural and Heritage Significance. ICOMOS International Cultural Tourism Committee. 2002.

ICOMOS Thematic Workshop on Cultural Heritage and Climate Change Report. 16th General Assembly and Scientific Symposium Quebec, Canada, 2008, E News No.18, Issued: March 2009.

ICOMOS International Workshop on Impact of Climate Change on Cultural Heritage, New Delhi. 2007. Issued: May 2008.

IPCC special report on Emissions Scenarios., 2000, Intergovernmental Panel on Climate Change (IPCC).

Jena K.C. and Mishra M.R., 2011. Effect of Global Warming and Climate Change on Coastal Zones and Sea Level, Orissa Review., Sep-Oct: 82-94

Patnaik J., Conservation Problems Remedial Measures of Lord Jagannath Temple, Puri - An over view. E.magazine., Srimandira: 63-65.

Patnaik U. and Narayanan K., 2009. Vulnerability and Climate Change: An Analysis of the Eastern Coastal Districts of India., Munich Personal

RePEc Archive, Paper no.22062.

Senapati S. and Gupta V., 2014. Climate change and coastal ecosystem in India: Issues in perspectives, International Journal of Environmental Sciences., **5**(3):530-543

Sathaye J., Shukla P.R. and Ravindranath N.H., 2006. Climate change, Sustainable development and India: Global and National Concerns., Current Science, **90**(3):314-325.

Sabbioni C., Cassar M., Brimblecombe P. and Leferve R.A., 2008. Report on Climate change, Vulnarability of Cultural Heritage to Climate Change., European and Mediterranean Major Hazards Agreement (EUR-OPA).

Watson D., Clark L. A. and Tellegen A., 1988. Development and validation of brief measures of positive and negative affect: The PANAS scales. Journal of Personality and Social Psychology, **54**(6), 1063-1070.

World Heritage report 22., 2006, Climate change and Heritage., World Heritage centre, UNESCO.