

CLIMATE CHANGE – IMPACT ON THE SUNDARBANS:

A CASE STUDY

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Abstract— Sundarbans is the world’s largest contiguous mangrove forest and is a designated world heritage site. Shared by India and Bangladesh, it is home to several species including tigers. The habitat supports approximately 4.37 million people. As per the research conducted it is believed that the Sundarbans have soaked in 4.15 crore tonnes of carbon dioxide.

Due to climate change the Sundarbans faces several challenges. With rising sea levels, islands are disappearing and the increasing salinity in the water and soil has severely threatened the health of mangrove forests and the quality of soil and crops. Additionally, there have been serious disturbances to hydrological parameters and change in fishing patterns, resulting in disastrous consequences for fishermen. Frequent cyclones and erratic monsoon raining pattern are damaging ecology and humanity.

In addition to general environment protection laws, India has also set up institutes at both the Central and State levels to specifically tackle the effects of climate change on Sundarbans. However, split responsibilities between Centre and States and multitude of institutions has resulted in overlap of responsibilities, loss of time and resources, which makes the institutions ineffective.

With risk of the Sundarbans submerging, there is an urgent need for global reduction of emissions and replacement of fossil fuels with renewable energy. Governments also need to promote plantation of local saline resistant seeds. Even as the State and Central Government of India finalise action plans to tackle the problems of climate change and take steps for poverty alleviation in one of the world’s poorest regions, there is a pressing requirement to set up flood relief centres and rapid action response teams to cyclones and storms.

Keywords-component; Sundarbans, climate change, sea level, salinity, biodiversity, threat, conservation, mitigation.

I. METHODOLOGY

For the purpose of writing this paper, we have reviewed and analysed secondary data, information and literature that is available in the public domain, including information available on official websites of several Governmental agencies, scientific data and reports. Reproduction of data and scientific analysis in this paper is only to the extent of

reiterating the unique challenges faced by the Sundarbans delta and we do not intend to infringe any existing copyright and we do not claim copyright over publicly available data.

II. INTRODUCTION

With an area of approximately 3,287,263 square kilometers, India is the seventh largest country in the world. Spanning over a large geographical area and despite being home to over 1.2 billion people, approximately 20% of India is still covered by diverse forests. In the north-eastern shores of India lies the Sundarbans, the world’s largest contiguous mangrove forest which is spread across approximately 9,630 square kilometers, of which 5,363 square kilometers is reclaimed area and the 4,267 square kilometers are protected mangrove forests. A further 6,000 square kilometers of contiguous mangrove forests are spread across neighbouring Bangladesh.^a The Indian administrative region of Sundarbans lies within the State of West Bengal.

The Sundarban ecosystem is one of the most biologically protective and taxonomically diverse ecosystems of the Indian Sub-continent.^b The entire area is a conglomeration of river channels, creeks and islands which total about 102 in number. Of these 54 islands are inhabited while the remaining 48 islands are forested. It is believed that the name Sundarbans is derived from the *Heritiera fomes* tree, one of the most abundantly growing mangrove trees that are locally called ‘Sundari’.

Approximately 200 years ago, the Sundarbans measured about 16,700 square kilometers and was home to several species such as the Javan rhinoceros (*Rhinoceros sondaicus*), wild buffalo (*Bubalus arnee*), swamp deer (*Rucervus duvaucelii*), barking deer (*Muntiacus muntjak*) and leopards

^a Government of West Bengal, Government of India, “West Bengal State Action Plan on Climate Change”; Wild Bengal. Directorate of Forests, Government of West Bengal, Government of India. June 10, 2012. http://www.wildbengal.com/urls/con_ar_tr_sunderban.htm.

^b Government of West Bengal, Government of India, “West Bengal State Action Plan on Climate Change”.

(*Panthera pardus fusca*) which due to change in habitat and human induced pressures have now become locally extinct.^c

The Sundarbans delta faces tremendous pressure by a burgeoning human population that is economically, educationally and socially backward and inhabits an area that is mostly inaccessible due to poor infrastructure facilities. As per 2011 census conducted by the Government of India, there are approximately 4.37 million people living in and around the Sundarbans delta. In the absence of any industry, the vast majority of the local population in Indian Sundarbans is dependent on agriculture. However, due to lack of irrigation facilities as well as basic infrastructure, agricultural practices are primitive and dependent on seasonal rainfall, yielding poor crop and acts as an erratic source of livelihood. Both landless as well as land owning people supplement their income by exploiting the mangrove forests, fishing, collecting and farming tiger prawn seeds in its waters, the latter particularly causing large scale damage to marine biodiversity.

The Sundarbans is an innocent victim of accelerating global warming and climate change and faces a direct threat to its very existence.

III. IMPORTANCE

Located in the delta of the three rivers, Ganges, Brahmaputra and Meghna, it is home to a significant portion of one of the world's largest contiguous block of mangrove forests and biodiversity. In 1987, the Sundarbans was designated as a UNESCO world heritage site and thereafter was declared as a protected biosphere reserve by the Government of India in 1989. The Sundarbans display high biodiversity as well as the occurrence of endangered and highly threatened species, including the only population of critically endangered Royal Bengal Tigers (*Panthera tigris tigris*) found in a coastal mangrove habitat. Sundarbans is also home to 300 species of flora and about 425 species of wildlife, including the Gangetic Dolphin (*Platanista gangetica*) and Irrawady Dolphin (*Orcaella brevirostris*). The Sundarbans account for 85 per cent of all mangrove habitats found in India; including 63 of the 69 mangrove plant species found in the country. Based on current research, it is believed that the Sundarbans may hold up to 140 mangroves and coastal zone flora. At least, seven of these mangrove species or species group are threatened and require immediate conservation measures, viz., *Aegiceras corniculatum*, *Heritiera fomes*, *Kandelia kandel*, *Nypa fruticans*, *Rhizophora spp.*, *S. apetala* and *S. caseolaris*.^d

The local population relies heavily on the mangroves as it provides fodder, fuel wood, tanbarks, fish, honey and medicines.^e The Sundarbans also provides a several significant environmental services such as nutritional inputs to coastal water, generation of nutrients by mangrove roots and biomass deposition. The mangroves release about 6,000 tonnes/ha of litter over the course of a year, contributing vast amounts of

^c Wild Bengal. Directorate of Forests, Government of West Bengal, Government of India. June 10, 2012. http://www.wildbengal.com/urls/con_ar_tr_sunderban.htm.

^d Anamitra Anurag Danda and Gayathri Sriskanthan, "Indian Sundarbans Delta: A Vision," WWF Policy Document, 2011, March 2011.

^e Wild Bengal. Directorate of Forests, Government of West Bengal, Government of India. June 10, 2012. http://www.wildbengal.com/urls/en_habitat.htm.

organic nutrients. These biological processes have made the brackish waters of the Sundarbans a unique nursery and breeding ground of commercially and ecologically important aquatic and marine fauna.^f

Further, the mangrove swamps and backwaters form a natural barrier to cyclones, tropical storms and tidal surges, providing protection to the inhabited areas^g and to the coastal fringes and form a protective margin which stabilizes the shoreline.^h

As per the research conducted by the University of Calcutta it is believed that the Sundarbans have soaked in 4,150,000,000 tonnes of carbon dioxide, valued at around \$79 billion in the international market.ⁱ

IV. THREATS

Sundarban area is cyclone-prone, monsoonal and low-lying^j, as a result of which changes in climate have significantly impacted the area, flora, fauna and the population living within it.

A. Increasing temperatures

Between 1980 and 2007, it has been observed that the temperature of the waters in the Sundarbans has increased at an accelerated rate of 0.5°C per decade compared to the observed global sea surface temperature warming at the rate of 0.06°C per decade.^k This accelerated increase in temperature of the sea has severe implications on aquatic life. This change greatly impacts the Sundarbans area as it is an estuarine delta. Further, it detrimentally affects the health of the mangrove ecosystem.^l

B. Rising sea-levels

In the past 25 years, sea level has risen at a rate almost double the global average. This is due to a combination of factors including land subsistence patterns.^m Due to continuous submergence in higher water, as an implication of rise of sea level, the plants are being noted to be shorter and narrower with fewer branches and leaves resulting in lower rates of photosynthesis and regeneration of the mangroves.ⁿ The sea level rise is also affecting the availability of sediment, directly impeding the establishment of new groves.

^f Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change"; Anamitra Anurag Danda and Gayathri Sriskanthan, "Indian Sundarbans Delta: A Vision," WWF Policy Document, 2011, March 2011.

^g Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^h Wild Bengal. Directorate of Forests, Government of West Bengal, Government of India. June 10, 2012. http://www.wildbengal.com/urls/en_habitat.htm.

ⁱ Prasanta Paul, "Sunderbans absorbs 4 cr tonnes carbon dioxide," Deccan Herald, May 31, 2012.

^j Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^k Center for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

^l Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^m Center for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

ⁿ Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

In 2010 it was observed that, with the sea levels rising ominously, the New Moore Island/ South Talpatti Island disappeared. Scientists have predicted that the other low-lying islands could also vanish as sea levels continue to rise.

C. Cyclones

It has been observed that there has been an increase in the intensity of cyclonic storms hitting the Sundarbans between 1951 and 2010. Recent research suggests that such increase in intensity may be attributed to an increase in sea surface temperature.

During the occurrence of Cyclone Aila in 2009, a 400 km stretch of embankment was breached and the waves crossed over the height of the embankment and entered the flood plains. The sea water got logged and more than 2 million people were marooned for several days affecting not only agriculture but also drinking water supply. Most of the thatched houses were damaged. Additionally, the farmland became non-productive due to salt water incursion in the soil.^o Frequent damage to property and crop failure due to cyclones and thunderstorms has rendered a large population to be poverty ridden. As a result, high levels of immigration to cities are reported from here.

D. Rise in Salinity; Impact on Agriculture

Studies suggest that in the last two decades, the run off in the eastern rivers of Sundarbans has decreased resulting in ever increasing salinity and sea water-sulfate concentrations. The decrease in fresh water run off has affected mangrove growth. Further, agriculture is being affected because of the high levels of salinity of the soils due to high tides, cyclones and storm surges, and problems of water stagnation, sometimes even beyond monsoon seasons.^p

E. Change in agricultural patterns

According to the West Bengal Government, in 2009, the agricultural area had shrunk between 2002 and 2009 from 2,149.615 square kilometers to 1,691.246 square kilometers. The area suffers from a low intensity of cropping because mono cropping of rice is practiced seasonally, and horticultural crops are rarely grown. Further, only 12% of the cropped area in the Sundarbans is irrigated through rainfed ponds, tanks and canals; majority of the agricultural land is rainfed.^q It has been observed that rainfall has become erratic and its intensity has increased^r causing further damage to the agricultural yield.

With continuous increase in population, agriculture production in the region is not able to meet demand. Historically, the main economic activity of rain-fed paddy agriculture was made possible by the construction of earthen embankments to keep brackish tidal water at bay and by cultivating salt-tolerant paddy varieties such as *Matla* and *Hamilton*. Such varieties could be cultivated on raised sections

^o Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^p Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^q Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^r Center for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

of the islands even without embankments. However, while searching for the six locally recalled salt-tolerant farmers' paddy varieties; scientists have discovered the availability of only two varieties; while the other salt resistant rice varieties are believed to have been lost under the onslaught of India's "green revolution".^s

F. Deforestation

Between 1777 and 1971, continuous deforestation and land reclamation activities have been carried out in the Sundarbans region.^t It has been observed that 5% of forest cover was lost between 1989 and 2009. This deforestation has increased man-animal conflict, local extirpation of several species and added to the biological loss of the region. Further, clearing of forests have not facilitated self-sustaining agriculture on the flood plain, as it tends to be submerged under saline water during high tides.

G. Pollution

Due to heavy siltation and disposal of solid waste from adjacent cities, the rivers in the Sundarbans do not receive fresh water from the upstream Ganges and are primarily tidal fed. The Sundarbans receives an additional supply of fresh water during monsoon which lasts for a period of May to October.^u

A pronounced ecological change has evolved in this delta due to huge discharges of untreated domestic and industrial effluents carried by tributary rivers as well as the disposal of contaminated mud from harbour dredging and from the rapid emergence of the Haldia Port Complex, a major oil disembarkment terminal in eastern India. The Sundarbans delta has become susceptible to chemical pollutants such as heavy metals which may have changed the estuary's geochemistry and affected the local coastal environment. Due to a diversity of inputs such as agricultural runoffs, wastewater and sewage discharges, and agricultural wastes, maximum concentrations of organochlorine pesticide residues were recorded at sites located along the main stream of the Hugli (Ganges) estuary. This has a disastrous impact on the biodiversity harboured by mangroves.^v

V. CHALLENGES AND DEFICITS

India has passed several policies and laws at the Central and State levels in respect of protection of the Sundarbans and measures have been taken to tackle the effects of climate change. However, despite the high level of protection and legal sanction granted to the mangrove forests on paper, there has been large scale encroachment of people into the Sundarban islands and diversion of forest land for agricultural purposes. This has put a tremendous biotic pressure on the Sundarbans.

^s Anamitra Anurag Danda and Gayathri Sriskanthan, "Indian Sundarbans Delta: A Vision," WWF Policy Document, 2011, March 2011; Krishnendu Bandyopadhyay, "Two varieties of rice lost for ever in Aila-ravaged Sunderbans," Times of India, Jun 25, 2010.

^t Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^u Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^v Anamitra Anurag Danda and Gayathri Sriskanthan, "Indian Sundarbans Delta: A Vision," WWF Policy Document, 2011, March 2011.

A. *Encroachment & Poverty*

It is typically witnessed that any measure to remove encroachments from the forested areas is likely to be strongly opposed by local politicians as well as people. Sundarbans is one of the most densely populated parts of India with a population density of about 929 persons/square kilometers in 2001, which has increased to 1,082 persons per square kilometers in 2011. With about 44 per cent of the population living below the poverty line and only one degree/technical college in every 250 square kilometers area, creation of alternate job opportunities to remove some of the biotic pressure off the Sundarbans is a distant dream. The economic profile of the local population dismally lags behind the national average. The per capita electricity consumption of the Sundarban inhabiting Indian is one-fourteenth of the national average, majority of households do not have access to electricity and about 60 per cent of the households do not have access to clean drinking water. About 87 per cent people in the area live with some sort of food shortage and healthcare infrastructure is in shambles. Approximately 33 percent of the population does not even have access to a primary health care.^w

Coverage of institutional banking and insurance facility in Sundarbans is very low. Only about 10 per cent of the population avails institutional banking and there is no agriculture insurance. Absence of marketing and value addition infrastructure do not allow better price for whatever the agriculture, fishery and forest yield. This is especially important in light of the fact that 78 per cent of the economy and 65 per cent of local workers are dependent on agriculture and there is an abject lack of any local industry.^x

B. *Over-exploitation of forest produce*

Fishery and collection of non-timber forest produce do supplement the meager agricultural income of the local population; however rampant deforestation and overfishing have put the environment under tremendous pressure. Fish stock is dwindling because of a combination of overexploitation and climatic changes. It has been noted that fish density in shallow waters has reduced and the catch of commercially important fish has declined. Further, increase in demand for prawn products has led to the local population to abandon sustainable traditional fishing practices and adopt excessive prawn seed culture. This has led to irreparable harm being caused to the environment due to erosion of the mangrove eco-system which comprises of mud dykes that protect the Sundarbans from the onslaught of the sea. Further, this has led to the destruction of the mangrove trees whose roots are essential to bind the mud dykes and the taking of a heavy toll of fish seedlings, which will adversely affect the delta's fish population. In the long run, this methodology of fishing will not be a sustainable source of livelihood for the local population.

C. *Lack of effective disaster management program*

Despite the fact that the Sundarbans is a cyclone prone area and is heavily inhabited, there is a lack of an effective disaster

warning protocol and disaster shelters.^y The problem of recurring natural disasters such as cyclones is compounded by the inaccessibility and remoteness of the delta, complete lack of infrastructure (such as roads, hospitals) and an access to limited resources. The continuous submergence of agricultural lands and frequent cyclonic storms has compelled large number of families to migrate as environmental refugees. As more and more land continues to be claimed by rising sea waters, more families find themselves joining the growing ranks of refugees. An effective long term mitigation goal would be to provide disaster resistant homes (to the extent possible) to the residents of Sundarbans as well as construct more disaster shelters.

D. *Increase in salinity*

At the time of British colonization, large swathes of the Sundarbans were cleared for agricultural purposes. Further, to prevent ingress of sea water approximately 3,500 km long embankments have been built over time along the bank of creeks and along the sea shore. However, the embankment impeded the natural process of sedimentation. The embankments trapped silt choking the river and making the channels increasingly shallow. As a direct result, while the river beds were elevated, the flood plains remained at the same height. As a consequence of which, the rainwater remained stagnant in the floor plains for long periods of time.^z

E. *Spread of diseases*

As a result of long periods of stagnation of water, the population is at a greater risk from water borne diseases resulting in increase in incidences of morbidity and mortality. Similarly increase in intensity of cyclones is likely to cause more injuries and deaths. Higher temperatures may lower yields which already are not enough for the population of the region.^{aa}

F. *Increase in man-animal conflict*

Even as climate change adversely affects the production of biomass and fruits on which the wild animals thrive and forest land is lost due to submersion, there is an increased threat of animals coming into greater direct conflict with man outside the forests.^{bb} A conflict situation has always been harmful for both man and animal and has resulted in the death of either of the two. This is particularly threatening to the existence of the critically endangered Royal Bengal Tigers in the Sundarbans region that are historically known to prey on humans. In fact several unfortunate tigers that have strayed into human habitat have been killed due to fear of man-eating.

^yCenter for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

^z Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^{aa} Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^{bb} Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^wCenter for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

^xCenter for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

VI. INDIAN LAWS AND REGULATIONS

A. Policies & Laws at Central & State level for environmental protection

In India, environment protection finds its place under the Indian Constitution. Article 21 of the Indian Constitution enshrines Right to Life as a fundamental right of citizens and has been broadly interpreted by the Indian judiciary to encompass, amongst others, right to clean environment, right to livelihood and right to live with dignity. Under the directive principles^{cc}, forming part of the Indian Constitution, the States are duty bound to protect and improve the environment and safeguard the forests and wildlife and it is a duty of every citizen to protect and improve the national environment including forests, lakes, rivers and wildlife, and to have compassion for living creatures. Further, under the Indian Constitution^{dd}, local bodies consisting of elected representatives have been entrusted with the responsibility of safeguarding the local environmental capital stocks.

India is also a signatory to a number of multilateral environmental agreements and conventions^{ee}, including the UN Framework Convention on Climate Change (UNFCCC)^{ff}, the Kyoto Protocol^{gg} and the Convention on Biological Diversity (CBD)^{hh}. India is also a Party to related conventions, namely the Convention on International Trade in Endangered Species of Wild Flora and Faunaⁱⁱ, the Ramsar Convention on Wetlands of International Importance, and the Convention on Migratory Species.

India has set out an elaborate set of policies with respect to conservation and governance of environment. One of the prominent legislations is the National Environmental Policy, 2006. The National Environment Policy, 2006 is intended as a guide and is based on the spirit of sustainable development^{jj}. Some of the principal objectives of the said policy are to protect and conserve critical ecological systems and resources, to ensure equitable access to environmental resources and quality for all sections of society, to ensure judicious use of environmental resources to meet the needs and aspirations of the present and future generations and to integrate environmental concerns into policies, plans, programmes, and projects for economic and social development.

The National Forest Policy, 1988 was prepared with the primary objective of ensuring environmental stability and maintenance of ecological balance including atmospheric equilibrium which are vital for sustenance of all life forms,

^{cc} Articles 48 A and 51 A (g) of the Constitution of India

^{dd} Amendment No. 73 of 1993

^{ee} MoEF. June 10, 2012. <http://moef.nic.in/divisions/ic/wssd/doc2/ch2.html>.

^{ff} India signed the UNFCCC in June, 1992 and ratified it in November 1993. The primary goals of the UNFCCC were to stabilize greenhouse gas emissions at levels that would prevent dangerous anthropogenic interference with the global climate.

^{gg} India acceded to the Kyoto Protocol in August 2002.

^{hh} India ratified the CBD on February 18, 1994.

ⁱⁱ India became a party in 1976: The aim of the said convention is to control or prevent international commercial trade in endangered species or products derived from them.

^{jj} The said policy provides that “while conservation of environmental resources is necessary to secure livelihoods and well-being of all, the most secure basis for conservation is to ensure that people dependent on particular resources obtain better livelihoods from the fact of conservation, than from degradation of the resource.”

human, animal and plant. The said policy specifically stipulates that derivation of direct economic benefit must be subordinated to this principal aim. It is the basic framework of the National Biodiversity Action Plan, formulated in 2008 to consolidate and augment existing strategies and programmes relating to biodiversity. It recognizes the devastating impact of climate change on biodiversity and proposes several action points to mitigate this which includes research into this area and policy making. The National Policy and Macro-level Action Strategy on Biodiversity was developed in 1999 to consolidate and augment the then existing strategies and programmes relating to biodiversity. In India, one primary method of conservation of biodiversity is by way of according special status and protection to biodiversity rich areas by declaring them as national parks, wildlife sanctuaries, biosphere reserves, and ecologically fragile and sensitive areas.

Additionally, the Government of India announced the National Action Plan on Climate Change (NAPCC) in June 2008. Directly linking development and climate change and in an attempt to tackle climate change and its devastating impact, the said policy sets out 8 missions that focus on solar energy, energy efficiency, sustainable habitat, water, sustaining Himalayan eco-system, green India, sustainable agriculture and strategic knowledge for climate care. It outlines India's national strategy to enable it to adapt to climate change and enhance the ecological sustainability of India's development path. Pursuant to the NAPCC, the Government of West Bengal has proposed the West Bengal State Action Plan on Climate Change that is currently in draft stage. It recognizes Sundarbans as one of the most vulnerable regions vis-à-vis climate change in West Bengal. It identifies threats, proposes several mitigation strategies to tackle climate change and proposes to set aside certain dedicated funds in identified time periods to implement this policy.

The Indian environment legislative framework broadly comprises of the Environment Protection Act, 1986^{kk}, the Water (Prevention and Control of Pollution) Act, 1974^{ll}, and the Air (Prevention and Control of Pollution) Act, 1981^{mm}. The conservation of biodiversity and forests is primarily governed by the Indian Forest Act, 1927, Forest (Conservation) Act,

^{kk} The said Act is an umbrella legislation designed to provide a framework for the co-ordination of Central and State authorities established under the Water (Prevention and Control) Act, 1974 and Air (Prevention and Control) Act, 1981. Under the said Act, the Central Government is empowered to take measures necessary to protect and improve the quality of the environment by, among others, setting standards for emissions and discharges, regulating the location of industries and management of hazardous wastes.

^{ll} The said Act prohibits the discharge of pollutants into water bodies beyond a given standard, and lays down penalties for non-compliance.

^{mm} The said Act provides means for the control and abatement of air pollution. The Act seeks to combat air pollution by prohibiting the use of polluting fuels and substances, as well as by regulating appliances that give rise to air pollution.

1980^{mm}, the Wild Life (Protection) Act, 1972 (WLP Act)^{oo} and the Biodiversity Act, 2002^{pp}.

The Ministry of Environment and Forest (MoEF) is the focal point in the Government of India for the implementation of the international environment conventions and for conservation of biodiversity. Roles of conservation of biodiversity and in relation to climate change are also borne by several other Indian Ministries and Departments, in light of the principal policy and Acts that they are each governed by.

B. Protection & Conservation of Sundarbans

1) Sundarban Biosphere

In addition to all of the above and pursuant to the provisions of the WLP Act, the MoEF declared the entire 9630 sq. km. of Sundarban as the Sundarban Biosphere Reserve in 1989 as part of the Man and Biosphere Programme accepted in the general conference of the UNESCO in 1970.

The forested areas of the Indian Sundarbans have been designated as the Sundarban Tiger Reserve which constitutes of the Sundarban National Park and the Sajnekhali Wild Life Sanctuary, briefly discussed below. An additional 1680 square km in the western side of Sundarbans, has the Lothian Wild Life Sanctuary, the Haliday Island Wild Life Sanctuary and a designated reserved forest. This area allows limited human intervention for extracting non timber forest products.^{qq}

The broad objectives of the programme of the biosphere reserve are primarily (a) identification and demarcation of the eco-system; (b) ecologically compatible economic development of the intertidal zone; and (c) research, training, monitoring etc. It also involves, the development of fishery, particularly prawn-culture, apiary, oyster-culture, mushroom-culture, pearl-culture, apart from providing basic needs of life including improving communication through water and removing illiteracy.^{rr}

Establishment of the Sundarban Biosphere Reserve, the conservation and management of Sundarban mangroves and intergrated afforestation and eco-development project are all 100% centrally sponsored schemes.

2) Sundarban Tiger Reserve

^{mm} With the aim to protect and conserve forests, the said Act restricts the powers of the State in respect of de-reservation of forests and use of forestland for non-forest purposes.

^{oo} The said Act provides for protection to listed species of flora and fauna and establishes a network of ecologically-important protected areas and empowers the Central and State governments to declare any area a wildlife sanctuary, national park or closed area.

^{pp} The said Act, amongst others, regulates access to biological resources and associated traditional knowledge so as to ensure equitable sharing of benefits arising out of their use.

^{qq} Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".

^{rr} Wild Bengal. Directorate of Forests, Government of West Bengal, Government of India. June 10, 2012. http://www.wildbengal.com/urls/con_ar_sunderban.htm.

The Sundarban, in its eastern side, has an area of 2,585 square kilometres demarcated for conservation of tigers i.e. the Sundarban Tiger Reserve, divided into core and buffer zones. The core zone consists of the Sundarban National Park having an area of approximately 1,330.12 square kilometres. Area outside the core zone is designated as the buffer zone and houses the Sajnekhali Wildlife Sanctuary with an area of 362.33 square kilometres. The core areas have been notified as a 'Critical Tiger Habitat' having an inviolate area of 1,699.62 square kilometres. The remaining area of 885.27 square kilometres has been designated as a buffer zone.

Government of India provides 100% funds for non-recurring expenditures and 50% for recurring expenditures in respect of Project Tiger implemented in Sundarbans Tiger Reserve and the State Government contributes 50% of the fund from State Plan for recurring expenditures.

3) Sundarban Affairs Department & Sundarban Development Board

In January 1994, Sundarban Affairs Department was created to give an impetus to the development efforts in Sundarban region and Sundarban Development Board, which was set up in 1973, was placed under the said Department. Sundarban Affairs Department implements developmental activities through Sundarban Development Board.

The functions entrusted to the Sundarban Development are primarily (a) formulation of integrated programme for effective utilization of the resources placed at its disposal; (b) co-ordination and supervision of execution of plans for the development of the region; and (c) review and evaluation of the progress of implementation and revision of policies and measures in light of such findings.

VII. CRITICISM OF PROTECTION STRATEGIES

One of the criticisms of the protection strategies imposed by the Government of India has been in respect of the multitude of institutes set up for its protection, including the split of responsibilities between Central and State level organizations. For example, it may be noted that the entire Sundarbans (both the forested as well as the inhabited areas) has been designated as a biosphere reserve by the Central Government. However, while the areas demarcated as protected forests for tiger conservation and for the protection of the coastal zone are being regulated directly by the Central Government, the inhabited areas are governed by the State Government. This is a cause for communication breakdown, loss of time and resources and duplication of work between the Central and State forces. Conservationists have also quoted instances where, due to overlapping responsibilities, in respect of the Sundarbans Affairs Department and Sundarbans Development Board budget and resources such as manpower for undertaking certain works have been inadvertently split between the two institutes.

With increasing sea ingress and rising salinity, there is an urgent need to improve water management and release increased fresh water into the Sundarbans. However, due to several domestic compulsions, there has been a lack of initiative in terms of release and management of the freshwater into the Sundarbans.

VIII. MITIGATION STRATEGIES

Over the last several years, India has been pursuing a policy of energy conservation and increased usage of renewable energy technologies. These measures have found legislative and regulatory backing. Taking this forward, the Central Government of India and the State Government of West Bengal are currently in the process of finalising an action plan, titled 'West Bengal State Action Plan on Climate Change' to address the problem of climate change and its impact on the Sundarbans as well as take steps for poverty alleviation. Noting the biological importance of the Sundarbans as well the extreme human dependence on it sustenance, we believe that neither a human-centric nor a pure conservation approach would help the long term health of the delta. While the local population recognizes the economic importance of the forests, extreme poverty has forced many to adopt certain practices that are harming the Sundarbans, already facing the onslaught of climate change. While making the entire Sundarbans or afforestation of all reclaimed areas may invite a sharp reaction from the millions of people inhabiting the area, we believe that the Government of India must take a middle ground approach to balance out conservation needs of the area along with the human needs of the people. In this regard, in addition to India continuing to reduce its emissions and liaise with all governments to collectively reduce emissions at an accelerated pace, we propose a series of short-term as well as long-term steps to protect biodiversity of the Sundarbans and also improve the living conditions of the people living in the area to help reduce the biotic pressure on the delta and our mitigation strategies are set out below:

A. Mitigation Strategies that may be implemented immediately

1) *Zoning Sundarbans according to vulnerability:* The Government of West Bengal should demarcate specific areas of the Sundarbans that are particularly susceptible to cyclonic storms. Upon completion of such demarcation, people living in and around the high-risk areas in the Sundarbans should be strategically relocated to safe inland areas. This is particularly relevant for those people who live in the critically vulnerable areas of islands that are submerging or are frequently devastated by cyclonic storms. Additionally, scientists have noted that increased human and animal interaction has led to man-animal conflict. Therefore, protection patrols, surveillance of non-forest activities in the Sundarbans areas and deployment of rapid action forces in case of conflict situations should be deployed at the earliest. Such measures would go a long way in protecting the endangered animals in the region and building a

relationship of trust between the people, regulators and forests.^{ss}

2) *Regional planning and rehabilitation & relocation:* Relocation of the population would be ineffective if the people are not given alternative job opportunities. Such alternate job opportunities could include actively participating in the conservation of Sundarbans (with individuals being deployed as forest guards or by generating employment in the tourism industry) or being provided jobs in cities and settlements close to Sundarbans. The long term sustenance of the Sundarbans is based on the people owning an economic stake in its conservation. Since the Sundarbans are located close to Kolkata and other urban settlements, the proximity could be utilised to promote tourism in the delta, which would bring along with it additional sources of income.^{tt}

3) *Creating opportunities that don't depend on nature:* For successful rehabilitation and relocation, it is imperative that opportunities be provided that do not depend upon nature. The State Government will be required to invest in creation of infrastructural facilities, which while providing employment opportunities at the short term, will help the Sundarbans be a more accessible area for dissemination of knowledge. Further, investments are required to provide education and health to the local people.

4) *Developing efficient disaster management systems:* The State Government must put in place effective early warnings systems. This must be communicated to the people in real time and the people must be educated on exactly what to do in such circumstances. The State Government has to improve its evacuation systems, put in place rapid action response teams and be more adept and efficient in providing supplies and first aid to people and animals caught in such disasters. Further, there is a pressing requirement to set up animal and human flood relief centres.

5) *Protection & distribution of saline resistant food grains and seeds:* Due to the extinction of certain traditional saline-resistant rice varieties as well as a marked increase in the salinity in the region, the State Government must protect remaining saline-resistant food grains and seeds that are saline resistant as well as increase distribution of such seeds at a subsidised rate to the local population.

B. Long Term Mitigation Strategies

1) *Bolstering existing livelihood patterns:* Bolstering existing livelihood patterns will require research and infrastructural support from Central and State Governments. Since the majority of Sundarbans practices monoculture of rice, it is imperative that intensification and diversification of agricultural practices be carried out on a long term basis.^{uu} Further, research in the field of saline resistance by plants and production and distribution of such saline-resistant seeds as

^{ss}Center for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

^{tt}Center for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

^{uu}Center for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".

well as dissemination of knowledge of better and more scientific agricultural methodologies would help alleviate the severe food shortage faced by the Sundarbans farmers currently. Further, through creation of robust storage and marketing infrastructure, the people could access other markets to sell their produce which would ensure better economic returns.

2) *Construction of disaster resistant homes*: Following a tidal surge in 2007, GOAL piloted an intervention to build disaster resistant houses for the poor residents of the Sundarbans. Since most homes built in the Sundarbans are made of mud and wattle, the organisation chose to use vernacular architecture with modern disaster resistant technology. Based on this, it was noted that in 2007 when cyclone Aila hit the Sundarbans, all 265 homes constructed by GOAL mostly withstood the natural disaster. The Government should liaise with the organization to build more such homes on a large scale basis. The Government's intervention is especially required as poor farmers may require assistance in replacement of certain construction material.

3) *Awareness and information*: The Central and the State Governments must educate the people about climate change and methods of adaptation. It has been observed that over a period of time the people have lost their traditional knowledge but have not been able to replace it with new or mainstream knowledge. The Government should conduct training and mass awareness programs in alliance with non-governmental organisations to ensure that the people are aware of the threats of climate change as well as measures to reduce their own carbon foot print in their daily lives.

4) *Tourism versus Eco-tourism*: It has been noted that in recent years tourism has increased exponentially in Sundarban Tiger Reserve. Currently close to 100,000 tourists, including foreign tourists, visit the area annually.^{vv} However, tourists are not practising 'eco-tourism' and waste products such as plastic have been found in the core areas of the national park. The State Government should take measures to ensure that tourists adhere to eco-tourism i.e. tourism that involves travelling to relatively undisturbed natural areas with the specified objectives of studying, admiring and enjoying the sceneries and its wild plants and animals, as well as in existing cultural aspects found in these areas. Thus eco-tourism, differing from purely commercial tourism or mass tourism, would require lesser infrastructure development and lower impact on the environment, while simultaneously providing employment opportunities to the local people.^{ww}

5) *Embankments*: The creation of a 3,500 kilometer embankment across the Sundarbans has created a problem of trapped silt, shallow channels and stagnation of water. The State Government needs to strategise new embankment engineering and resources should be channelized towards in-

depth research on what kind of embankment in which areas would last without causing collateral damages. Further, the Government must construct/retrofit embankments along the sea as well as rivers based on the likely return periods and raise heights to a maximum to prevent storm surges.

6) *Adaptation Governance*: Management of Sundarbans within the context of the challenges faced due to climate change should be the prime focus of the Government's policy. At the first level, successful adaptation governance in Sundarban will depend on carrying out extensive research about how the climate change impacts interact with developmental failures. At the second, it would be key to understand how these findings lead to better management policies, followed by how effectively they can be implemented. Success of these two steps will depend on how aware the population is about the changes in the natural systems, interpret their implications and make informed choices about the solutions provided by the Government.

7) *Release of additional fresh water*: The rise in salinity in the Sundarbans has been exacerbated by rise in sea levels and deep ingress by saline water. However, a primary cause for rise in salinity and resultant change in the ecological patterns is because of increased consumption of upstream freshwater and release for very little freshwater into the Sundarbans. The lack of freshwater has caused several creeks to turn completely saline, with only the monsoons providing freshwater supply. The Government will be required to increase the supply of freshwater into the Sundarbans to ensure the existence of the area as an estuarine delta.

8) *Afforestation programs*: Certain portions of the Sundarbans have been designated as 'deforested mangrove swamps', mostly in the western and central regions of the delta. Since these areas are uninhabited, the Government must carry out afforestation programs at the earnest to ensure that the loss of mangrove cover is offset to the maximum extent possible. Further, the Government should invest in studies in research to identify the level of tolerance of the various existing mangrove species

9) *Protection of threatened species*: The MoEF and the Government of West Bengal should jointly take steps to identify both floral and faunal species, especially the *Heritiera fomes* or 'Sundari' mangrove species and identify strategies for their conservation and protection.

10) *International Funding*: For a poor country such as India, development activities in itself are an expensive investment. The added pressure of emission cuts and adoption of cleaner energy technologies have added an additional financial burdens that needs to be dealt with. The additional climate burden is a result of unchecked emissions in the developed world over the last two centuries and has little to do with the way locals in India have lived for ages. Therefore, adoption of energy efficient technology as well as measures to alleviate problems caused by climate change would require international funding arrangements to offset the incremental cost of development and adaptation. As an equal measure, the Government of India should continue to reduce

^{vv} Wild Bengal. Directorate of Forests, Government of West Bengal, Government of India. June 10, 2012.
http://www.wildbengal.com/urls/con_ar_tr_sunderban.htm.

^{ww} West Bengal Forest Department. June 10, 2012.
http://westbengalforest.gov.in/urls_all/activities_eco_tourism.html.

its emissions as well as educate the local population in Sundarbans regarding their own responsibilities and in addressing their own failures. It may be noted that under the twelfth Five-Year Plan (2012-2017), the Central Government intends to invest approximately Rs. 2 trillion through various missions. The report seeks setting up of a dedicated structure of governance to oversee the different programmes under the said twelfth Plan with such large funds to be invested. The agriculture mission under the National Action Plan on Climate Change alone is to spend upwards of Rs. 2 trillion over five years to make the primary sector more resilient to inevitable changes in climate change. The report pointed out that the Government already spends 2.8% of its GDP on programmes that bring adaptation benefits to people.

REFERENCES

- [1] Anamitra Anurag Danda and Gayathri Sriskanthan, "Indian Sundarbans Delta: A Vision," WWF Policy Document, 2011, March 2011.
- [2] Anbarasan Ethirajan, "Rogue tigress terrorizes Bangladesh Villagers," BBC, February 7, 2012
- [3] Anurag Danda (Ed.), "Sundarbans: Future Imperfect, Climate Adaptation Report," WWF Report, 2010.
- [4] BBC News Report, "Disputed Bay of Bengal island vanishes say scientists," March 24, 2010.
- [5] Center for Science and Environment, "Living with changing climate: Impact, vulnerability and adaptation challenges in Indian Sundarbans".
- [6] Central Soil Salinity Research Institute. May 15, 2012. <http://www.cssri.org/cssri.html>.
- [7] Climate Change. MoEF. June 10, 2012. <http://envfor.nic.in/cc/index.htm>.
- [8] Department of Sundarban Affairs, Government of West Bengal. June 10, 2012. <http://www.sadepartmentwb.org/>.
- [9] Dr Sukanta Das Gupta, "Agriculture at Nature's Mercy," Infochange News & Features, July 2010.
- [10] Environmental Information System. Department of Environment, Government of West Bengal, Government of India. June 10, 2012. <http://www.enviswb.gov.in/>.
- [11] Government of West Bengal, Government of India, "West Bengal State Action Plan on Climate Change".
- [12] Krishnendu Bandyopadhyay, "Two varieties of rice lost for ever in Aila-ravaged Sunderbans," Times of India, Jun 25, 2010.
- [13] Lindsay Evans, "Salinity tolerance in irrigated crops," NSW Government, September 22, 2006.
- [14] Memorandum of Understanding between the Government of the Republic of India and the Government of the People's of Republic of Bangladesh on Conservation of the Sundarban, September 2011.
- [15] MoEF, "National Biodiversity Action Plan", November 2008.
- [16] MoEF, "India, Climate-friendly Development", TERI, IG Printers, New Delhi, 2002.
- [17] MoEF, "National Environment Policy, 2006".
- [18] MoEF, "National Forest Policy, 1988".
- [19] MoEF, "Sustainable Development in India: Stocktaking in the run up to Rio+20".
- [20] MoEF. June 10, 2012. <http://moef.nic.in/divisions/ic/wssd/doc2/ch2.html>
- [21] Nitin Sethi, "India to pump in Rs. 2 lakh cr in the 12th Plan to save climate," Times of India, April 30, 2012.
- [22] Nirjhar Dasgupta, Paramita Nandy, Chandan Sengupta and Sauren Das, "Salinity Impact on the Precarious Mangroves: A Biochemical Study on Some Taxa from Indian Sundarbans," American Journal of Plant Physiology, vol. 7, pp. 53-69, March 12, 2012.
- [23] Planning Commission, Government of India, "Faster, Sustainable and More Inclusive Growth: An Approach to the Twelfth Five Year Plan (2012-2017)," October, 2011.
- [24] Prasanta Paul, "Sunderbans absorbs 4 cr tonnes carbon dioxide," Deccan Herald, May 31, 2012.
- [25] Pratima Pathar, "Farmers in Sundarbans peg hope on traditional paddy," The Hindu, September 16, 2009.
- [26] Press Information Bureau, Government of India, "Impact of Climate Change and National Action Plan on Climate Change," October 22, 2008.
- [27] Press Trust of India, "Two years after Aila, farmers in Sunderbans adopt new crops," Kolkata, February 5, 2011.
- [28] Suryatapa Bhattacharya, "Terrifying beauty of Sundarbans Tiger Country," The National, February 17, 2012
- [29] Syed Azizul Haq, "Impact of Climate Change on Sundarbans, the largest mangrove forest: ways forward," 18th Commonwealth Forestry Conference.
- [30] United Nations Development Programme, Project of the Government of India, Project Document, "Strengthening sustainable livelihoods for biodiversity conservation in Sundarbans."
- [31] Wild Bengal. Directorate of Forests, Government of West Bengal, Government of India. June 10, 2012. <http://www.wildbengal.com/>.
- [32] West Bengal Forest Department. June 10, 2012. <http://westbengalforest.gov.in/>.