

---

## Alteration in Climatology and its exigency in Conserving the Archaeological sites in Tamilnadu

Dr. E. INIYAN, M.A., Ph.D., Assistant Professor of Archaeology

School of History and Tourism Studies, Tamil Nadu Open University, Saidapet, Chennai – 600 015. Tamilnadu

---

**Abstract:** *Archaeology is the scientific study of past cultures through analysis of physical remains. Archaeologists search for and analyse these remains in order to understand something about the culture of the people that left them. Archaeologists often work closely with historians and anthropologists. The research works carried throughout the world evince that the climatic change persisting all-over the world has a very high impact both, positively and negatively on the Cultural Heritage resources. This multi - geographical environmental ambience fabricated the circumstances in the emergence of different Archaeological sites in the long span of the earth's history right from the ice age. The literary studies on the climatology and its possible influence in the environmental condition of Tamilnadu are done extensively at present. It is considered to be important that we, playing the role of an archaeologist and cultural heritage conservator must be aware of the culturally important places hitherto getting into discussion on the feasible consequences leading to the climate change in Tamilnadu. Due to the fluctuation in the climate conditions, numerous numbers of ancient sites in Tamilnadu either being a build monuments like temples, mosques, churches or rock shelters of Palaeolithic period, rock painting sites, burial monuments etc., are in the road to vulnerability.*

**Keywords:** *Cultural Lanscapes, Landscape Pattern, Marine Archaeology, Climatology*

### 1. INTRODUCTION

The research works carried throughout the world evince that the climatic change persisting all-over the world has a very high impact both, positively and negatively on the Cultural Heritage resources. Tamilnadu in particular is the place which is surrounded by the coastal region on all the three sides and also composed of hills, pastoral region, rivers, dry regions like Ramanathapuram, Virudhunagar etc. This multi - geographical environmental ambience fabricated the circumstances in the emergence of different Archaeological sites in the long span of the earth's history right from the ice age. But, the surveillance was focused on the constructed heritage with subtle attention is concentrated on the archaeological sites and the cultural landscapes. So, in this paper, a small attempt is done to reveal how various sources focus the impacts of climatological variations on the archaeological sites and monuments and also by extrapolation from various secondary and primary sources, this paper provoked the author to accentuate puissance and frailty about the present research status on the archaeological sites and monuments. Different paces of impuissant methodologies were adapted and the impacts theory from different sources were collated and applied on the site called Mamallapuram. The paper ends by highlighting the knowledge gap in various sources with regard to the impacts on the buried archaeological remains.

### 2. ARCHAEOLOGICAL SITES AND ASSEMBLAGES

Archaeology is the scientific study of past cultures through analysis of physical remains. Archaeologists search for and analyse these remains in order to understand something about the culture of the people that left them. Archaeologists often work closely with historians and anthropologists. UNESCO says heritage is our legacy from the past, what we live with today and we pass on to future generations. Our cultural and natural heritages are irreplaceable sources of life and inspiration, our touchstone, our reference point, our identity.<sup>1</sup> The European Convention on the Protection of the Archaeological Heritage mentions Archaeological Heritage is the preservation and study of which help to retrace the history of mankind and its relation with the natural environment for which excavations or discoveries and other methods of research into mankind and the related environment are the main sources of information.<sup>2</sup>

### 3. CULTURAL LANDSCAPES

The word landscape itself combines land with a verb of Germanic origin, scapjan/ schaffen to mean, literally, shaped lands.<sup>3</sup> The geographer Otto Schlüter is credited with having first formally used cultural landscape as an academic

term in the early 20th century.<sup>4</sup> World heritage convention terms that cultural landscape, embraces a diversity of manifestations of the interaction between humankind and its natural environment. Cultural landscapes often reflect specific techniques of sustainable land-use, considering the characteristics and limits of the natural environment they are established in, and a specific spiritual relation to nature.<sup>5</sup> Cultural landscape of India could be coined as Cognitive landscape, which is the cluster of various religious and cultural interpretations attributed to the geographical elements via collective process, where the people belonging to older generations involve themselves in active participation, enabling the nature and land pattern to transform from physical to metaphysical condition. Likewise, Tamilnadu is the multi-faceted region which comprises of varied cultural framework right from the Stone Age culture. This cultural landscape exposes the evolution of human society in the Tamil country, their settlement pattern that emerged due to the physical coeres and the possibilities to lead the life style accorded to them by the available environmental conditions.

#### **4. PROGNOSIS OF CLIMATE CHANGE IN TAMILNADU**

The maximum temperature over Tamil Nadu is projected to increase by 1.00C, 2.00C and 3.10C for the periods 2010-2040, 2040-2070, 2070- 2100 respectively in addition to 32.9 degree Celsius in existence.<sup>6</sup> The further studies also states that the minimum temperature in the state too would rise from 23 degree Celsius to nearly more than 3.5 degree Celsius around 2100 AD. As far as rainfall is concerned there would be drastic change with reduced 9% in the flow and the monsoon would make way towards the northeast leading to heavy flood and critical cyclonic conditions. In future, the number of cyclones hitting the eastern Indian coast including Tamil Nadu is likely to reduce, however, the intensity i.e., the wind speed of the cyclones may increase.<sup>7</sup> The projected level of rise in the coastal region would be 0.73 m around 2100 AD from 0.19 m which is in active today.<sup>8</sup> With the availability of different sources of climatic change inputs, it could be surmised that the extensive spatial variability could reduce the water availability and also makes difficult to supply water to the starving areas and storing the excessive rainfall for further usability would face effective challenge.

#### **5. OVERVIEW**

The literary studies on the climatology and its possible influence in the environmental condition of Tamilnadu are done extensively at present. It is considered to be important that we, playing the role of an archaeologist and cultural heritage conservator must be aware of the culturally important places hitherto getting into discussion on the feasible consequences leading to the climate change in Tamilnadu. Due to the fluctuation in the climate conditions, numerous numbers of ancient sites in Tamilnadu either being a build monuments like temples, mosques, churches or rock shelters of Palaeolithic period, rock painting sites, burial monuments etc., are in the road to vulnerability. The synthesis report of IPCC's (Intergovernmental Panel on Climate Change) fifth assessment report (AR5), 2014 stresses that every effort to ensure that global temperatures do not rise by dangerous levels of 30 to 40 Degree Celsius would require substantial emission reductions over the next few decades and near zero emissions of carbon dioxide and other long-lived greenhouse gases by the end of the century. So, necessary substantial works must be carried out in the coming years to preserve the monuments by finding out the possible options available to decrease the impact leading to the changing in the climate pattern. Works on the impact of the climate change over the monumental heritage and archaeological sites is to be conducted for further conservation of cultural heritage of Tamilnadu. Direct weathering and indirect weathering are two important factors which has high impact on the climate change. Tamilnadu has innumerable number of ancient monuments constructed out of impregnable stones. Other important concerns regarding the climate change are flood, moisture, windstorm, salt water etc., Cause of heavy flood over the heritage buildings destroys them due to natural water pressure and the also water remaining in the structure even after the flood causes serious mold problems that will eventually wear the building away and create health dangers. Windstorms normally create mechanical damage to the structures and materials, most likely to the roof structures. The crystallization of salts on the material surface, wetting and dry cycles happening through thermal changes causes which basically alter the appearance of the heritage structure. Soluble salts are a principal agent of decay in porous building materials and a source of great frustration to those involved in the conservation of historic buildings. The behaviour of salts may seem unpredictable since they can remain dormant for long periods and then suddenly become active causing damage and disfiguring historic fabric. In other cases the action of salts is progressive, weakening surfaces on a microscopic level over decades and

centuries, causing natural erosion of the kind that would occur to stone in a quarry face. Without inequity among the heritage resources either being archaeological sites or monuments, the preservation works should be concentrated unlike the focus being intensive in the build heritage monuments at present. Build heritage monuments are easily accessed and understandable to the government agencies and policy makers in addition to the general public to whom they are preserved for being visited to conduct any survey or research. But, utmost responsibility should also be there to preserve the other archaeological sites which are under sensitive threat by environmental alterations. Furthermore, alterations and changes occurring in the landscape pattern will have a great impact on the integrity of many archaeological assemblages, both physically and aesthetically.

## **6. BURIED ARCHAEOLOGY**

There is not much articles that were published in Tamilnadu relating to the sub-surface archaeology and climate change impacts on them. The archaeological sites are excavated for the purpose of unearthing the artefacts to prove the antiquity of the ancient Tamil country. The excavated remains are documented and the artefacts are preserved in the museums for further research. But rarely attention is cornered on the preservation of excavated sites. It is instrumental in preserving the excavated sites to exhibit the periodical changes in the surface structure, earth particles influencing the soil, etc., to the common man. Likewise the burial monuments in the remote accesses also should be subjected to research for the factors which impacts the climatic variations leading to the deteriorating of monuments. Apart from classification of monuments on their typology, analysing their structural forms, artefacts unearthed, the sub surface soil formations which are being affected by various climatic changes should also be taken into concern and proper necessary action should be implemented in preserving them. The central axis for all these process is the allocation of regular and sufficient funds for the preservation of monumental heritage. In Tamilnadu much concern is shown on the vulnerability of anaerobic waterlogged environments which are associated with high level of preservation for organic artefacts. Certain places in the state like Thiruvannamalai, Dharmapuri, Pudukkottai, Madurai, districts has excessive amount of black granite stones, blue metals,<sup>9</sup> grey granite, high quality black granite, maliptinum, quartz,<sup>10</sup> granite, blue metal, rough stone,<sup>11</sup> graphite, quartz, blue metal jelly, feldspar.<sup>12</sup> But ground water abstraction as a result of quarrying and agriculture paves way for the spoliation of organic materials, soil shrinkage and building subsistence. Many sites like Keezhadi in Sivaganga district, Kodumanal in Erode district, Thiruverkadu<sup>13</sup> in Kanchipuram district, etc needs to have grave concern to preserve the organic materials in those sites as the predictions for dries summers are in near future to exist. A comprehensive research work should be undertaken to analyse the effects of changes occurring in the water quality due to the alteration in the climatic condition and in addition to this the maintenance of anoxic environment is influenced by the micro – organisms present on them which are sensitive to minute changes in the water properties. Excessive rainfall pouring at present and in coming days and drying following it, results in the alteration of climate and initially influencing the stratigraphic condition known from the cracking and heave due to the penetration of oxygen leading to the rapid microbial action and oxidation of metals and other artefacts in the layers of the trench.

Many sites in the state were exposed during the course of erosion, manmade disturbances or by natural calamities like Tsunami the one happened in 2004 at Saluvankuppam near Mamallapuram, a port city of Pallava dynasty. The above circumstances are also the positive development which may trigger the researchers and correspondent agencies to take intensive care on the preservation of cultural heritage if possible proper resources are available to record the information's hidden beneath the earth. Though the basic consensus is that the heritage would be badly affected when a storm or flood happens to appear, but it is for Tamilnadu to be proud that though after thousands of years even after countless number of natural calamities the build heritage and archaeological sites are in-situ. This is an example for the architectural excellence, life style, social stability etc. But the man-made disturbances are the serious cause for the destruction of ancient archaeological remains. Necessary technological advancement should be implemented at the heritage sites and the use of computer modelling to simulate the impact of future climate change should be effectuated in those areas.

## **7. LANSCAPE PATTERN**

Phenomenal outcome of the altered climatology is evident from different types of agricultural activities and eco-systems like distribution of plants and other grains of species or from the changes existing in the growing seasonal

outcomes. The utilization of research activities and technological support from other disciplines like physics, chemistry, biology, computer science could be instrumental in the monitoring and conservation of cultural heritage in Tamilnadu. Shifting process in agricultural practices, forestry and population census is carried out by the environment agencies and government departments are very much pertinent to the values of archaeological landscape pattern. The increasing bout in the agricultural practices and the growing population creates a complication during the winter and summer season. As Tamilnadu mainly gets its river water sources from adjoining states like Karnataka, Kerala and Andhra Pradesh, there exists a firing issue regarding the distribution of water between the states. The severity and extent of drought in the state is believed to be the result of aberrations in rainfall, overexploitation of ground water, lower reservoir levels, and crop stress conditions. Red, black, and alluvial soil types predominate in Tamil Nadu, but sandy soils in the southeast part of the state are prone to chronic droughts.<sup>14</sup> The southern zone of Tamil Nadu, comprising the districts of Ramanathapuram, Tirunelveli, Dindigul, South Madurai, and Pudukottai, is under the rain shadow region, having a prolonged dry climate. Only northeast monsoon rainfall is dependable here.<sup>15</sup> Increased drought during the summer seasons at some places of hill slopes like Western Ghats leading to wildfire and other dry lands like Ramanathapuram and other drought related areas results in the reduction of vegetation activity, basically threatening the archaeological resources. The depletion in the plant species havoćs the sub-surface archaeology when it coincides with the heavy rainfall and the increased level of carbon-di-oxide will accelerate the plant growth in certain climatic conditions leading to the permeation of roots into the archaeological deposits and vandalizing the cultural assets of the state. Human adaptive measurements including dredging, improvement to storm drains, agricultural activities such as planting new crops penetrating deeper into the root, manmade plantation, development in the irrigation facilities, leisure and tourism activities though were the processes included in the infrastructural development, but unknowingly destroys the cultural glory of the state.

## **8. MARINE ARCHAEOLOGY**

The coastal regions face heavy loss in the course of climatic variations. Coastal cultural heritage consists of land based sites like Chennai (consisting of number of colonial buildings), Mamallapuram, Rameswaram, Thoothukudi, the intertidal sites including Puttan Thurai, Mana Kudi, Korkai, Alagankulam, Poompuhar<sup>16</sup> and the underwater sites namely Saluvankuppam. The possible threats to these sites were the rise in the mean sea level, increasing in the wave energy, flooding, erosional activities in the coastal regions and the saline intrusion. Influences in the tidal waves are cited at the higher reaches of river courses and the combination of high tide and sea level rise could cause significant flooding. The varying coastal morphology influences the heritage structures and causes serious disturbances to the one's located at low lying coastal regions, reclaimed land and near the high water mark areas. The inundation of sea level in the Tranquebar region could be assessed by using the GIS technology. From the vulnerability map prepared by the Sheik Mujabar et al<sup>17</sup> it is obtained that the parts of Tuticorin and Thiruchendur experience accretion due to the presence of thamarabarani river delta, and parts of navaladi, ovari experience high erosion rate. The overall erosion rate in South of Tamilnadu is higher than accretion rate. It is a paradox that the changes in coastal climatic scenario will extremely results in the destruction of archaeological sites, but in lesser term significantly the change also exposes the richness of the cultural resources in the intertidal zones. Though the wrecks may be exposed frequently in the coastal regions, the deterioration of wood under the sea would be subjected to the erosion of protective sediments which happens due to the oxygenated water and exacerbate existing bacterial action. It poses significant challenge for the archaeologists in the near future to protect the coastal cultural resources as there exists contending and colloidal demands. Various adaptation strategies when formulated to conserve coastal areas would tend to affect the cultural heritage in the coastal regions. Hence it is the primary duty of the government to take strict actions in the preventive measures to protect the coastal heritage with concerned guidance from the systematically trained marine archaeologists before carrying out more environmentally sensitive soft engineering works in the coastal areas.

## **9. MATRIX**

Various possible ways predicted to effect the climate change, their controlling measures, possible impact over the archaeological heritage of Tamilnadu has been dealt briefly; increasing annual temperature poses a great threat to the environment. It could be controlled by the plantation of trees with certain degree of distance from the heritage

monuments which leads to the increase of moisture in the temperature. The raise in the temperature would initially paves way for changes in the habitats and species in the environment, increases the biological growth in the heritage structures, increases the arable farming in-turn damaging the ploughs. Excessive north-eastern monsoon rainfall creating floods, altering the water table, storms etc leads to the soil erosion, tilting in the river beds exposing varied stratigraphic structures, relocation of irrigation activity, deterioration of water quality, humidity alterations, surface deposits variations and instability in the subsoil level. The increase in the temperature level, catchment hydrology and precautionary measures taken by the respective agencies to protect the reliable environmental resources also in addition protects the cultural resources. Heavy wind flow erodes the soil in corresponding to the mechanical erosion and physical damage, which could be naturally controlled by the rain intensity and duration, as it is not a easy way to prevent wind flow.

## **10. CASE STUDY**

The above mentioned matrix provides us the possible risk criteria's influencing the climate change. Hence in order to perceive the impacts on an individual site, it is pertinent to assess the value of the cultural resource to be protected, basic geographical position of the site and predicted climatic change to be occurred in the near future. In this case study, possible impact matrix discussed above is utilized in the vulnerability assessment process of the World Heritage Site namely Mamallapuram to predict the future climatology alteration.

## **11. DESCRIPTION OF THE SITE**

Mamallapuram is one among the World Heritage Monuments in Tamilnadu. It was added in the World Heritage list in 1984 under criteria's (i) to represent a masterpiece of human creative genius, (ii) to exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design, (iii) to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared, (vi) to be directly or tangibly associated with events or living traditions, with ideas, or with belief, with artistic and literary works of outstanding significance<sup>18</sup> as an outstanding architectural marvels of ancient Pallava dynasty. Mamallapuram also called Mahabalipuram was considered one of the seven Pagodas (A pagoda is a tiered tower with multiple eaves, built in traditions originating as stupa in historic South Asia and further developed in East Asia or with respect to those traditions, common to Nepal, China, Japan, Korea, Vietnam, Myanmar, India, Sri Lanka and other parts of Asi)<sup>19</sup>. It is assumed that the name 'Seven Pagodas' was given because of the seven temples, either located near the shore or visible as group from a distance. Also as the Pallava Narasimha Varman was a great wrestler he attained the title Mamalla. This is an elegant place to watch which was a well established sea port during 7<sup>th</sup> to 10<sup>th</sup> Centuries. This is also the second capital of Pallavas of Kanchipuram. The monuments are a fusion of religion, culture and legend relating to the Hindu religious pantheon. They are expressions through rock or inside boulders, on a grand scale, integrating nature and sculpture. The site has about forty monuments, in varying degrees of completion, categorized into five groups; Rathas, Mandapas, Rock reliefs, Structural temples, Excavated ones. Mamallapuram consists of ten major rathas, nearly ten mandapas, two rock bas-relief, and three structural temples.<sup>20</sup> The monumental plan is based on a square and circle, or stacked squares (producing a rectangle). The reliefs, sculptures and architecture incorporate Shaivism, Vaishnavism and Shaktism, with each monument dedicated to a deity or a character in Hindu mythology.

## **12. CLIMATE PREDICTION IN FUTURE AT MAMALLAPURAM**

Meteorological measurements achieved through the traditional methods and the model produced by various climatic predictions doesn't provide the information related to conservation of heritage like relative humidity or measuring the wet condition. Previously in India from 1989-2017 the forecasts for the southwest monsoon seasonal rainfall over the country as a whole were issued based on power regression models.<sup>21</sup> The India Meteorological Department (IMD) has been issuing long-range forecasts (LRF) based on statistical methods for the southwest monsoon rainfall over India (ISMR) for more than 100 years. Many statistical and dynamical models including the operational models of IMD failed to predict the recent deficient monsoon years of 2002 and 2004. Two new models were developed to facilitate the IMD's present two-stage operational forecast strategy. They are models based on the ensemble multiple linear regression (EMR) and projection pursuit regression (PPR) techniques were developed

to forecast the ISMR. These models used new methods of predictor selection and model development.<sup>22</sup> On the basis of UK Met Office Hadley Centre regional climate model PRECIS, it is predicted that the annual mean temperature tend to be 28.2 degree celcius and it is likely to raise upto 1.1 degree around 2040 and 1.8 around 2040-2070 which is a gradual increase in the annual temperature which makes people more uncomfortable to run the life span. The fluctuation in the rainfall from more intense in North-East monsoon than the South-West monsoon creates a great impact in the environment leading to the growth of micro-organisms. In the case of the number of cyclones hitting including Tamil Nadu in the east coast where Mamallapuram is located, is likely to reduce however, the intensity i.e., the wind speed of the cyclones may increase.<sup>23</sup> Usage of CLIM SYSTEM by various Global Climate Models projects the raise of sea level in Tamilnadu coast to be from 0.19m to 0.73 m around 2100. This should be concentrated with high-priority as the monuments in Mamallapuram are located in the sea coast, water laden with salts is transported in stone through capillaries. The rate of leaching is greatest for stones with high porosity. On a moist stone surface the rate of deposition of pollutants is high compared to that on a dry surface. Water in various forms is involved in various types of stone deterioration. Decay due to thermal variations: Stresses are developed in building stones due to thermal changes and diurnal variations. Most of the rocks are poly-minerallic in nature; each mineral expands in different rates, thus setting up minor stresses and strains which tend to pull apart the minerals and disrupt the rocks. Sudden cooling of the outer surface during rain causes a strain between the outer and inner portions of the rock elements in buildings, which results in disintegration. Algae, moss and lichens are commonly found on damp stone surfaces. The growth becomes rapid immediately after rainfall, showing up bright green in colour and becomes dry imparting a dark appearance. Acids generated from moss and lichens leads to damage of stone. Growth of small plants and vegetation causes physical stresses due to propagation of roots; further, the roots penetrate the joints and lead to cracks. Dampness is retained on the stone due to the presence of vegetation thus inducing continuous damage. So, preventive measures in preserving the monuments should be taken as a first hand operation.

### **13. VULNERABILITY ASSESSMENT**

The implementation of necessary strategies in accessing the climatic variations depends on the information provided by the assessments of the risk factors. Risk variables such as geomorphology, shoreline change, slope, wave height, tidal range, and bathymetry are used to derive coastal vulnerability index.<sup>24</sup> The United Nations Geological Survey (USGS) allows the six physical variables like (Geomorphology, Coastal Slope, Relative Sea level change, Shore line erosion/accretion, Mean tide range, Mean wave height) to be related in a quantifiable manner that expresses the relative vulnerability of the coast to physical changes due to sea-level rise. This method yields numerical data that cannot be equated directly with particular physical effects. It does, however, highlight those regions where the various effects of sea-level rise might be the greatest. On the basis of the study on the coastal region of Chennai the following result is derived; Mamallapuram lies under the high vulnerable category as beach was considered to most vulnerable in addition to anthropogenic activities like building construction, dredging of coastal areas and fishing activities are most common in those areas.<sup>25</sup> The coastal vulnerability index (CVI) provides insight into the relative potential of coastal change due to future sea-level rise. The thematic layers such as geomorphology, shoreline change, coastal slope, and significant wave height are the most important variables in determining the CVI for part of Chennai seashore. The entire beach was highly vulnerable, therefore, preventing or combating problems related to inundation during storms was recommended. The damage to life and property could be reduced during storms or tsunami by planting mangroves and saline tolerant trees.<sup>26</sup>

### **14. CONCLUSION**

Considering the facts and factors discussed in brief above, analysis on the case study provides current status of knowledge in the Climate Change scenario among the researchers. There needs to be an enhancement in the expertise in the cultural preservation more particularly the build heritage and archaeological sites. It is accorded Archaeological Heritage is the preservation and study of which help to retrace the history of mankind and its relation with the natural environment for which excavations or discoveries and other methods of research into mankind and the related environment are the main sources of information. As archaeologists, it is the bounded duty to analyse the strength and weakness of the archaeological research through the present case study done practically rather than having a theoretical accumulation of knowledge on the cultural resources. Interpreting the climate

variations and co-relating it with the cultural heritage management is relevant to preserve the cultural resources. Existing works on the climatology alteration and its impact on the heritage resources are few in the archaeological research. So, a small attempt was made to have an in-depth study in various aspects pertaining to changes and alterations in the cultural landscape, factors influencing the deterioration of sub-surface archaeological artefacts, coastal climatic scenario and its possible impact in exposing the cultural heritage and also equally the variations occurring in the tidal waves resulting in the destruction of heritage structure and the preventive measures to be adapted, future climatic prediction in Mamallapuram coastal region and the factors which will affect the monuments in the site through which reasons and the urgency in the preservation of those monuments.

## REFERENCES

- [1] [www.unesco.org](http://www.unesco.org)
- [2] European Convention on the Protection of the Archaeological Heritage, European Treaty Series - No. 143, 1992
- [3] **Gibson, W.S**, Mirror of the Earth: The World Landscape in Sixteenth-Century Flemish Painting, Princeton University Press, Princeton, New Jersey, 1998
- [4] **James, P.E & Martin, G**, All Possible Worlds: A History of Geographical Ideas, John Wiley & Sons. New York, p.177, 1981
- [5] World Heritage Operational Guidelines, Annex 3, 2008
- [6] Centre for Climate Change and Adaptation Research (CC&AR), Anna University and Tamilnadu State Action Plan for Climate Change (TNSAPCC), 2012
- [7] **Ibid**
- [8] **Ibid**
- [9] Brief Industrial Profile of Thiruvannamalai District 2015-16, Ministry of Micro, Small & Medium Enterprises (MSME),
- [10] Demographic Profile of Dharmapuri district, 2001
- [11] Brief Industrial Profile of Pudukkottai District 2015-16, Ministry of Micro, Small & Medium Enterprises (MSME),
- [12] Brief Industrial Profile of Madurai District 2012-13, Ministry of Micro, Small & Medium Enterprises (MSME),
- [13] **Ravisankar R., et al.**, Estimation of the firing temperature of archaeological pottery excavated from Thiruverkadu, Tamilnadu, India by FT-IR spectroscopy, Scholars Research Library, Archives of Physics Research, 2011, p.108-114
- [14] **Nathan K.K.**, Draughts in Tamilnadu - A Qualitative and Quantitative Appraisal, Drought Network News (1994-2001), Digital Commons @ University of Nebraska - Lincoln October, 1998
- [15] **Ibid**
- [16] **Gaur A.S., Sundaresh**, Onshore and Near Shore Exploration along the Southern Tamilnadu Coast: with a view to Locating Ancient Ports and Submerged Sites, National Institute of Oceanography, CSIR, 2006
- [17] **Sheik Mujabar P. and Chandrasekar N.**, Coastal Erosion Hazard and Vulnerability Assessment for Southern Coastal Tamil Nadu of India by Using Remote Sensing and GIS, Nat Hazards, 10-13 (2011)
- [18] **www.whc.unesco.org**, World Heritage list, Group of Monuments at Mahabalipuram
- [19] The Origin of Pagodas, China.org.cn, 2002, Pagodas, webpages.uidaho.edu, 2017
- [20] **Ramasamy N.S.**, 2000 Years of Mamallapuram, Navrang, 1989, p. 10, 27-31
- [21] India Meteorological Department, Previous Long Range Forecast

- [22] **M. Rajeevan, D. S. Pai, R. Anil Kumar**, New statistical models for long-range forecasting of southwest monsoon rainfall over India, Climate Division, Indian Meteorological Division, Nov, 2005
- [23] Tamilnadu State Action Plan for Climate Change (TNSAPCC), 2012
- [24] **Nethaji Mariappan V.E., Santhi Devi R.**, Chennai Coast Vulnerability Assessment Using Optical Satellite Data and GIS Techniques, International Journal of Remote Sensing and GIS, Volume 1, Issue 3, 2012, p. 175-182
- [25] **Ibid**
- [26] **Ibid**

#### **AUTHOR'S BIOGRAPHY**



**Dr. E. Iniyan, M.A., Ph.D (Ancient History and Archaeology).** He is specialized in Pre and Proto History with much specialization in Iron Age culture. To his credit 12 Books has been published (Including 9 study materials for Tamilnadu Open University). He also published 16 papers in National and International Journals and presented 5 papers in conferences. The author had also received JRF from Central Institute of Classical Tamil. The author had visited Malaysia 3 times to present papers in conferences and to take classes for students about Archaeology. The Author had also conducted field surveys in many districts of Tamilnadu and surveyed more than 1100 villages in Thiruvannamalai district, Tamilnadu as part of his Research work. He has participate in many excavations conducted by Dept. of Ancient History and Archaeology, University of Madras from 2005 to 2014.