

## Climate change impact – A novel, initiative for Kerala

“Climate Change is the greatest ecological, economic and social challenge of our time”

Earth's Climate is undergoing noteworthy natural changes for centuries. However the variations in the last couple of centuries cannot be explained by natural climatic variations alone. Inter-governmental Panel on Climate Change (IPCC) had observed that this is due to global warming. The increase in global average temperature is due to the observed increase in anthropogenic greenhouse gas concentrations. Anthropogenic climate change has a significant role on physical and biological systems all over the globe. In the last century the global average surface temperature has risen by 0.74°C. A few degree change in temperature can attribute marked difference in global environment. During the last interglacial the Polar Regions were 3 to 5°C warmer than today. The Sea Levels at that time were 4 to 6 M higher than the present. The sea level rise was 1.7 mm during the period 1870 to 1993. Whereas during the year 1993-2007 the average rise in sea level per year is 3.4 mm. Warming of the Oceans and melting of ice are expected to lead to continued sea – level rise of 18 to 79 cm in this century. Inter-governmental panel on climate change has estimated a sea level rise of 21 to 71 cm in the year 2070 due to thermal expansion of Oceans as well as melting of glacier. This will have widespread effects on coastal zone and natural coastal protective mechanisms.

Since the last little ice age, there is an invasion of coastline towards land at the rate of 1 KM per century. Apart from the above natural process coastal zone is under tremendous pressure due to accelerated sea level rise (anthropogenic impact) and other invasions due to natural process. According to the report of UNEP benefits from marine and coastal ecosystem and other activities viz. coastal tourism, trade and shipping, offshore oil and gas and fisheries amounts to more than US \$ 500 billion per year. UNEP report states that the estimated global average of Marine Biomes from per hectare estuary per year is more than 20,000 US \$, mangrove/tidal marshes is more than 8000 US \$, sea grass/algal bed is more than 16,000 US \$ and coral reefs is more than 4000 US \$.

The ocean and coastal areas influence all sectors of the global economy. It is the only source of protein for 1-2 billion people. The human presence, influence and activity have reached in every parts of the ocean. The growing contributions of human generated emissions as a by-product of industrialization are responsible for forcing the “greenhouse effect”. The global warming due to greenhouse gas is triggering and further accelerating the amplitude of climate variability and rate of climate change. This will cause increasing pressure on the ability of ecosystems and human society to adapt with the changing climate scenarios. The trend in greenhouse gas emissions for the next few decades will have a significant influence on climate by 2050 and beyond.

The security of coastal population is at risk due to the sea level rise and increased intensity and frequency of storms. The greenhouse effect on the impact of hydrological cycle will cause increasing scarcity of fresh water in the coastal region. The climate change will have a variety of impacts on agriculture, human health, biodiversity, coastal areas and water stress, which will vary from region to region. A preliminary assessment of expected regional impacts in Asia, based on Intergovernmental Panel on Climate Change (IPCC), published during the year 2007 states that

“(i) In parts of Asia, crop yield will decrease between 2.5 to 10% by the year 2020s and 5 to 30% in 2050s; (ii) 120 million to 1200 million people experience increased water stress by 2020s and 185 million to 981 million people by 2050s; (iii) predicted significant sea level rise results in greater risk of flooding and sea water intrusion, loss of coral reefs estimated at 24% in the next ten years and 30% within thirty years; (iv) increase in coastal water temperatures could lead to causes of cholera in South Asia, increase in mortality caused by diarrhoea disease in East, South and South-East Asia; (v) within next 20-30 years, glacier melt in Himalayas will lead to increased flooding and avalanches and reduced river flows and increased extinction rates.

Asia will be particularly vulnerable to the climate change, because of its concentration of major

population centers at low elevations. Mumbai, India; Shanghai, China; Jakarta, Indonesia; Tokyo, Japan; and Dhaka, Bangladesh are a few low lying major population centers that are in a vulnerable situation due to sea level rise. It is reported that five most vulnerable countries with large populations are China, India, Bangladesh, Vietnam and Indonesia. The impact of climate change on developing nation is highly significant. The implications of these potential effects range from changes in ocean chemistry, forecasted sea level rise, melt of glaciers, human health and the displacement of coastal people.

### **India and Climate Change**

India has a distinct geographical entity since it is marked off from the rest of Asia by mountain and sea. The geologic and tectonic history of the region is complex. It is reported that during the year 2004 more than 261 earthquakes events occurred in this region before the divesting earthquake of 26<sup>th</sup> December 2004 and the tsunami that followed. There is an apparent seismic quiescence around the seas of India. This may change into extreme weather events occasionally. It is detrimental to the coast and Islands of India. India has 667 Islands in Bay of Bengal and 508 in Arabian Sea. Length of coastline of mainland and Islands is 7516.6 KM. India have a land area of 3287263 sq.km and territorial waters of about 2465447.5 sq.km. Security of India's coastline, stability of economic life and better governance in coastal region and Islands is highly significant.

The UNDP Human Development Report, 2007-08 reveals that developing nations near the equator will be much vulnerable to sea level rise. Sea level rise will be a pressing issue to countries in Asia. Based on the above analysis, areas in India are more susceptible to sea level rise. There are many small Islands in Arabian Sea and Bay of Bengal. It is a fact that there is very high density of population living in close proximity to the coast. The Lakshadweep Islands are regarded as atoll formation of corals. It consists of 36 islands. All these atolls are very small Islands. The largest island has an area of 4.8 sq. km. and the smallest is with an area of 0.1 sq. km. isotopic studies carried out at NGRI, Hyderabad in the scleractinian corals from these islands have shown decadal to inter-decadal changes in SST during the last 120 yrs. Also bacteria associated with the pollution are reported in Porites corals from the Kavaratti (Lakshadweep) island.

It is inferred that there will be increased coastal erosion, inundations, persistent storm events, shifts in wetlands, incursion of saline water into fresh water aquifers, migrations of coral reefs, mangroves, tidal flats, in the coastal environs of India. There are a few studies related to the impact of sea level rise on the fresh water aquifer of coast and Islands of India. The impact of Sea Level Rise (SLR) for a scenario of 20 cm has been predicted for the Islands. There are many sector specific initiatives to study the climate change and the impact of sea level rise on the coastal environment of India. However, there is no attempt to assimilate integrated and reliable climate change contextual information that is useful and usable to local decision makers. There is no clear information on the coastal ecosystem, Islands and Islets on which the local adaptation decisions can be based and the capacity of the local people to adapt and mitigate from the vulnerability of impact of climate change. This will drastically affect the livelihood and the economic security of the local people.

### **Kerala and Climate Change**

Kerala is acclaimed for its unique development trajectory leading to high human (social) development disproportionate to its economic growth. Kerala stands first in the UNDP's ranking of states in Human Development Index for Indian States (Planning Commission, 2002, Council for Social Development, 2008). In per capita consumption, Kerala stands at the top though it ranks only fifth in per capita NSDP (GoI, 2009).

Kerala has a fragile and closed eco-system. There are both threats and opportunities for Kerala's sustainable development. Threats include the following. State has the third highest population density in India. (Kerala: 819, India: 324). Acute food insecurity and import of food grains. Land hunger in the state for housing and lively hood leads to encroachment of forests and low lying wetlands. Due to heavy unemployment, the slogan of industrial development at any cost gets support, for the employers using polluting technologies from the workers as also the unemployed. Unregulated back-water tourism (house boats) and 'eco' tourism in the ecologically fragile lands. Pro-environment lobbies are too weak, localized and fragmented. A major weakness of these movements is the lack of scientific and technical knowhow. The financial weakness of the State government does not allow for financing cleaner technologies to replace the existing polluting

technologies. The existing low industrial base allows for a strategy of future industrialization of the state using less energy intensive and low GHG emission technologies.

The state has a rich biodiversity potential. Kerala possess 95 percent of the flowering plants in the Western Ghats. Contains 90 percent of the vertebrate fauna. Western Ghats in Kerala is one of the 34 world's hot spots of biodiversity. Among the 34 it is placed in the list of most important hottest biodiversity hotspots. (Latha A, 2010). Kerala has three floristic hot spots-Agastyamala, Anamala and Silent Valley. Western Ghats in Kerala have 4500 species of flowering plants. Western Ghats have 145 species of mammals (of which 14 are endemic to Western Ghats), 169 species of fresh water species, 93 species of amphibians (of which 40 are endemic). There are 486 species of birds (of which 16 are endemic to Western Ghats). There is also innumerable micro flora and fauna. The State has two biosphere reserves- Nilgiri and Agastyamala (GOK, 2008). State has three out of twenty-five wetlands of international importance included in the Ramsar list viz., Ashtamudi, Sasthamkotta and Vembanad-Kolland.

In Kerala, the emission rate of CO<sub>2</sub> and other green-house gases (GHG) are low. Kerala has a critical eminence for Carbon Sequestration Potential. In the percentage of geographic area covered by forest, Kerala's rank was the fourth (Kerala: 28.9%, India: 23.4%) (GoI, 2005). The forests in Kerala are better stocked than forests in other parts of India.

Kerala has high population density along the coastal villages along with equally high density of open wells. The climate induced changes are going adversely affect livelihood options of the people of Kerala, which has a 590 km long coastline. This clearly indicates the vulnerability of the coastal population of Kerala even to a few millimeter rise in sea level. There are many sector specific initiatives to study the climate change and the impact of sea level rise on the other coastal environment of India. However, there is no attempt to assimilate and integrate the climate change contextual information that is useful to the planners and decision makers of the State. There is lack of explicit information on the coastal ecosystems and islets upon which to base the local adaptation decisions. It is imperative to develop an integrated climate change contextual database and information system in spatial domain for Kerala to understand the interrelationship between the elements

of ecosystems, the changes that are likely happen to them and their physical, social and economic impacts.

The International Conference on Climate Change and Environment held at Cochin University of Science and Technology during 24-27 October 2010 had recommended developing a multidisciplinary project to study the impact of Climate Change in Kerala. Researchers associated with climate change studies had met many times during the year 2010 and 2011 and developed the project entitled "Climate Change Database for Impact Assessment and Development: Adaptation and Mitigation Options for Kerala- A Multi disciplinary simulation and modeling" Four national institutes of Council of Scientific and Industrial Research (CSIR) viz. CSIR Centre for Mathematical Modeling and Computer Simulation (C-CMACS), Bangaluru, National Institute for Interdisciplinary Science & Technology (NIIST), Thiruvananthapuram, Central Road Research Institute (CSIR-CRRI) and National Institute of Science Communication And Information Resources, New Delhi are the Central Institutes associated with the development of the project. Centre for Socio-economic and Environmental Studies (CSES) a nongovernmental organization had submitted detailed program along with Department of Statistics of CUSAT and Department of Futures studies of University of Kerala. Six Universities of Kerala viz Kerala Fisheries and Ocean Science University, University of Kerala and Kerala Agriculture University (KAU), Vellanikkara, Trichur and Cochin University of Science and Technology, Kannur University and Kerala Veterinary and Animal Science University are the participating organizations of the project. Many departments of Cochin University of Science and Technology viz. Department of Statistics, Kochi (CUSAT), Department of Physical Oceanography, Kochi (CUSAT), Department of Marine Biology, Kochi (CUSAT), Department of Chemical Oceanography, Kochi (CUSAT), Department of Atmospheric Science, Kochi (CUSAT), Department of Ship Technology and Department of Industrial Fisheries are involved in the project. Indian Institute of Information Technology and Management, Kerala had submitted specific program for the study. National Institute of Science Communication And Information Resources (CSIR-NISCAIR), New Delhi is the nodal organization and Dr Gangan Prathap, Director, NISCAIR is the mentor of the project. The

project will be submitted to the Department of Science and Technology, Government of India for financial support.

### Objectives of the present study

- A. To analyze the trends in climatic elements, their spatial pattern and its relationship with extreme events such as El Nino, cyclones, etc.
- B. To assess the impact of climate change to following sectors of Kerala a). Agriculture (including plantation crops and spices), b) Fisheries (marine and inland), c) Industries, d) Transport—vehicular and inland water transports, e) Tourism, f) Bio-diversity, g) Forestry, landshide & rood, i) Road lagiog, maintenance.
- C. To examine the spatial and temporal changes in water resources (surface and groundwater -quantity and quality), a) Specifically assess the dynamics of riverine discharge and saline water incursion under changing climate scenarios, b) Monsoonal variations and its impact, c) Climate change scenario on the islets of Kerala, d) Sea level rise and natural resources of the coastal areas of Kerala: demarcating the vulnerable regions. e) Examine the biogeochemical evidences of climate change, f) Develop a framework and decision support tool to assess the climate change impacts on Livelihood and developmental processes, g) Evolving a region wise/localised specific adaptive measures for Kerala. H) Looking into suitable sectoral mitigation options under changing climate scenarios, i) Assess the carbon sequestration potential of Kerala, j) The study of the atmospheric chemistry related to climate change and monsoonal variations in the perspective of Kerala, k) Developing large scale forecasting and modeling of the various parameters using high power computer simulation tools, l) Assist the local bodies and stake holders in adopting appropriate measures in developmental activities namely industries, agriculture, and other livelihood options of Kerala.

### Expected Outcome of the study

The oceans, marine ecosystems and environment were considered and managed in a sectoral way. There were traditional management scheme for each sector. Fisheries management did not consider other marine uses. Use of ecosystem and fresh water discharge to the coastal waters are managed with different processes. Use of oceans under national jurisdiction did not relate to uses of ocean areas beyond national jurisdiction. Poverty alleviation was not linked to a healthy marine environment. Whereas the impacts of climate change threaten to alter the marine environment at an extreme different entity and scale. It is affecting all issues, sectors and peoples of the world, an imperative for integrated and sustainable marine management. Impact of climate change had conceptualized and recognized that all oceanic and atmospheric problems are linked and must be considered as a whole system.

Present study is an attempt to integrate climate change information into development and adaptation efforts. It is planned to publish a guidance manual for development planning to assist with the integration of climate information into development efforts. This is a prime tool to assist planners and stakeholders in adapting to the changing climate. These basic processes are essential for assessing vulnerability and identifying and implementing climate change adaptations. The present study will leads to strategic interventions for developing capacity to improve governance in the coastal regions under various scenarios of climate change and extreme weather events.

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