Impacts of Climate Change and Sea Level Rise on Biodiversity and Livelihood of Andaman and Nicobar Islands

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Introduction

Andaman and Nicobar group of islands is an archipelago of 572 islands which stretch over 800 km^2 between 06° 5' and 14° 45' N Latitude and 92° and 94° E Longitude in the southern reaches of Bay of Bengal. The total geographical area of the Islands is 8249 km^2. Also termed as Bay Islands, this treasure trove constitutes a zone of 0.6 million km^2 of marine water, the Indian subcontinent's richest rain forests and a coral reef ecosystem. About 88% of the Andaman and Nicobar Islands total geographical area has been placed under reserved and protected forest. The Andaman and Nicobar Islands are well known for their rich and good variety of fish. About 1484 fish species were reported from both fresh and marine water habitats in these islands of which 74% are coral inhabitants. The rich icthyofaunal diversity of these islands is due to the diversity of marine habitats which includes mangroves, creeks, lagoons, estuaries, muddy shores and coral reefs. Andaman & Nicobar being the hotspot of biological diversity deserves the focus of our attention. Around 86% of the Islands are still covered by dense forests which support 6,540 species of fauna and 2500 species of flora (Roy *et al.*, 2009), quite a few of which are endemic to these islands.

Andaman and Nicobar Islands represents one of the richest repositories of biodiversity in the whole of south and south East Asia. These islands are a virtual bio reserve, which is unique both in terms of biodiversity and abundance. Situated between two major biodiversity hot spots, namely the Indian sub continent and the Malaysia- Indonesia region, it is hardly surprising that the islands manifest biodiversity of extra-ordinary range with in a limited geographical area. The dense tropical rain forests of the islands support a wide range of plant and animal life having characteristics of the Indian, Indo-Chinese and Malayan type. Owing to the isolation of the Andaman and Nicobar islands, the plants and animals have evolved over thousands of years in a unique way. Ten percentage or more of these life forms are endemic found nowhere else. Today, however, due to rapid population growth and unsustainable use of living resources, the rich biodiversity of these islands stands threatened and remedial action is urgently required.

Though island ecosystem is rich in biodiversity, exhibit high degree of endemism, provide livelihood to people and maintains culture gap from mainlanders, they are fragile and vulnerable. Also several natural factors affect and pose threats to island ecosystems due to small size, similar to fragmented habitats and small catchments hence low water retention capacity, greater exposure to waves and winds highly susceptible to minor ecological changes, extinction rate much faster than in mainland. More vividly, there are several socio-economic problems of Island e.g. distinct culture, small economies, remoteness from international market, high cost of transport, limited diversification in production and export, dependency on external markets, vulnerability to exogenous economic shocks as well as biodiversity problem like invasive alien species, tourism development, climate change and variability, natural disasters, overexploitation and unsustainable uses, pollution and waste disposal.

Biological diversity

There is a good scope to understand the relationships between different species and their response to the native ecosystem and some species can be categories of threatened species viz. Extincts, Endangered, Vulnerable, Rare, Insufficiently known.

Causes of biodiversity loss

Humans have had an effect on every habitat on earth, particularly due to the conversion of land for

agriculture. Cultivated systems (areas where at least 30% of the landscape is in croplands, shifting cultivation, confined livestock production, or freshwater aquaculture) now cover one quarter of earth's terrestrial surface. Shift in species dynamics and food web also hosts a major change over habitat which further changes the coverage drastically. Habitat loss also occurs in coastal and marine systems, though these changes are less well documented. Trawling of the seabed, for instance, can significantly reduce the diversity of benthic habitats. (MEA 2005). Climate change phenomenon especially warmer regional temperatures, have already had significant impacts on biodiversity and ecosystems, including causing changes in species distributions, population sizes, the timing of reproduction or migration events, and an increase in the frequency of pest and disease outbreaks. By the end of the twenty-first century, climate change and its impacts are likely to be the dominant direct driver of biodiversity loss and changes in ecosystem services globally (MEA, 2005). The spread of invasive alien species has increased because of increased trade and travel. While increasingly there are measures to control some of the pathways of invasive species (for example, through quarantine measures and new rules on the disposal of ballast water in shipping), several pathways are not adequately regulated, particularly with regard to introductions into freshwater systems (MEA 2005).

For marine systems, the dominant direct driver of change globally has been over fishing. Demand for fish as food for people and as feed for aquaculture production sytems is increasing, resulting in increased risk of major, long-lasting collapses of regional marine fisheries. 50% of the world's commercial marine fisheries are fully exploited whilst 25% are being overexploited. For example, the Atlantic cod stocks off the east coast of Newfoundland collapsed in 1992, forcing the closure of the fishery, the depleted stocks may not recover even if harvesting is significantly reduced or eliminated (MEA 2005). Since 1950, human mediated increases in nitrogen, phosphorus, sulphur and other nutrients (nutrient loading) has emerged as one of the most important drivers of ecosystem change in terrestrial, freshwater, and coastal ecosystems, and this driver is projected to increase substantially in the future. For example, humans now produce more biologically available nitrogen than is produced by all natural pathways combined. Aerial deposition of reactive nitrogen into natural terrestrial ecosystems, especially temperate grasslands, shrub-lands, and forests leads directly to lower plant diversity; excessive levels of reactive nitrogen in water bodies, including rivers and other wetlands, frequently leads to algal blooms and eutrophication in inland waters and coastal areas. Similar problems have resulted from phosphorus, the use of which has tripled between 1960 and 1990. Nutrient loading will become an increasingly severe problem, particularly in developing countries and particularly in East and South Asia.

Climate change and island ecosystem

Climate change is any long-term significant change in the "average weather" that a given region experiences. Average weather may include average temperature, precipitation and wind patterns. It involves changes in the variability or average state of the atmosphere over durations ranging from decades to millions of years. These changes can be caused by dynamic process on earth, external forces including variations in sunlight intensity, and more recently by human activities. Climate change refers to the consequences of the recent accumulation of greenhouse gases in the earth's atmosphere.

Reasons for the vulnerability of the islands

- Limited physical size in case of Nicobar Islands: e.g. Coastal retreat is virtually impossible where entire islands may be inundated.
- Relative isolation: The distance to major markets renders it difficult in reaching the essential commodities to the needy at the times of grave need.
- Limited natural resources and over exploitation: Already heavily stressed from unsustainable human activities leading to degradation of natural systems.
- Import dependence and high sensitivity to external market shocks.
- Poor infrastructure, limited funds and human resource skills severely limit the capacity to adapt.

Risk is a function of hazard, vulnerability and

probability of the occurrence of the hazard. The same is put in a mathematical expression below.

Risk = (hazard + vulnerability) × probability

With climate change, islands cannot change the magnitude of a hazard, nor can they change the probability of the hazard occurring. The small islands can invest only to reduce vulnerability of damages caused by environmental hazards.

Sea level rise and its impact on island ecosystem

Sea-level rise is a phenomenon caused by mixed reasons including the melting of polar glacier, the expansion of heated sea water etc., Worldwide, sea level has risen about 20 cm during the past century and will inevitably be affected by climate change in the future.

Effects of sea-level rise

Rising sea levels affect coastal regions in the following ways

- Submerging low-lying lands
- Eroding beaches
- Converting wetlands to open water
- Causing more severe coastal flooding
- Increasing the salinity of estuaries and freshwater aquifers

Impacts of climate change and sea level rise

Small islands are among the most vulnerable to future sea level rise and climate change (Mimura 1999). **Despite negligible contribution to global climate change, small islands bear the maximum brunt of climate associated disasters**, it is therefore important to examine the significant impacts of changing climate on agriculture, forestry and rural livelihoods (Molua 2006). Sea level rise associated with global climate change produces greater wave attack and flooding leading to greater erosion and amplified impact of storm (Patwardhan 2006). Developing countries are likely to be more vulnerable to climate change, not only because of projected magnitude but poor adaptive capacity (IPCC 2001) due to institutional and resource constraints. Patwardhan (2006) calls for adaptation-centric climate policy against the conventional approach in terms of response to an environmental problem for all developing countries, which have no obligation for mitigation under the UN Framework Convention on Climate Change.

Impacts of sea level rise on mangrove stands of Andaman

The earthquake (9.0 Richter scale) which struck Andaman and Nicobar Islands on 26 December 2004 and the consequent tsunami have caused considerable change on the mangrove stands of Andamans. The tidal waves that swamped the mangrove stands have affected the giant fern *Acrostichum aureum* and the aquatic sedge *Fimbrisstylis littoralis*. The true mangroves, *viz.*, *Rhizophora* spp, *Bruguiera* spp, *Avicennia* spp, *Sonneratia* spp, etc. have also got affected in various degrees based on their physiological response to the continuous inundation/exposure under the changed scenario. In particular localities of south Andaman, 30-80% of mangrove stands were affected. In Middle Andaman the impact is negligible, whereas in the North Andaman due to the elevation of land, the sea water is not reaching some of the mangrove stands.

Some visible impact has also been felt in the habitat of various fin fishes and shell fishes. During the pre tsunami period, fish landing was of the order of 200 to270 kg $boat^{-1}day^{-1}$ (Nov. Dec. 2004), while during the post tsunami period, it has come down to 44 to 55 kg $boat^{-1}day^{-1}$. This reduction could be mainly due to loss of fishing boats during tsunami. Immediately after the tsunami, mortality of shellfishes such as prawns and crabs was observed in the vicinity of mangrove areas due to leaching of acid sulphate salts and water quality deterioration (Dam Roy and Krishnan, 2005).

Conserving biodiversity

The Millennium Ecosystem Assessment (MEA 2005) lists the following actions that have been at least partly successful in reducing biodiversity loss and can be further strengthened in the future:

- Protected areas.
- Species protection and recovery measures for threatened species.
- *Ex situ* and *In situ* conservation of genetic diversity (e.g. genebanks).
- Ecosystem restoration.
- Payments and markets for biodiversity and

ecosystem services (*e.g.* for ecotourism or carbon sequestration).

- Incorporating considerations of biodiversity conservation into management practices in sectors such as agriculture, forestry, and fisheries.
- Capture of benefits by local communities (*i.e.* ensuring local people benefit from the conservation of the biodiversity around them).
- Increased co-ordination among multilateral environmental agreements and between environmental agreements and other international economic and social institutions (*i.e.* ensuring that ecosystem services are considered in all international agreements and treaties and that those concerning biodiversity co-ordinate with those focusing on other areas such as economics and trade).
- Public awareness, communication and education.
- Enhancement of human and institutional capacity for assessing the consequences of ecosystem change for human well-being and acting on such assessments.
- Increased integration of sectoral responses (i.e. biodiversity issues in agriculture, fishery, and forestry management in many countries are the responsibility of independent ministries, these ministries need to establish processes that encourage the development of cross-sectoral policies).
- Elimination of subsidies that promote excessive use of ecosystem services.
- Sustainable intensification of agriculture.
- Slowing and adapting to climate change.
- Addressing unsustainable consumption patterns.
- Slowing the global growth in nutrient loading.
- Correction of market failures and internalisation of environmental externalities that lead to the degradation of ecosystem services. (Because many ecosystem services are not formally traded, markets fail to provide appropriate signals that might otherwise contribute to their efficient allocation and sustainable use. In addition, many of the harmful trade-offs and costs associated with the management of one ecosystem service are borne by others and so are not weighed in sectoral decisions regarding the management of that service).
- Integration of biodiversity conservation and development planning.
- Increased transparency and accountability of government and private-sector performance in decisions that affect ecosystems, including through greater involvement of concerned stakeholders in decision-making.
- Scientific findings and data need to be made available to all of society.

Major conservation and management issues

1. **Protection**

   Remote/ scattered islands separated by vast sea and a very long coastline

   Inadequate infrastructures for mobility and patrolling

   Inadequate infrastructures for frontline staff in remote and inaccessible localities
2. Research, survey and monitoring
3. Management of Invasive Species
4. Balance between conservation and development
5. Capacity Development of officials and frontline staff at all levels in conservation and management of marine biodiversity
6. Need of the hour; any activity directed at development, needs to be sensitive to the ecological integrity of island ecosystems.

Conclusion

From biodiversity point of view the islands are unique at any circumstance and when natural disasters strike, crops and livestock are flattened, drowned by storms, and scorched by droughts, water supplies are polluted by salt, and wells run dry and people lose their livelihoods and such crises hit the poor, socially underprivileged sections and women the hardest (Swaminathan 2009). The Islands also have past experiences from Tsunami in understanding on the impacts of changing climate on agricultural and allied sectors of the Andaman and Nicobar group of Islands. Though the contribution of islands to global climate change is insignificant due to their very low greenhouse gas emissions (Mimura 1999), they bear the maximum

brunt of climate associated disasters. While the direct impact of climate change would be gradual, some of the consequent events associated with climate change like storm surges would cause severe damages, which calls for an adaptation-centric, pro-development climate policy for the islands against the conventional approach of responding to climate change as an environmental problem. From the viewpoint of adaptation to future climate change and sea level rise, natural barriers to the hazardous forces of the sea viz., corals and mangroves are to be preserved (Mimura 1999). It is evident that human settlements located behind the mangrove stands suffered little loss during natural calamities. It is therefore in the interest of the people to protect and preserve mangroves in order to protect themselves. People's proper understanding of future threats and participation in planned countermeasures is needed to implement adaptive options.

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