Assessment of impacts and vulnerability to India's coastline due to climate change

The recently concluded Second National Communications Project, coordinated by the Ministry of Environment and Forests (MoEF), Government of India involved participation of about 130 institutions spread across the country. A summary of these reports are expected to be prepared soon to be communicated to the United Nations Framework Convention on Climate Change (UNFCC). In the meantime, the MoEF has come out recently with an Indian Network for Climate Change Assessment (INCCA)[1].

Many sectors considered for assessment in the National Communications Project include agriculture, forestry, coasts, water, etc. Among them, the coastal sector had the least number of participating organizations. Only a limited number of studies coming from a few organizations were available for issues on the coastal sector. The number of peer-reviewed papers in the field of science, impacts and vulnerability along the Indian coasts has been low. India has a long coastline of about 7500 km and the livelihood of many depends on the activities related to the coast. There are already many anthropogenic problems varying from infrastructure development, pollution, etc. threatening this sector. Climate change will enhance such already existing problems.

One of the impacts of global warming is the increase in sea level. Estimates of sea-level rise along the Indian coast in the past century are relatively well known[2]. However, there are no regional projections available for the 21st century. Most of the IPCC rise in sea-level projections are available only on global scales. Many countries have started research on estimating regional and local rise in sea-level projections using various methods, for instance, fingerprinting techniques[3]. However, not many efforts in this direction have been made in our country. Moreover, studies on the impacts of climate change on sensitive ecosystems such as mangroves[4] and coral reefs are few.

Considering the magnitude of these problems and also the long-term national interests, research on impacts and vulnerability to the coasts and the necessary adaptation measures is needed. Universities need to take up local issues on impacts and adaptation. For instance, GIS tools are found to be useful for preparing inundation maps and determining impacts of a projected sea-level rise. Studies on the impact of climate change on coastal ecosystems need to be taken up. Government funding agencies need to promote funding of research related to climate change in the coastal sector. Assessment of the changes taking place in the coastal regions, using a good number of peer-reviewed papers will give sufficient information for the planners and coastal zone managers for taking necessary adaptation measure.

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Natural disaster compels biota to adapt

Ecosystems are unsteady in terms of its stability, particularly when it is over exploited and vulnerable to natural disasters and natural changes. These might have positive or negative impacts on the survival, extinction and adaptation of the biota in the affected environment, although negative impacts are frequent[1]. The 2004 Indian Ocean tsunami has drastically affected and altered many coastal and terrestrial ecosystems, including the marine environment. It had a severe impact on the human settlements, a variety of ecosystems and their biota. The consequence of the tsunami on the undisturbed natural ecosystems and their biota is less assessed scientifically. We have studied the ecological characteristics and fish diversity of an undisturbed Kokilamedu (KKM) Lake ecosystem that has been severely devastated by the tsunami. The lake is a shallow water body (0.5 sq. km area) within the campus of the Department of Atomic Energy, Kalpakkam and is approximately 200 m ashore the southeast coast of India. It has a maximum depth of about 1.6 m, is fed by rainfall during two monsoons and has no tributaries leading to it.

The impact of the calamity led to a probable shift in regime and resulted in a reasonably high concentration of nutrients[2,3] in the lake. Interestingly, this originally freshwater lake[4] has been converted to a near-brackish water ecosystem[2] due to the impact of the tsunami. To assess the impact, we studied the fish diversity which is a sensitive indicator of ecosystem change. We encountered a total of 20 species of fishes, out of which 19 were not reported previously from this lake environment. Remarkably, out of the total number, five were marine (Figure 1), nine were brackish and the remaining six were freshwater inhabitants. This gives an impression that the marine species encountered were recruited during the ingress of sea water during the tsunami, as the lake is not connected to any fresh/saline environment. The fishes seemed to adapt well to the new environment, as they were well grown and some were even bigger than the usual adult forms. This freshwater environment was used for the monoculture of *Ctenopharyngodon* sp. around 1970s when it was not in a prohibited area. A mass fish kill (900 kg) of *Ctenopharyngodon* sp. was reported[4] during May 1995, which further confirms that the

Table 1. Adapted marine and brackish water fishes in the Kokilamedu Lake (salinity is 2–10 psu approximately)

Fish species	Maximum length (cm)*	Maximum weight (g)**	Reported habitat*
Marine			
Elops machnata (Forsskål, 1775)	71	2800	Pelagic-neritic, oceanodromous, brackish, marine
Sphyraena jello (Cuvier, 1829)	85	5030	Reef-associated, oceanodromous, brackish, marine
Cociella punctata (Cuvier, 1829)	31	570	Reef-associated, non-migratory, marine
Platycephalus indicus (Linnaeus, 1758)	39	640	Reef-associated, oceanodromous, brackish, marine
Chanos chanos (Forsskål, 1775)	67	3550	Benthopelagic, amphidromous, freshwater, brackish, marine
Brackish			
Terapon jarbua (Forsskål, 1775)	4.5	90	Demersal, catadromous, freshwater, brackish, marine
Ambassis gymnocephalus (Lacepède, 1802)	13	220	Demersal, amphidromous, freshwater, brackish, marine
Oreochromis mossambicus (Peters, 1852)	16	280	Benthopelagic, amphidromous, freshwater, brackish
Glossogobius giuris (Hamilton, 1822)	3	40	Benthopelagic, amphidromous, freshwater, brackish, marine
Etroplus suratensis (Bloch, 1790)	16	300	Benthopelagic, brackish
Lates calcarifer (Bloch, 1790)	93	14120	Demersal, catadromous, freshwater, brackish, marine
Megalops cyprinoides (Broussonet, 1782)	52	2500	Benthopelagic, amphidromous, freshwater, brackish, marine
Anguilla bicolor bicolor (McClelland, 1844)	74	910	Demersal, catadromous, freshwater, brackish, marine
Acanthopagrus berda (Forsskål, 1775)	28	350	Demersal, oceanodromous, freshwater, brackish, marine

*From Fishbase (www.fishbase.org); **Observed length and weight during the study at the Kokilamedu Lake.

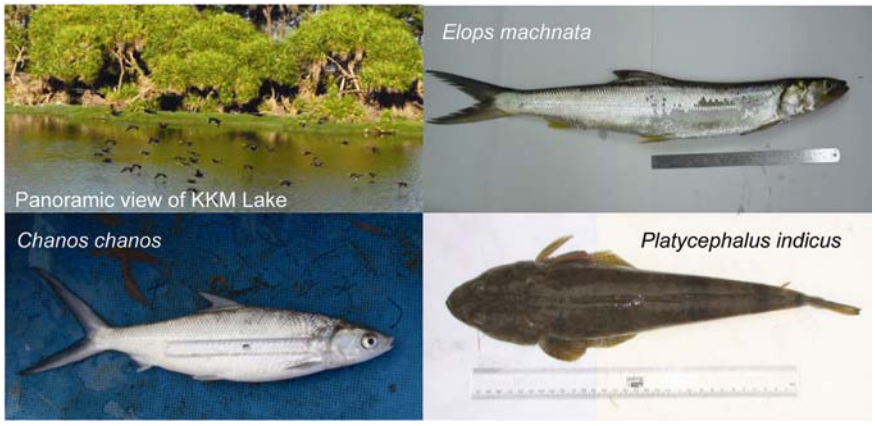

Figure 1. Key fish species encountered during the study at the Kokilamedu Lake.

lake was dominated by this single species. The species diversity observed during the present study appears to be high for this small and shallow ecosystem.

Our observations indicate that the encountered marine fishes had adapted well to this near-brackish environment, which is evident from the size of the adult fishes. Survival of these marine species encourages further studies on adaptation of biota in a changing aquatic environment, which is an isolated ecosystem. Recruitment of more number of marine species during the tsunami cannot be overruled and there could be a possibility of lack of adaptability leading to local extinction in the changed condition. The process of reproduction of these species in this secluded environment is interesting as they need different salinity conditions during their spawning, juvenile and adult stages. Lack of human interference in this high security zone probably helped the continued survival of these adapted species. Table 1 provides a list of adapted marine and brackish water fish species in the KKM Lake.

Natural disaster can be better assessed in terms of its impact in undisturbed natural systems like the KKM Lake. Changes due to natural disaster sometimes compel the biota to adapt to the changed environmental conditions, although this is not universal. It is always necessary to manage the impact of natural calamities in any possible way; at the same time priority should also be given towards the ecosystem response and how the inhabitants cope with the changes.

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