

*Research Journal of Marine Sciences*. Vol. **2(1)**, 1-5, January (**2014**)

**Review Paper** 

# Effects of Sea Level Change on Vulnerable East Coast of India

Praveenkhanna Udayakumar

Department of Earth Science, Uppsala University, 753 12 Uppsala, SWEDEN

Available online at: www.isca.in, www.isca.me Received 24<sup>th</sup> September 2013, revised 23<sup>rd</sup> November 2013, accepted 24<sup>th</sup> December 2013

### Abstract

The climate system is so complicated to understand since it interacts with each and every object on the earth. This report is about the sea level rise and its impacts due to climate change along the coast of India covering the states of Tamilnadu, Andhra Pradesh, Odhisa, and West Bengal on the East. Agriculture is the major livelihood along the coastal areas of tamilnadu and Andhra Pradesh. The sea level rise impacts can be noticed along the Cauvery delta and Godavari delta, (which are formed by the major rivers of Tamilnadu and Andhra Pradesh) as saltwater intrusion, soil erosion, and reduction in the availability of fishery resources due to increased ocean temperature. Thus the landscape changes due to climate change can be clearly demarcated and also in vice versa, the impacts of Landscape change inducing climate change can be explained as the change in energy flux of incoming solar radiation which is compared with the changes in agricultural areas and shrinking water bodies.

Keywords: Sealevel rise, east coast of india, landscape, temperature.

# Introduction

The climate can clearly explains that the system is in equilibrium, where the incoming radiation is balanced by outgoing radiation. The change in equilibrium leads to climate change. Climate change will have impact over global mean climate/temperature which in turn increases drought condition, reduction in agriculture, coastal erosion and sea level rise etc. But it will have more contrasting regional implications. In some areas temperatures may not rise for several years, but rainfall occurrence may change, and tropical cyclone activity may also get altered.

The sea level rise is the best indicator of climate change than any other atmospheric variable. The melting of polar ice sheets and glacier melts due to rise in ocean temperature are the direct effect of atmospheric temperature change. Various studies were carried out in the twentieth century based on the tidal data that are available. There are implications with using tidal data since there will be variation in tidal data in regional scale based on number of tidal stations and location of tide gauges which cannot be related globally. But there are enough evidences which can explain increase in ocean temperature and melting of polar ice which can be related to sea level rise. It is important to add about Effective Sea level rise known as the change in eustatic sea level with respect to delta surface including the subsidence values and fluvial sediment deposition. Thus effective sea level rise can explain regional variations.

**Study Area:** India has a long coast line of about 8,000 kms. Based on the geomorphology the coasts of India can be divided as East coast and West coast<sup>1</sup>. The west coast is rocky and got wide continental self also it receives southerly wind flow with high wave climate during June to September. The east coast got a narrow shelf and lined with deltas, estuaries, bays, salt marsh, lagoons and some smaller islands and it receives maximum northerly wind and active with cyclones and flood during the period October to November<sup>1</sup>. Most of the Indian rivers flow across the east and they brings large quantities of sediments, which are suitable for agriculture. The east coast experience high sediment flow rate and regular cyclonic damages by flooding. In the south part of east coast lies Tamilnadu, which has a narrow coastal plain with a large delta formed by the river Cauvery. Andhra Pradesh lies in the mid part of the east coast, which is mainly a deltaic coast formed by river Godavari and Krishna<sup>1</sup>.

Major landforms<sup>1</sup> along the Tamilnadu coast are Mudflats, spit, rock outcrops, mangroves, beaches, coastal dunes, strand features, and coral reefs. Major landforms<sup>1</sup> along Andhra Pradesh coast are bays, alluvial plains, tidal mudflats, ridges, creeks, spits, bars, mangrove swamps, lagoons and marshes.

# **Data and Interpretations**

**Climate change:** The figure-1 explain the global mean temperature obtained from various climate models for over a period of 160 years. The global mean temperature starts to increase after the 20<sup>th</sup> century. From IPCC report the changes are related to global warming due to increase in green house gases which trap the outgoing radiation.

The graph is about the global mean surface temperature, to understand about the regional temperature rise the local surface

#### Research Journal of Marine Sciences \_ Vol. 2(1), 1-5, January (2014)

temperature data must be analysed. The mean average temperature of Pondicherry (Union Territory in Tamilnadu) between 1901-1980 is compared with average temperature of Pondicherry between 1996-2000 in table-1. This helps in determining the local temperature changes upto 20th century.



Published Global Mean Surface Temperature over large region<sup>2</sup>

Mean average temperature Pondicherry <sup>3</sup>		
MONTHS	1901-1980	1996-2000
January	24.5	24.95
February	25.55	26.1
March	27.5	27.6
April	29.75	29.9
May	32	31.85
June	31.9	31.5
July	30.3	30.8
August	29.6	29.8
September	29.4	29.4
October	27.85	28
November	26	26.65
December	24.85	25.25
Annual	28.25	28.483

 Table -1

 Mean average temperature Pondicherry<sup>3</sup>

Now it's clearly identified that the temperature is also increasing in the regions of east coast of India. The analysis can also be carried out in various coastal regions.

# Discussion

**Impacts of Climate Change over Landscape:** From the paper by Nageswar Rao, et al., it concludes that Sea level rise inversely affects agricultural activities in the parts of Andhra Pradesh along the deltaic regions of Krishna Godavari river, where the agriculture activities are intense. They used IRS-P6 LISS III data merged over SRTM elevation model. Based on the IPCC report the predicted Sea level rise would be 0.6m, the high tide level is 1.5m and then by overlapping the predicted inundation (at 2.1m Sea Level) over the SRTM model Figure-2, helps in determining the impacts over the coastal regions of Andhra Pradesh<sup>4</sup>.



Land use & Land cover map showing 1.5m/ existing high tide level and vulnerable/ inundation contour at 2.1m sea level, 5.0m contour and possible inundation<sup>4</sup>

Salt water intrusion is also a major impact of Sea level rise. The paper by Ghosh Bobba, explains the impacts of saltwater intrusion in the Godavari delta. The hydrogeology of the place is formed by shallow alluvial cover with crystalline base rock called khondalites. The alluvial silt and gravel layers are mixed up with clay. The granular alluvium extends upto 300m inland and lies upto a depth of 18 to 258m. The water table lies in 0.2m till 8.5m below ground level. There are tube wells and dug wells used for domestic purpose upto a depth of 20m. Using Saturated-Unsaturated Transport model the two dimensional salt water movement simulation is made. The model is created with 261 nodes and 227 elements, with each node specifying the boundary condition such as transmissivity, hydraulic head and storage co-efficient, also the boundary and stream nodes included. The input parameter values for the modelling are obtained from literature. From figure-3, shows simulated fresh water levels for different environmental condition such as rainy and drought season. In which higher water table levels indicates recharge of rain water and flushing out of salt water to sea during rainy days and possibility of salt water intrusion during drought condition since lower ground water levels. (Darker line specifying freshwater level during rainy condition and dotted line represents drought condition)<sup>5</sup>.

**International Science Congress Association** 

\_\_\_ ISSN 2321–1296 Res. J. Marine Sci.



Simulated Model for Different Environmental Condition<sup>5</sup>

The paper by Saranathan et al., can explain inundation of sea level in tranquebar region which lies in the south of nagapattinam district (Tamilnadu) after 1918 using GIS technique. Figure-4 shows the various shore lines and encroachment of sea inland<sup>6</sup>.



Shoreline changes in Tranquebar Region<sup>6</sup>

A similar paper by Sheik Mujabar et al., analysed the shore line and coastal erosion of south Tamilnadu coast to determine and vulnerability prepared a vulnerability index for disastrous situation in regions of Tamilnadu. From the results obtained the coastal vulnerability map is prepared figure-5, in which the parts of tuticorin and thiruchendur experience accretion due to the presence of thamarabarani river delta, and parts of navaladi, ovary experience high erosion rate. The overall erosion rate in South of Tamilnadu is higher than accretion rate<sup>7</sup>.



Coastal vulnerability map for South Tamilnadu coast<sup>7</sup>

The above mentioned papers are useful in understanding East Coast of India, most of the places experience sea level rise and coastal erosion impacts, this situation increase the confidence that the coastal landscape is very dynamic because of the climate change.

**Impacts of Landscape Change over Climate:** The paper by Johannes J. Feddema gives an overall picture about land use change which can be used for simulating future climate. The paper says that the landscape can affect the climate by the process of biogeochemical reactions, albedo and energy flux. The model predicts the climate change due to the changes in existing crop lands of India in 2050 and 2100. Model shows cloud cover and precipitation over India during june, july and august 2050, which could be because of increased latent heat flux and reduction in incident radiation but during 2100 the situation is being reversed in such a way that India changes to dry and warmer climates due to global reforestation<sup>8</sup>.

# Research Journal of Marine Sciences Vol. 2(1), 1-5, January (2014)

In the paper by Defries et al., shows that human modifications in land cover has impact over climate in South East parts of Asia by 2050. The existing vegetation type was found to be evergreen forest in most of the areas and it was estimate that most of the forest would change to crop land. The increase in agriculture land in India and South Asia is estimated to be 0.18 million km<sup>2</sup> and hence the change in albedo between existing and future is found to be 0.04 during January and 0.02 during July, also it is found that the carbon assimilation of canopy decreases by 29.0 micromoles/m<sup>2</sup>/s, and latent heat of canopy and total latent heat is reduced by 316.2 W/m<sup>2</sup>, 132.9 W/m<sup>2</sup>, diurnal temperature range is reduce by 0.8 °C. The Figure-6 shows the monthly change in latent heat/ total heat flux, where the dark line is for existing land cover and the dotted line for the future, the grey line is the difference between them<sup>9</sup>.



Figure-6 Monthly variations in Evaporative fraction in existing condition and in future<sup>9</sup>

The changes in energy fluxes are also calculated for Indian monsoon belt in the research work by Ellen. M. Douglas et al., The vapour flux during pre agriculture and during contempory agriculture is found to be (in both wet and dry season) 208.6 km<sup>3</sup>/yr, 296.93 km<sup>3</sup>/yr in Tamilnadu and 194.66 km<sup>3</sup>/yr, 221.05 km<sup>3</sup>/yr in Andhra Pradesh. In humid Tamilnadu it is estimated that the latent heat flux is high from the tropical forest, even if most of the croplands are irrigated and hence there is a reduction in overall latent heat flux. The figure-7 Shows the latent heat flux change for India during wet and dry seasons, from the figure the latent heat flux for Tamilnadu is increased by 10-50 W/m<sup>2</sup> during wet season and reduced by 5 W/m<sup>2</sup> during dry season, Andhra Pradesh experience the same change in wet season but the during dry season the humidity is not high as in Tamilnadu so the latent heat is inceased by  $5-10 \text{ W/m}^2$  in this region during dry season<sup>10</sup>.



Change in latent heat flux during wet and dry seasons<sup>10</sup>

To support the above paper the land use change of Nagapattinam district, Tamilnadu by Arunachalam et al., estimated that there is increase in cropland of about  $171.77 \text{ km}^2$  between 2000 and 2009. There is increase in agricultural activities, because the image was taken during the onset of monsoon 2009. But it is also mentioned that there is change in grassland and dry lands into croplands between 2000 and 2009<sup>11</sup>.

# Conclusion

Various studies proves that the coastal regions of Tamilnadu, Andhra Pradesh along the East coast of India being affected by sea level rise. The values and predictions regarding impact of agriculture, salt water intrusion and erosion are increasing and so far they match with the prediction values. Similarly changes in climate due to land use are being modelled and predicted for future and found that there will be increase in latent heat flux, reduction in vapour flux and reduction in albedo which reduces regional temperature over East coast of India.

#### References

- Nayak G.N., Indian Ocean Coasts, Coastal Geomorphology, *Encyclopedia of Earth Science*, 7, 555 (2005)
- 2. Hervé Le Treut, Richard Somerville., Historical Overview of Climate Change Science, Fourth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, 101 (2007)
- 3. www.imdchennai.gov.in (2013)
- Nageswara Rao K., Subraelu P., Naga Kumar K.Ch.V., Demudu G., Hema Malini B., Ratheesh R., Bhattacharya S., Rajawat A.S. and Ajai., Geomatics Analysis of the Impact of Predicted Sea-Level Rise on the Agriculture

along the Coastal Zone of Andhra Pradesh, Impact of Climate Change on Agriculture, 176-179 (**2009**)

- **5.** Ghosh Bobba A., Numerical Modelling of Salt-Water Intrusion Due to Human Activities and Sea-Level Change in the Godavari Delta, India, Hydrological Sciences-Journal-Des Sciences Hydrologiques, S70-S79 (**2002**)
- Saranathan E., Chandrasekaran R., Soosai Manickaraj D., Kannan M., Shoreline Changes in Tharangampadi Village, Nagapattinam District, Tamil Nadu, India—A Case Study, *J Indian Soc Remote Sens*, 109-114 (2011)
- 7. 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)
- 8. Johannes J. Feddema, Keith W. Oleson, Gordon B. Bonan, Linda O. Mearns, Lawrence E. Buja, Gerald A. Meehl and

Warren M. Washington., The Importance of Land-Cover Change in Simulating Future Climates, *Science*, **310**, 1675-1677 (**2005**)

- **9.** Defries R., Bounoa L., Collatz G.J., Human Modification of the Landscape and Surface Climate in the Next Fifty Years, Global Change Biology, 442-456 (**2002**)
- Ellen M. Douglas, Dev Niyogi, S. Frolking, J.B. Yeluripati, Roger A. Pielke Sr., Nivedita Niyogi, C.J. Vörösmarty and U.C. Mohanty, Changes in Moisture and Energy Fluxes Due to Agricultural Land Use and Irrigation in the Indian Monsoon Belt, Natural Hazards, 9-13 (2005)
- 11. Arunachalam S., Maharani K., Chidambaram S., Prasanna M.V., Manivel M. and Thivya C., A Study on the Land Use Pattern Change along the Coastal Region of Nagapattinam, Tamil Nadu, *International Journal of Geomatics and Geosciences*, 1(4), 705-712 (2011)