# Climate change adaptation methodologies in the Bay of Bengal fishing communities

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**The Bay of Bengal Large Marine Ecosystem (BOBLME) comprising the Bay of Bengal, the Andaman Sea and the Straits of Malacca is a large but relatively shallow embayment of the north-eastern Indian Ocean. Eight countries border the BOBLME: the Maldives, Sri Lanka, India (east coast), Bangladesh, Myanmar, Thailand, Indonesia and Malaysia. Located in the tropics, the climate of the BOBLME is dominated by the two monsoons, the South-west and the North-east monsoon. However, the monsoonal rainfall is not continuous, rather discrete with periods of heavy rainfall events. The region is also highly prone to cyclones and storm surges and about seven per cent of the global cyclonic events occur in this region.**

The waters of the BOBLME are highly productive and rich in biodiversity. Until the 1970s, marine fishery in the Bay was limited to coastal waters using traditional craft and gear. However, since the 1980s, rapid motorization and mechanization in the region has led to considerable expansion of the fishery into offshore waters. The total marine capture fisheries production from the BOBLME has increased from 1,451,905 tonnes in 1979 to 4,170,138 tonnes in 2006, with an annual average growth rate of seven per cent[1].

### The socio-economic scenario in the BOBLME

The countries surrounding the BOBLME are largely lower to middle income economies, characterized by high population and below average level of human development (see table). This macro-economic scenario is mirrored in the coastal region in general and fisheries in particular. Some studies have estimated that during 1990 about 400 million people were living in the LME's catchment area and many of them were subsisting at or below poverty level[2].

Being a traditional activity in the region, marine capture fishing has not only been practiced from time immemorial, but is usually associated with the same social or ethnic groups. However, this composition is changing rapidly as people from other primary activities are migrating to fisheries and constituting a growing part-time work force in the sector. Although a small portion, relatively well-off people from traditional fishing communities are also migrating to other sectors.

Marine fisheries, being de facto open access regime in the region, are characterized by a large number of fishers and fishing vessels (see table), and growing. For example, the total number of fishing vessels in Bangladesh, India, Maldives and Sri Lanka has increased from 0.17 million to 0.92 million between 1998 and 2010. This race to fish can to an extent be attributed to improving integration of coastal economies with national and international economies.

To sum up, despite being an important economic activity in the region, the fisheries sector is passing through a difficult stage. The sector is yet to stabilize and sustainability of the observed growth is questionable. The situation is further aggravated by a general lack of information on the state of fisheries resources as well as socio-economic attributes of fishers in the region.

**Human development in the BOBLME region**

| Country | Population (2010)[a] | Population Density (people per sq. km, 2010)[a] | Human Development Index – 2011 (Level)[b] | Population living on less than $1.25 a day at 2005 international prices[c] |
|---|---|---|---|---|
| Bangladesh | 148,692,000 | 1032.6 | 0.500 (low) | 43.3 (2010) |
| India | 1,224,614,000 | 372.5 | 0.547 (medium) | 32.7 (2010) |
| Indonesia | 239,871,000 | 125.9 | 0.617 (medium) | 18.1 (2010) |
| Malaysia | 28,401,000 | 86.1 | 0.761 (high) | 0.2 (2009, $2) |
| Maldives | 316,000 | 1060 | 0.661 (medium) | - |
| Myanmar | 47,963,000 | 70.9 | 0.483 (low) | NA |
| Sri Lanka | 20,860,000 | 317.9 | 0.691 (medium) | 7.0 (2007) |
| Thailand | 69,122,000 | 134.7 | 0.682 (medium) | 0.4 (2009) |

Source: a. FAO: FAO Statistical Yearbook 2012; b. UNDP: Human Development Report, 2011; c. World Bank: World Development Indicator

**Fisher population and total fishing fleet in the BOBLME region**

| Country | Fisher folk population (2010) | Total fishing fleet (2010) | Exclusive economic zone (sq km)[c] | Marine capture fisheries production, 2010 (in tonnes) |
|---|---|---|---|---|
| Bangladesh[a] | 902,961 | 50,555 | 78,538 | 607,492 |
| India[a] | 4, 054,802 | 194,490 | 2,290,268 | 3,226,213 |
| Indonesia[b] | 5,971,725 | 570,827 | 3,617,349 | 5,039,416 |
| Malaysia[b] | 155,913 | 49,756 | 447,276 | 1,428,881 |
| Maldives[a] | 14,241 | 979 | 916,189 | 94,953 |
| Myanmar[b] | 3,160,070 | 32,824 | 520,262 | 2,048,590 |
| Sri Lanka[a] | 825,200 | 46,138 | 530,684 | 385, 058 |
| Thailand[b] | - | - | 306,365 | 1,617,399 |

Source: a. Anon (2012) Annual report of the Bay of Bengal Programme Inter-Governmental Organisation. BOBP-IGO, 2012; b. Anon (2010) Fishery Statistics Bulletin of Southeast Asia. SEAFDEC, 2010; c. Sea Around Us Project, 2012 (May differ with EEZ presented by national governments)

Given the scenario, it is difficult to predict the impact of a shock or stimulus such as changing climate. While gauging the impacts of the changing climate is a priority area in research and policy discussions, different scenarios have emerged from such discourses, which are at best conjectures. As a result, dealing with climate change requires flexibility and constant monitoring for timely action.

### Possible impact of changing climate on the fisheries sector in the BOBLME region

A global study, Vulnerability of National Economies to the Impacts of Climate Change on Fisheries,[3] has estimated the sensitivity, adaptive capacity and vulnerability of the national economies to changing climate and shows that the region has low adaptive capacity and is moderately vulnerable, except Bangladesh, which is highly vulnerable.

Analyzing the data on sea surface temperature (SST) and other parameters from a variety of global sources, Vivekanandan et al. (2009) found warming of the sea surface along the entire Indian coast. The SST increased by 0.2°C along the northwest, southwest and northeast coasts and by 0.3°C along the southeast coast during the 45-year period from 1961 to 2005. The study has predicted that the annual average SST in the Indian seas would increase by 2.0°C to 3.5°C by 2099. The study has also predicted several scenarios, which include regional extinction of some tropical fish stocks and some other stocks moving towards higher latitudes. Other studies carried out by the Indian Council of Agricultural Research in this regard show that different Indian marine species will respond to

Image: S Jayaraj

Interaction with Sembasipalli fishers on the impact of climate change on fisheries

Image: S Jayaraj

Awareness programme for fishers in Cox's Bazaar, Bangladesh

Image: S Jayaraj

Changes in the distribution of fish species in the Bay of Bengal region is also necessitating alterations in the fishing gear and harvesting practices

Image: S Jayaraj

Climate change has greater implications on the small-scale and artisanal fisheries in the Bay of Bengal region

climate change differently and the overall change may remain unpredictable.

For example, the oil sardine *Sardinella longiceps* and the Indian mackerel *Rastrelliger kanagurta* accounted for 21 per cent of the marine fish catch in 2006. These small pelagics, especially the oil sardines, have been known for restricted distribution — between latitude 8ºN and 14ºN and longitude 75ºE and 77ºE (Malabar upwelling zone along the southwest coast of India) where the annual average SST ranges from 27 to 29ºC. Until 1985, almost the entire catch was from the Malabar upwelling zone and there was little or no catch from latitudes north of 14ºN. However, during the last two decades, with the warming of waters in latitudes north of 14ºN (by 0.04ºC per decade), the oil sardine is moving to northern latitudes. It has also been found that catches from the Malabar upwelling zone have not gone down. This infers that the oil sardine fishery is extending northward, not shifting northward.

In a similar way, the study also shows that the Indian mackerel is found to be extending northwards. However, besides exploring northern waters, the Indian mackerel has been descending deeper as well during the last two decades. The species normally occupies surface and sub-surface waters. During 1985-89, only two per cent of the mackerel catch was from bottom trawlers, the remainder was caught by pelagic gear. However, during 2003-2007 an estimated 15 per cent of the mackerel has been caught by bottom trawlers, indicating that mackerel has been extending deeper and downward as well.

Hilsa, the national fish of Bangladesh, accounts for 13-14 per cent of the total fish production of the country. During the last two decades, hilsa production from inland waters has declined by about 20 per cent, whereas a threefold increase is seen in the yield from the marine waters. Scientists are attributing this shift to climatic aberrations occurring during the last decade or so.

However, one of the biggest challenges will be dealing with rising sea level and coastal erosion. Erosion due to sea level rise in the region is estimated to be 7,125$m^3$ per year, implying an erosion rate of 0.3x106$m^4$ per year. Using the extreme conditions of wave height and sea level rise, erosion is expected to increase by 15.3 percent by the year 2100. Presently, most of the fishers in the region are living within the high tide line. Due to expanding urbanization and industrialization, cities are also rapidly inching towards the buffer zone. In India between 2001 and 2011, coastal population has increased from 163 million to 184 million (13%) putting more pressure on the already densely populated coastal regions of the country.

Apart from such impacts, climate change will have implications for health, availability of food and physical infrastructure. Fishers living very close to the sea are ill-prepared to face such changes and in the final analysis these general socio-environmental impacts may further accentuate the sector specific risks from changing climate, thereby increasing the vulnerability of fishers.

**Improving fisheries management**

By now most countries in the BOBLME region have developed adaptation plans for climate change. However, these plans being economy-wide have little specific measures for the fisheries sector and action on them has also been tardy. The primary reason for the slow development is lack of resources and lack of an effective implementation programme that could make best use of available limited resources. From the present state of affairs, it is also seen that for adapting to climate change it is neces-

sary to first strengthen the existing management measures and their successful implementation.

The fisheries sector is facing the familiar problems of overfishing, pollution and habitat degradation. Reducing fishing mortality in the majority of fisheries, which are currently fully exploited or overexploited, is one of the principal means of reducing the impacts of climate change. Reduction of fishing effort will (i) maximize sustainable yields, (ii) help adaptation of fish stocks and marine ecosystems to climate impacts, and (iii) reduce greenhouse gas emission by fishing boats. In this regards, it is also necessary to seriously consider adapting the FAO's Code of Conduct for Responsible Fisheries.

Monitoring, Control and Surveillance (MCS) mechanisms need to be improved to observe and manage the fish stocks and fishing efforts. MCS should also include collection of climatic and oceanographic data. Long-term environmental and ecological monitoring programmes are important, since data cannot be collected retrospectively. In India, spatial marine fish catch and effort data are available for the last four decades but a synergy between climatic and oceanographic data and fisheries data is lacking. Projections on climate change impact on fish populations need to be developed as the first step for future analytical and empirical models, and for planning better management adaptations. In most of the other countries in the region, the data collections mechanisms also need to be further strengthened to draw conclusions on the impact of climate change on fisheries.

### Towards a methodology for adapting to climate change in the BOBLME region[4]

*Taking preventive measures* — Coastal planning should take into account the impacts of climate change, especially sea level rise, SST, prolonged droughts, severe rainfall, cyclones and storm surges. Integrated coastal zone management is essential for coastal zone planning, management, monitoring and evaluation. It requires close coordination with government agencies and communities. Coastal communities should be prepared to combat climate change through disaster preparedness activities.

*Increased awareness on the impacts of climate change* — Countries should prepare specific policy documents on the implications of climate change for fisheries sector. These documents should take into account all relevant social, economic and environmental policies and actions including education, training and public awareness related to climate change. Effort is also required to raise awareness of the impact, vulnerability, adaptation and mitigation related to climate change among all stakeholders so that they can become watchful and perceptive.

*Research requirements* — All these procedures should be guided by a cooperative research programme. That is a programme not just specifically for climate change but more on how to move from the present state to a state of readiness. This should also involve a two-way interaction with the fishers to keep them informed of the developments at all times.

Presently, options for adaptation to climate change in the BOBLME region are limited but do exist. In the present context, the primary challenge before the fisheries sector is to ensure food and nutritional security, improve livelihood and economic output, and ensure ecosystem integrity. These objectives call for identifying and addressing the concerns arising out of climate change; evolving adaptive mechanisms and implementing action across all stakeholders at national, regional and international levels.

Image: S Jayaraj

Increased landings of low value species such as oil sardines require interventions in post-harvest methodologies, especially for fisher women in the region

**Case study: Sembasipalli village, Pulicat, Tamil Nadu**

Sembasipalli village is located 50km to the north of Chennai city and lies on margin of Pulicat Lake, one of the largest brackish water lakes in India. The village has 250 households, with a total population of 920.

Sembasipalli has 262 active fishers and a fleet of 86 motorized boats. Fishing and fishing-related activities and rearing of livestock form the major economic activity in the village. Most fishing is carried out with set bag nets in the estuarine waters during monsoon and gill nets and purse-seines throughout the year in the lake and the adjacent sea. The major species harvested include: Indian mackerel, oil and lesser sardines, prawns and crabs.

Mullets and Lactarius spp. formed the dominant fishery in the late eighties, but have gradually declined and are now rarely found in the lake fishery. This is due primarily to: reduced rainfall, siltation of the lake mouth and consequent decreased inflows and less water exchange, increase in temperature and reduction in water level due to heavy intake of water by the neighbouring thermal power plant at Ennore. The villagers feel that besides the impacts of the thermal power plant, the repeated delay in the onset of monsoon in the area is affecting the spawning of fish and thereby reduction in fish abundance.

Due to the decline in fish catches from the lake and coastal waters, the fishers are venturing into the deeper waters. Ten years ago the fishers were fishing in depths of 12-15 fathoms, but now they are fishing in 25-35 fathoms, an increased distance of 5-8km from the traditional fishing grounds. As compared to previous years, the Indian mackerels and oil sardine are now dominating the landings.

The fishers of Sembasipalli seem to be more aware of the phenomenon of changing climate. From the general observations, the villagers have reported occurrences of erratic winds after the December 2004 Asian Tsunami, increased SST and sea level. The villagers feel that their day-to-day life is affected by the changing climate and they would like to learn more about the science behind the climate change phenomenon and adaptation of climate change through awareness programmes.