Impact of Climate Change on Coastal Agriculture

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Abstract

Climate change is recognized as a significant man-made global environmental challenge. It is also treated as a threat. Consequently, there is now a growing recognition of the vulnerability of key sectors of economy and development due to climate change. It is predicted that climate change could have devastating impacts on agriculture. The predicted sea-level rise will threaten valuable coastal agricultural land, particularly in low-lying areas. Biodiversity would be reduced in some of the most fragile environments, such as Sunderbans and tropical forests. Climate change imposes higher level of vulnerability mostly in crop agriculture sector and then fisheries, livestock and health respectively. Yield of most of the crops would be negatively impacted by rise in temperature and erratic rainfall, flooding, droughts, salinity, etc. As a consequence of climate change the trend shows that drier regions would be drier in the winter season. Therefore, possibility of growing rain fed crops would be diminished. During the dry months of March and April, salinity problems, resulting from seawater intrusion, are more acute and lands are commonly let fallow as crop productions restricted by the presence of salt. The Temperature Humidity Index (THI), an index used to define losses due to thermal stress is highest in the months of September–April and is likely to remain under highly stressful conditions in the 2030s. The livestock in the Coastal regions are likely to be highly vulnerable with consequent adverse impacts on its productivity throughout the year in the 2030 scenario with THI above 80.

Keywords: Climate change, costal agriculture, humidity index, temperature

1. Introduction

The climate can clearly explains that the system is inequilibrium, where the incoming radiation is balanced by outgoing radiation. The change in equilibrium leads to climate change. Climate change is recognized as a significant man-made global environmental challenge. It is also treated as a threat. Consequently, there is now a growing recognition of the vulnerability of key sectors of economy and development due to climate change. The various assessment reports brought out since 1990s by the Intergovernmental Panel on Climate Change (IPCC) have progressively tracked the development and build up of knowledge and understanding of the science, impacts and mitigation of climate change at the global and regional levels.Climate change will have impact over global mean climate or temperature which in turn increases drought condition, reduction in agriculture, coastal erosion and sea level rise etc. Agriculture is extremely vulnerable to climate change that is related to changes in temperature, radiation, atmospheric humidity, wind speed that consequently affect evapotranspiration (Kotsopoulos et al., 2003); the latter most likely leads to reduced yields of desirable crops.

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 effects 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.

Obviously, the most vulnerable to sea-level rise due to climate change (IPCC, 2007) are the low-lying lands, e.g. river deltas where the soil surface is less than 1.0 m above sea level (Ericson, 2006). From a societal perspective, the six most important biogeophysical effects of climate change are (Klein and Nicholls, 1999; Nicholls et al., 1999): (i) Increasing flood-frequency; (ii) Erosion; (iii) Inundation; (iv) Rising water tables; (v) Saltwater intrusion and (vi) Biological Effects. It is, therefore, of great importance for the national economy, to enhance the scientific knowledge into matters of environmental monitoring and management of the effects of climatic change on the coastal agricultural lands, with

emphasis to deltaic areas.

2. Observed And Projected Changes In Climate

In IPCC's fourth assessment report, based on the Special Report on Emission Scenario (SRES) CO_2 concentration in the atmosphere is projected to be in range between 540 and 970 ppm. This has resulted in many changes including increase in surface temperature in many regions over the globe. In the last 100 years the mean annual surface air temperature of India has increased by 0.4 - 0.6°C (Rupakumar, 2002). Annamalai et al. (2010) has reported decreasing rainfall tendency in both southwest and northeast monsoon seasons in most parts of central and northern India. In contrast, peninsular parts of India, particularly over the region 9-16°N encompassing the rice growing areas showed an increasing rainfall tendency. This increase was particularly strong during the northeast monsoon season.

A marked increase in rainfall and temperature over India could also be seen during this century. The maximum expected increase in rainfall is likely to be 10-30% over central India. Temperatures are likely to increase by 3-4 degree Celsius towards end of the Century. It is more pronounced over northern parts of India. The mean sea level rise is likely to be slightly less than 1mm per year along the Indian coast. Greater number of high surges and increased occurrences of cyclones in post-monsoon period along with increased maximum wind speed are also expected as per the Ministry of Environment and Forests (MoEF), Govt. of India and U.K. Department of Environment, Food and Rural Affairs (DEFRA).

3. Climate Change In Coastal Regions

• In the eastern coast, the rainfall is likely to range between 858±85.8mm to 1280± 204.8mm in the 2030s. The increase in the 2030s with respect to the 1970s is estimated to range between 0.2% to 4.4%. Projections for the western coast indicate a variation from 935±185.33mm to 1794±247mm, which is an increase of 6%–8% with respect to the1970s.

• In the eastern coastal region, the mean annual air temperature is likely to rise from 28.7± 0.6 °C to 29.3±0.7 °C. The rise in temperature with respect to the 1970s is around 1.6 °C to 2.1 °C. In the western coastal region, mean annual temperatures are likely to increase to 26.8±0.4 °C to 27.5±0.4 °C in the 2030s. The rise in temperature with respect to the 1970s will be between 1.7°C and 1.8°C.

• The rise in minimum temperatures along the eastern coastal regions is likely to be lower than in the western coastal region. The change in minimum temperatures along the eastern costal region is projected to range from 2.0°C to 4.5°C, the higher end of the change being limited to Tamil Nadu. The change in maximum temperature in the 2030s with respect to 1970s ranges between 1°C and 3.5°C.

• The western coast experiences similar extremes in temperature as the Western Ghats. In the eastern coast, the numbers of rainy days are likely to decrease by 1–5 days, with a slight increase along the Orissa coast. The intensity of rainfall is likely to increase between 1mm day^{-1} and 4mm day^{-1}.

• Since 1986, a decreasing frequency in cyclones along the eastern coast surrounded by the Bay of Bengal and the northern Indian Ocean have been observed. Also, no trend is seen in the western coast for the same period which is along the Arabian Sea. The projected number of cyclonic disturbances along both the coasts in the 2030s is estimated to decrease with respect to the 1970s. However, cyclonic systems might be more intense in the future.

• Storm surge1 return periods could only be estimated at a 100 year time scale. It is found that all locations along the eastern coast of India, that are north of Visakhapatnam, except Sagar and Kolkata, show an increase in 100-year return periods of storm surges by 15% to 20 % with respect to the 1970s.

Observations based on tide gauge measurements along the Indian coast, for a period of 20 years and more for which significantly consistent data is available indicate that the sea level along the Indian coast has been rising at the rate of about 1.3mm $year^{-1}$ on an average. In the absence of the availability of regional projections, for the 2030s, global projections can be used as a first approximation of sea-level rise along the Indian coasts in the next few decades.

Climate change will exacerbate environmental and social problems in the coastal areas of the Indian Ocean basin. In Southeast Asia, climate change poses a grave threat to agriculture and food security, water resources, natural ecosystems, forestry, biodiversity and human health. Throughout the region, rising sea levels constitute the most serious risk for coastal nations, with Bangladesh, India, Indonesia, the Maldives, Myanmar, the Philippines, Tanzania and Vietnam figuring among the most vulnerable. The LDCs, particularly the small island developing states (SIDS), will disproportionately bear the brunt of climate change impacts. They contribute little to world greenhouse gas emissions, yet they possess limited capacity to mitigate the impacts of global warming and face other natural hazards as well. Rising not more than 3 meters above sea level, the Maldives faces the grim prospect of being completely submerged by rapidly rising seas within the century (Table 1).

4. Vulnerability Assessment

The assessment of vulnerability focuses on gaining an understanding of how climate variability and change will impact coastal communities, the goods and services provided by natural resources and human-built infrastructure. Vulnerability assessment for climate change in specific coastal regions considers three factors: 1) the nature and magnitude of climate variability and change; 2) the human, capital and natural assets that will be exposed to and impacted by climate change; and 3) the current capacity of coastal communities and ecosystems to adapt to and cope withclimate impacts.

Table 1: Major threats to coastal environment due to climate change in india

Sector	Climate change threat	Other human threats
Coral reef and coastal Ecosystem	Loss of coral reefs from coral Bleaching; Loss or Migration of coastal ecosystem; Coastal erosion and sedimentation; Change in the distribution of marine species; Increased spread of exotic and invasive species	Intense coastal development and habitat loss; Pollution and marine deadzones; Conversion of mangroves and wetland for mariculture; Damage to sea grass beds; Coral mining and oil spills; Spread of invasive species
Fisheries	Overall decline in ocean Productivity; Eutrophication and coralmortality; Loss of shift in critical fish habitat; Temperature shift causing migration of fishes; Extreme events, temperature increase and oxygen depletion; Ocean acidification	Over harvesting; Destructive fishing practices; Land based source of pollution; Sedimentation of coastal system from land based sources
Mariculture	Increase in water temperature could result in unpredictable changes in cultural productivity; Increase stress and Vulnerability to pathogens; Changes in weather pattern and extreme weather events	Overexploitation of juveniles and larvae seedstock for fish farm; Loss of protective habitats from improper sitting for mariculture facilities
Freshwater Resource	Storms, erosion and precipitation damaging infrastructure and causing losses to beaches; Compromised water quality and increasing beach closures; Increases in tourism insurance costs; Saltwater intrusion of freshwater sources; Encroachment of saltwater into estuaries and coastal rivers; Waves and storm surges reaching further inland, increasing coastal inundation and flooding; Decreased precipitation, Enhancing saltwater intrusion and exacerbating water supply problem	Discharge of untreated sewage and chemical contamination of coastal water; Unregulated freshwater extraction and withdrawal of groundwater; Upstream dams; Enlargement and dredging of waterways
Human Settlement	Coastal inundation; Infrastructure damage; Sea level rise during storm surge; Reduced clearance under bridges; Overtopping of coastal defense structure; Degradation of natural coastal	
region	Inappropriate sitting of infrastructure; Habitat conservation and biodiversity loss	

Climate is changing in response to increased greenhouse gas emissions and projections for the coming decades paint a sombre picture. There is scientific consensus that increases in greenhouse gases in the atmosphere drive warming temperatures of air and sea and that the world's oceans acidify as theyabsorb the carbon dioxide warming of air and sea causes shifts in precipitation patternsand hydrological cycles, sea level rise and more frequent and severe extreme weatherevents (e.g., storms and storm surge). These effects are already being witnessed in the India's coastal regions and are projected to intensify in years to come. According to scientists, the rising temperature of the earth's surface would spell down for the planet in the long run. The consequences of global warming on the coastal zones are one ofthe major concerns among scientists. Rise in sea levels, a direct impact of globalwarming and climate change is the key factor threatening the coastal areas of the worldand India. The coastal zones of the India are mostly populated because of reasons like fertile soil, opportunity for the development of fishing and shipping industry and so on. Global warming and the subsequent rise in sea levels would cause frequent floods inthe coastal zones. The effects of global warming would be first felt on these coastal zones.

5. Impact Of Climate Change On Coastal Agriculture

It is predicted that climate change could have devastating

impacts on agriculture. The predicted sea-level rise will threat en valuable coastal agricultural land, particularly in low-lying areas. Biodiversity would be reduced in some of the most fragile environments, such as Sunderbans and tropical forests. Climate change imposes higher level of vulnerability mostly in crop agriculture sector and then fisheries, livestock and health respectively. Yield of most of the crops would be negatively impacted by rise in temperature and erratic rainfall, flooding,droughts, salinity, etc.

As a consequence of climate change the trend shows that drier regions would be drier in the winter season. Therefore, possibility of growing rain fed crops would be diminished. During the dry months of March and April, salinity problems, resulting from seawater intrusion, are more acute and lands are commonly let fallow as crop productions restricted by the presence of salt. Yields of crops are drastically reduced when the threshold value for tolerance is crossed. More than 50% of the potential yields of most crops are reduced when the salinity is above 5 dSm^{-1} (EC). Among the crops, cotton is the most resistant crop followed by Burmuda grass (EC 6.75 dSm^{-1}) and wheat (EC 6.0dSm^{-1}). Normally, rice can tolerate EC value up to3.0 dS m^{-1}.

Figure 1: Relative Vulnerability Of Coastal Deltas Shown By The Indicative Population Potentially Displaced By Current Sea Level Trends To 2050

The productivity of irrigated rice is likely to reduce by 4% in most of the areas in this region. However, irrigated rice in parts of southern Karnataka and northern-most districts of Kerala is likely to gain. In case of rain-fed rice, all areas in the region are likely to lose yields by upto 10%. The results thus indicate that irrigated rice is able to benefit due to CO_2 fertilization effect as compared to the rain-fed rice, which is supplied with less amount of fertilizers.

Climate change is likely to reduce yields of maize and sorghum by up to 50% depending upon area in this region. These crops have C_4 photosynthetic systems and hence do not have relative advantage at higher CO_2 concentrations. Coconut yields are projected to increase as much as 30% in the majority of the region by the 2030s. Increase in coconut yield may be mainly attributed to the projected increase in rainfall(~10%) and relatively less increase in temperatures, apart from CO_2 fertilization benefits. However, some areas like south-west Karnataka, parts of Tamil Nadu and parts of Maharashtra may show reduction in yields up to 24%.

The Temperature Humidity Index (THI), an index used to define losses due to thermal stress is highest in the months of September–April and is likely to remain under highly stressful conditions in the 2030s. The livestock in the Coastal regions are likely to be highly vulnerable with consequent adverse impacts on its productivity throughout the year in the 2030 scenario with THI above 80. An increase in recruitment and catches of oil sardine during the post-southwest monsoon season along the coastal region, especially along the Kerala coast, is expected in the future due to warming, elevated Sea Surface Temperature (SST), favourable wind (and perhaps current) and increasing Coastal Upwelling Index (CUI) inducing higher chlorophyll concentration during the southwest.

A qualitative assessment indicates that morbidity and mortality of the population inthe regions under focus are likely to increase with warming temperatures and variable precipitation as they have direct as well as indirect effects. Direct effects can manifestas heat stress and indirect effects can be in terms of vector borne diseases, water borne diseases and malnutrition etc. Malaria transmission in coastal areas, particularly the east coast, is projected to experience reduction in the number of months open for transmission. The number of times it is open for in 10–12 months may reduce by 34%.

In conclusion it can be said that coastal region of India is highly vulnerable by extreme events and climate change risk, which need to focus for sustainable development and adaptation.

6. Conclusion

The sea level rise is the best indicator of climate change than any other atmospheric variable. Keeping the above point in view it can be said that coastal region of India is highly vulnerable by extreme events and climate change risk, which need to focus for sustainable development and adaptation.The livestock in the Coastal regions are likely to be highly vulnerable with consequent adverse impacts on its productivity throughout the year in the 2030 scenario with THI above 80.

7. References

Annamalai, H., Hamilton, K.P., Sperber, K.R., 2007. South Asian Summer Monsoon and its relationship with ENSO in the IPCC AR4 Simulations: Journal of Climate 20, 1071−1092.

Ericson, 2006. Effective sea-level rise and deltas: Causes of change and human dimension implications. Global and Planetary Change 50(1-2), 63−82.

Gangwar, S. 2013. Climate Change Vulnerability and Risk Assessment: Focusing on Coastal India. International Journal of Environmental Engineering and Management 4(6), 605−612.

IPCC, 2007. Summary for Policy Makers. In: Climate Change.

2007: The Physical Science Basis. Contributing of Working Group I to the Fourth assessment Report of the Inter govermental Panel on climate Changee. Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt K.B., Tignor, M ., Miller H.L. (eds). Cambridge University Press, UK.

Klein, R.J.T., Nicholls, R.J., 1999. Assessment of coastal vulnerability to sea-level rise. Ambio 28, 182−187.

Kotsopoulos, S., Kalfountzos, D., Alexiou, I., Zerva, G., Karamaligas, C., Vyrlas, P., 2003. Actual evapotranspiration and soil moisture studies in irrigated cotton fields, European Water (e-bulletin of EWRA), ¾, 22−28.

Nicholls, R.J., Hoozemans, F.M.J., March, M., 1999. Increasing flood risk and wetland losses due to global sea-level rise: Regional and global analyses. Global Environmental Change, 9, 69−87.

Rupakumar, K., 2002. Regional Climate Scenarios. TERI Workshop on Climate Change: Policy Options for India, New Delhi.

Sikder, T., 2010. The Impacts of Climate Change on the Coastal Belt of Bangladesh: An Investigation of Risks & Adaptations on Agricultural Sector. Proceedings of International Conference on Environmental Aspects of Bangladesh (ICEAB10), Japan, Sept. 2010.

