Living with changing climate

Impact, vulnerability and adaptation challenges in Indian Sundarbans

Centre for Science and Environment

Living with changing climate

Impact, vulnerability and adaptation challenges in Indian Sundarbans

Centre for Science and Environment

Research direction
Chandra Bhushan

Lead researcher and writer
Aditya Ghosh

Editor
Jyotirmoy Chaudhuri

Design and layout
Kirpal Singh and **Surender Singh**

Production
Rakesh Shrivastava and **Gundhar Das**

Cover Photo
Sayantan Bera

We are grateful to DanChurch Aid, Church of Sweden, Swedish International Development Agency (SIDA) and Evangelischer Entwicklungsdienst e.V (EED) for their support.

Acknowledgments:
We are also grateful to these people for their help and support in this project:
Kakoli Banerjee, Kunal Mondal, Satadru Biswas, Anurag Danda, Angshuman Das, Debal Roy, Subhash Acharya, Rabindranath Bhattacharya, Subhendu Bandyopadhyay, S P Gon Chowdhury, Tushar Kanjilal, Subhankar Goldar, Navonil Das, Chiranjib Chakrabarty and Kanailal Sarkar

Prepared by:
Centre for Science and Environment
41 Tughlakabad Institutional Area
New Delhi – 110 062, India
Ph: 91-11-2995 6110, 2995 5124, 2995 6394, 2995 6499
Fax: 91-11-2995 5879, 2995 0870
Email: chandra@cseindia.org **Website:** www.cseindia.org

Contents

CHAPTER 1

Introduction

Global warming, riding on spiralling emissions, has been bringing about irrevocable changes in the climate and environmental systems around the globe. For citizens of the world, especially for the poor and impoverished who depend on natural resources for their lives and livelihoods, mere survival now means negotiating through substantial additional burdens and challenges. In other words, they must now adapt to more hostile environments for their sustenance.

What is adaptation?

Not about only managing disasters

The global discourse on climate change does not seem too concerned about this challenge of adaptation for survival in the poorer parts of the world. In fact, the debate has chosen to focus only on disaster risk reduction.[1] In some platforms for instance (as in the work of the International Commission on Climate

ADITYA GHOSH / CSE

Endless wait: One of the four jetties in Mousuni where one boat every hour, depending on weather conditions, is the only connection to the mainland for the people. It takes at least two hours to reach the block headquarter Namkhana, which is the shortest people have to travel for any public facilities

DEFINING ADAPTATION

IPCC: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.[1]

UNFCCC: The United Nations Framework Convention on Climate Change defines adaptation as a host of "practical steps to protect countries and communities from the likely disruption and damage that will result from effects of climate change. For example, flood walls should be built and in numerous cases it is probably advisable to move human settlements out of flood plains and other low-lying areas…"[2]

UNDP 2005: The United Nations Development Project explains it as a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented.[3]

UNDP 2006: Changing existing policies and practices and adopting new policies and practices so as to secure MDGs in the face of climate change and its associated impacts.[4]

UK Climate Impact Programme: Countries, however, have different notions about adaptation as well. This programme defines adaptation as a process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits associated with climate variability and climate change.[5]

Change and Development), only flooding events are prominently discussed. It is critically important that long-term adaptation processes are kept in consideration when planning for short-term disaster management, as the success in the latter will largely be determined by how the former is handled.[2,3]

Definition of adaptation: vague, at best

The global adaptation discourse is obsessed with phraseology, with little agreement on what adaptation is and for whom it is relevant. It remains trapped in a debate on whether it should be an 'outcome' or be considered a 'process'.[4] Different definitions (see Box: *Defining adaptation*) use different words to describe adaptation – ranging from 'adjustment', 'practical steps', 'resilience', 'process' and 'outcome' – all of which are ambivalent, very broad and open-ended terms that do not include particular time or subject references. 'Adjustment', for instance, seems to imply a process that leads towards some standard or goal, but these goals are not defined domestically or globally, and lack principles of participative policy process and justice. Most importantly, all these definitions have their origins in the 'North'; a Southern perspective is largely missing in the adaptation discourse.

A compromise

The notion of adaptation in its current globally accepted form seems a compromise. It does not include vital aspects of 'choice,' 'aspiration' and 'prosperity.' Even today, adaptation target groups are considered static ones and not dynamic entities by many.[5,6] In reality, these target groups are highly dynamic and demand a paradigm shift in the adaptation discourse, because it has an obligation towards improving the quality of life of those affected by changing climates. The demand on the ground is to operationalise adaptation strategies within the existing development framework, but not without critically analysing areas of possible synergy and conflicts.

Global models fail to connect ground realities

Apart from failing to resolve the question of principle of what adaptation should constitute, global impact projections and models have had limited relevance to local adaptation and developmental needs. Their

main failure has been in conveying the right information to help local communities devise local adaptation strategies, further limiting the scope of strategising policies and processes at local levels.[7]

A small section of scholars have actually been demanding that climate change adaptation must be recognised as a social process that should work in conjunction with local development planning. This necessitates individual exploration of the vulnerable areas independently and arriving at case specific remedial actions. This approach describes sector- (such as agriculture and migration) and region-specific adaptation as the key, one that hinges on local managers.[8] This is why adaptation must differ in purpose, across time and space and according to actors. The findings of this study also support this hypothesis.

But to achieve this, the first step is to garner knowledge about region-specific climate change impacts on human settlements and local natural systems, including possible costs of and limits to adaptation.

Challenging state apathy to adaptation

Why do we need to adapt

India, according to a report published in October 2010, is the country which is second most vulnerable to climate change, only after Bangladesh. Compiled by UK-based global risks advisory firm Maplecroft, the report suggested a new Climate Change Vulnerability Index (CCVI). It evaluated 42 social, economic and environmental factors to assess national vulnerabilities across three core areas, including exposure to climate-related natural disasters and sea-level rise; human sensitivity, in terms of population patterns, development, natural resources, agricultural dependency and conflicts. The index also assessed future vulnerability by considering the adaptive capacity of a country's government and infrastructure to combat climate change.

India – said the report – will suffer menacingly from climate vulnerability. "Almost the whole of India has a high or extreme degree of sensitivity to climate change, due to acute population pressure and a consequential strain on natural resources. This is compounded by a high degree of poverty, poor general health and the agricultural dependency of much of the populace," it said.[9]

In 2011, India ranked a low 134 among 187 countries in the global human development index (HDI), which assesses long-term progress in health, education and income indicators.[10] Low HDI leads to lower adaptive capacity – which is the capacity of resident populations to cope with the changing ecosystems; lower this capacity, greater would be the people's vulnerability. State's failure to provide the requisite infrastructure and support has diminished the adaptive capacities of already marginalised people.

Poor national and local response

Despite such a high degree of vulnerability, the Central government and the states have been found apathetic towards developing a comprehensive plan to tackle additional burdens that climate change will engender.

Our preliminary analysis shows that the incremental costs that climatic changes now impose on development are impossible for the government to cover on its own. Despite this, the government has not even staked its claim to the global adaptation funds. India's only claim to the adaptation fund is for "Integrating Climate Risks and Opportunities into the Mahatma Gandhi National Rural Employment Guarantee Programme", under which it has sought US $5,425,000.[11] The MNREGS is a national scheme that aims at poverty alleviation and has only limited adaptation co-benefits as we will explain through this study later.

The National Action Plan on Climate Change in 2008 detailed certain areas of focus such as solar energy and energy efficiency, sustainable habitat, water mission, sustainable agriculture, green India and

strategic knowledge. But there have been little localisation or strategic channelization of these efforts in correct local contexts in a country endowed with uniquely diverse ecosystems, cultural practices and development parameters that change adaptation perspectives quite dramatically across regions.

At the next level, State Action Plans on Climate Change were sought by the Centre in 2009, ostensibly to understand local level adaptation and mitigations needs. But long after the deadline, only eight states have filed their reports and they are all in draft stages; none have been finalised yet.

Poor ideas: adaptation must be ecosystem-based, not state-specific

The idea of drawing up state-wise climate change action plans appears incongruous and unscientific as well: as impacts of climate change are ecosystem-specific, so must be adaptation. Ecosystems are not quite bound by state boundaries and there are more overlaps than there are clear demarcations. "Adaptation plans should be ecosystem-specific. Climate change impacts are not restricted within political or administrative boundaries; livelihood practices such as agriculture and fishing are culture-specific, which depends on the ecosystems common through states," says a senior official in one of the states that is struggling to compile its state report.

Ecosystem-based adaptation is already an accepted academic and interventional process. It treats an ecosystem as an entity and correlates its interaction with human settlements therein which draws from and feeds into various ecosystem services. It urges collective action among governments, communities, conservation and development organisations, and other stakeholders to plan and empower local action that will increase environmental and community resilience to the changing climate.[12]

Protecting people: adaptation with an ear to the ground

Poverty and population pressure in precarious ecosystems have historically been a major challenge in India. Non-inclusive development has hardly offered these vulnerable people welfare and wellbeing that they are entitled to. Now their lives and livelihoods are further threatened by climatic changes. The challenge for the country is two-fold: protecting an ever increasing number of people living in these ecosystems while mitigating impacts of climate change on these ecosystems. While at the outset these two appear in conflict, they actually are complementary where one will help in achieving the other.

Adaptation research for India must reveal specific concerns, gaps, threats and solutions. This brings us back to cumulative local level analyses of how climate change and development deficits escalate the misery of the people in fragile ecosystems. This can be achieved only by documenting local responses, collating scientific data on the local changes in environment parameters and understanding state of development on the ground (see Box: *Methodology of research*). Only such exercises carried out in every vulnerable ecosystem will lead to insights into varied adaptation needs in this country and help prioritising intervention.

This exploration of adaptation challenges in Sundarbans – perceived as one of the most threatened globally – tries to relate climatic changes in the regional ecological levels and their impacts on the local residents, their lives and livelihoods. It unpacks adaptation realities and offers a holistic approach where development deficits are as much parts of the adaptation policy challenge as rising sea levels, temperature changes, increasing salinity and erratic rainfall. The outcomes of this exploration are clearer intervention points and policy suggestions at the national, state and local levels that, we hope, will initiate a people-centric adaptation discourse in this country.

Sundarbans: one of the most threatened in India

The Sundarbans, a coastal, underdeveloped area, is one of the most visible victims of the ravages of climate change in India. Fragility of the ecosystem coupled with underdevelopment has made this region particularly vulnerable.

METHODOLOGY OF RESEARCH

Most of the impact predictions in vulnerable ecosystems including Sundarbans have historically been carried out with a very limited set of socio-economic indicators (such as population, GDP per capita, and land-use change and technological improvement). For global models, this minimalist treatment is appropriate. But at smaller, local scales, where adaptation actually takes place, much more detail is needed about the residents, and how they live and work in communities. The culture of societies, their forms of social solidarity and organisation, are all important factors in shaping adaptation policy.[1]

There is also a growing recognition to the fact that adaptation in the South is a multi-scale environmental governance challenge[2] – where sensitivities to climate change in institutions and their ability to respond are based on ability to connect across scales of decision-making.

This necessitates individual exploration of the vulnerable areas independently and arriving at case specific remedial actions. This report is the culmination of such an effort where CSE researchers spent 20 days on the ground across four blocks in the Indian Sundarbans recording the perceptions of local people on climate change and its effect.

In order to garner evidence for this report, interviews were conducted with key informants in the Sundarbans and Kolkata between July 2011 and August 2011. The interviews were qualitative and semi-structured. The interviewees comprised academics, researchers, scholars, policy actors, bureaucrats, representatives of the *gram panchayats* across Sundarbans and representatives of non-governmental organisations.

The field visits provided an opportunity of participatory ethnographic analysis where the researcher becomes an actor himself in the field and experiences the local way of life. For example, always travelling by public transport and walking distances that the people regularly do.

The time of monsoon, while absolutely vital for agriculture, brings about additional hardships to the lives of people. Roads become impossible to walk on, boat rides become riskier and vehicles need to be pushed out of mud-holes every now and then. This is why the season of monsoon was selected for the field study to showcase the extent of hardships inflicted on people.

Apart from these, qualitative interviews of 50 residents across 35 households from across Sundarbans were conducted to understand the ground level concerns and priorities. The interviews for household surveys were conducted in five villages across four blocks of the 19 that comprise Indian Sundarbans, four in South 24 Parganas district – Mousuni (Namkhana block), Satjelia and Rangabelia (Gosaba block), Brajaballavpur (Patharpratima block). The other, Dhamakhali in Sandeshkhali-I block is in North 24 Parganas. In Brajaballavpur a focus group meeting was organized with the help of a local NGO Sabuj Sangha.

These blocks were selected to represent maximum possible diversity within the Sundarbans in terms of the environmental hazards that they face, adaptive responses, policy failures and geomorphology. A focused questionnaire was also developed to get a glimpse of concerns and priorities of people quantitatively.

Apart from the interviews, secondary data was collected from various government departments, human development reports, published articles and yet unpublished reports. These data were contexualised with the experience of people on the ground and extrapolated with these focus group interviews.

The interview data, as well as participatory ethnographic observations have been triangulated with published literature, reports, policy documents and data obtained from West Bengal Statistical Bureau archives as well as various departments that are stakeholders in development of Sundarbans.

With rising sea levels, coastal areas face the threat of more severe and frequent floods, erratic rainfall and cyclones. The Inter-governmental Panel on Climate Change or IPCC in 2007[13] has already warned that low-lying areas of the world would bear the maximum brunt of climate risks because of sea level rise and salt-water intrusion into underground aquifers.[14] Salt water intrusion into the ground and groundwater makes agriculture difficult and contaminates sources of drinking water, something that has started affecting Sundarbans.

The vulnerability of the people living in this delta region spread across India and Bangladesh has steadily increased as these climatic changes in the natural atmosphere have not proved to be favourable for agriculture, fishing and other natural resource-based livelihood practices. When the capacity of resident populations to cope with changing ecosystems takes a hit, their vulnerability increases.

The Sundarbans area has, in the recent past, attracted the attention of researchers and scientists looking into climate change. However, the plethora of research work carried out on the region, and the presence of international donors and various projects seemed to have hardly helped the people of Sundarbans. While there has been little collaboration and coalescing of information among researchers, the government has also never paid any heed to most of these research findings.

It is surprising that despite generating a high volume of research across leading institutions around the world, there is no central information database on these research outcomes – either at the state or at the central levels. Finding authenticated data is often a challenge. Research work available in public domain at best are indicative assessments; data collected are seldom interpreted in the right context. In sum, the impacts of climatic changes on the ecosystem and on the lives people live here are far from being well-understood.

The most crucial understanding that is lacking is how the culmination of climate risks and development deficits in such a vulnerable ecosystem are having an impact on lives and livelihoods of people. This is where the present study by Centre for Science and Environment (CSE) hopes to step in and plug the gaps. The idea was to disaggregate the development deficits from climate induced changes, but at the same time understand how one impacts the other. This, we thought, would be vital to design new policies and strategies aimed at mitigating the ill effects of climate change on the region.

CSE has been documenting the effects of climate change consistently through its research and reportage. A documentary, *Mean Sea Level,* produced by it in 2008, presented the plight of environmental refugees from the Sunderbans. It poignantly captured the voices of the local people of Lohachara and Ghoramara islands in western Sundarbans on the loss of land, lives and livelihoods, their perceptions about the changing climate and how it was impacting their lives. The video highlights the need for a more insightful inquiry into the kind of policy interventions and strategic governance needed in the wake of climate change in this country. This report is a continuation and firming up of that effort. This will provide us a template and a model that can be replicated in other vulnerable ecosystems around the country.

CHAPTER 2

The Indian Sundarbans

Indian Sundarbans lies on the southern fringes of the state of West Bengal, where the Gangetic plain meets the Bay of Bengal. The site of the world's largest mangrove ecosystem, the Sundarbans is an archipelago of several hundred islands, spread across 9,630 sq km in India and 16,370 sq km in Bangladesh. On the Indian side, it extends over two districts: 13 blocks in South 24 Parganas and six in North 24 Parganas (see Map 1: *Administrative blocks that make up Indian Sundarbans*).

The Sundarbans delta has taken its current shape over the past 300 years. The islands are low, marshy, alluvial plains that are still in the process of being formed through siltation and powerful tidal currents, a continuous process of erosion and accretion. As new land is added to the existing mass, some parts are eroded away as part of a natural cycle.

SUNITA NARAIN / CSE

Between one island and the next, residents have to be extremely resilient in the face of inclement weather and bad infrastructure

Map 1: Administrative blocks that make up Indian Sundarbans

The delta is characterised by beaches, mudflats, coastal dunes, sand flats, estuaries, creeks, inlets and mangrove swamps[1]. The maze of rivers, estuaries and creeks carry saline water nearly 300 km inland from the Bay of Bengal. Approximately 2,069 sq km area is occupied by the region's seven main tidal river systems or estuaries, which finally end up in the Bay of Bengal (see Map 2: *Shared between India and Bangladesh*). The delta comprises of 102 low-lying islands, of which 48 are inhabited. All habitation is on reclaimed land, which amounts to an area of 5,363 sq km.

A rich, and threatened, biodiversity

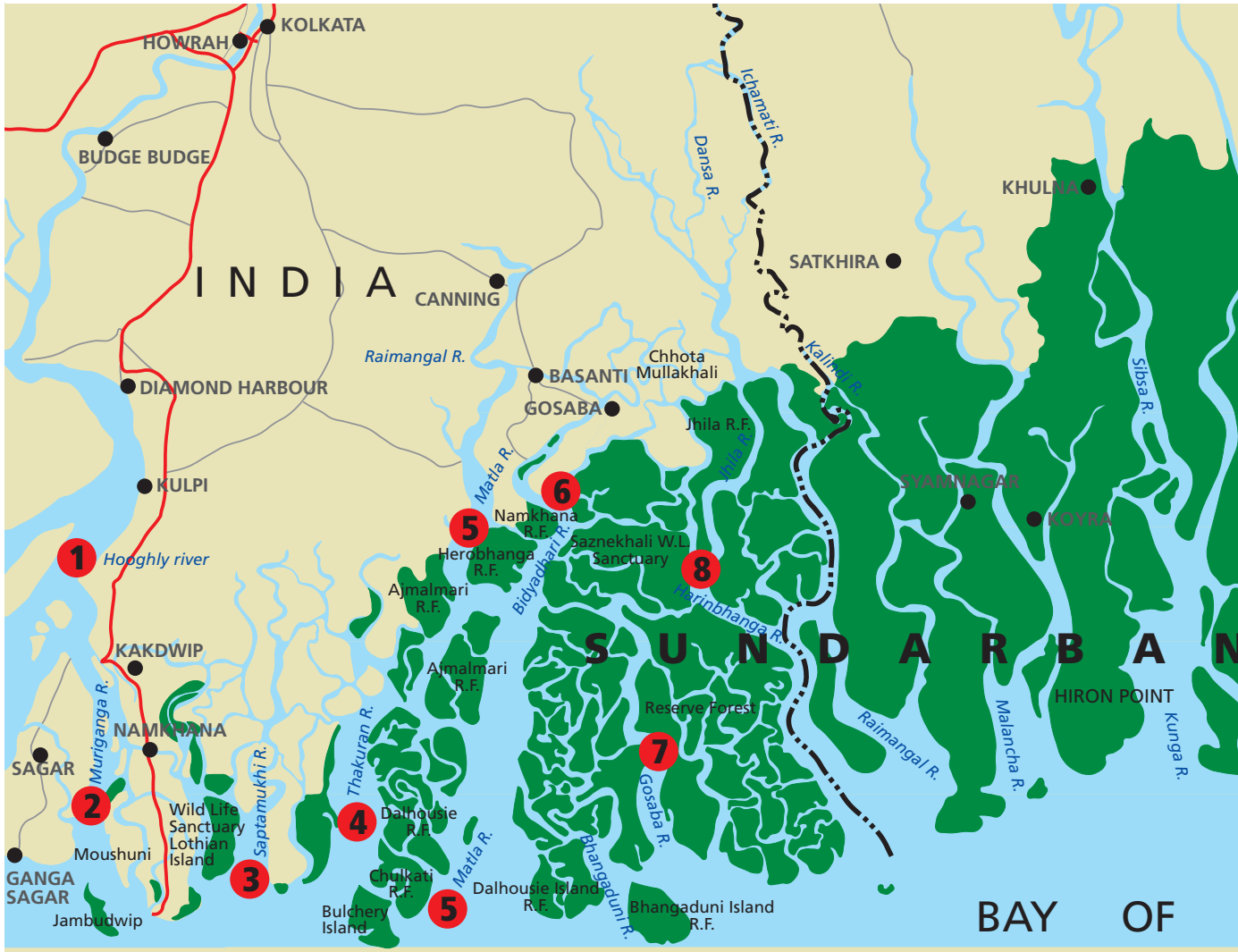
Mangroves are unique to areas where freshwater meets saline water of the sea, as in Sundarbans. A mangrove species is characterised by a tangled mass of aerial roots, known as pneumatophores, that grow upward from the anaerobic mud (that has little oxygen) to grab oxygen for the trees. A mangrove ecosystem, classically, acts as a nursery that helps fish to spawn, birds to nest and lay eggs, and many animals to survive the sea. It also works as a buffer between the marine and land-based ecosystems, and as a wall against cyclones, floods and tsunamis.

Some 4,266 sq km of the Indian Sundarbans are covered by these swampy estuarine forests that make up at least 60 per cent of India's mangrove stock[2]. The Sundarbans has 84 species of mangrove plants, the highest recorded among the mangroves of the world, and the *Sundari* tree (*Heritiera fomes*) is one of these. These trees are eponymous with the region, the area deriving its name from them. Over the years, however, the *Sundari's* stock has been severely depleted, with some studies reporting that there are hardly any left.[3] *Shula* – the dead structure of the *Sundari* – can be seen all over Sundarbans now.

ANIL AGARWAL / CSE

The mangrove ecosystem, characterised by roots that grow upward from the mud, acts as a protection against cyclones and tsunamis

Map 2: Shared between India and Bangladesh



1. HOOGHLY

- Forms the western border of the Indian Sundarbans.
- Is the main river of West Bengal and a continuation of the river Ganga.
- Most of the coastal industries of West Bengal are concentrated along the western banks of this river.

2. MURIGANGA

- A branch of the Hooghly river.
- Flows along the eastern banks of Sagar, the largest island in the deltaic complex.
- Unique mangrove vegetation is found along the banks of this river.

3. SAPTAMUKHI

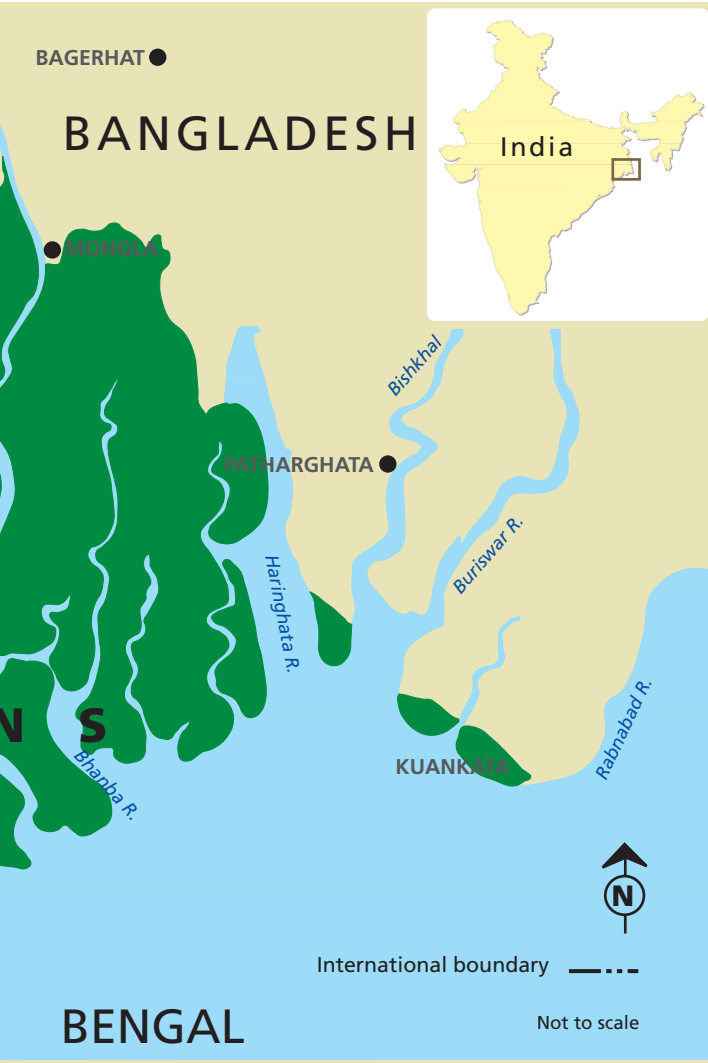
- Is connected with the Muriganga (Bartala) branch of the Hooghly river through the Hatania-Duania canal.

4. THAKURAN

- Begins near Jayanagar in South 24 Parganas and has a number of connections with the Saptamukhi.
- Was connected in earlier times with the Kolkata canal through the Kultali and the Piyali rivers, which are today in a dying state.

5. MATLA

- Originates at the confluence of the Bidyadhari and Khuratya rivers and the Rampur khal close to the town of Canning in South 24 Parganas.
- Connected to Bidyadhari, ultimately flowing to the Bay of Bengal. The freshwater connection and discharge to this river has been lost in recent times.
- Salinity of the river is relatively high (in comparison to the Hooghly or the Muriganga) owing to freshwater cut-off from the upstream.



6. BIDYADHARI

- Was a flourishing branch of the Bhagirathi during the 15th and 16th centuries, but now serves only as a sewage and excess rainwater outlet from the city of Kolkata.
- The river bed is completely silted and presently, it is almost in a dying condition.

7. GOSABA

- The waters of Matla and Harinbhanga (Raimangal) form this estuary through a large number of canals.
- The estuary and its numerous creeks flow through the reserve forests.

8. HARINBHANGA

- The easternmost river in the Indian Sundarbans deltaic complex.
- Also known as Ichamati and Raimangal, it forms a natural demarcation between India and Bangladesh.

In fact, the *Sundari's* crisis is symptomatic of much that has gone wrong with the Sundarbans ecosystem. Soil salinity has been increasing steadily in the region, the rise higher in the deep soil or the root zone of plants compared to top soil. As a result, the trees have started absorbing harmful amounts of sodium salts and are wilting away.[4]

The *Sundari* trees have also been hit hard by the outbreak of the 'top-dying' disease, locally known as '*agamora*'. First detected in 1930, the disease has spread like a wildfire after 1994. Symptoms include burning and firing of leaf tips and margins, bronzing, premature yellowing, abscission of leaves, and eventual death of the trees.[5]

The crisis deepened with two consecutive cyclones – the Sidr in 2007 and the Aila in 2009 – mauling the Sundarbans severely. Apart from the physical damage they caused to the trees, the cyclones increased the salinity levels in the soil further.

Besides these trees, the Sundarbans is home to a number of other unique and endangered flora and fauna. It is the only mangrove forest in the world which holds a tiger population – the Royal Bengal Tiger, like the *Sundari* tree, also evokes the Sundarbans. However, with growing pressure on its habitat from humans and competing species, the tiger is also fighting with its back to the wall (see Box: *Conflict with the ecosystem*).

A CONSERVATION TIMELINE

1973: The first conservation effort takes off, with the setting up of the Sundarban Tiger Reserve.

1987: Sundarbans receives recognition as a World Heritage Site.

1989: The government constitutes the Sundarban Biosphere Reserve.

2001: The UNESCO recognises the Reserve under its Man and Biosphere (MAB) Programme.

2001: The Sundarban Biosphere Reserve is nominated a Ramsar site.

CONFLICT WITH THE ECOSYSTEM

With growing population, there has emerged a state of constant tension and conflict between conservation and humankind's search for a livelihood. Conservation necessitates imposing restrictions on the access to forests and their resources. The costs of this conservation are generally high, and the benefits more globally dispersed than locally enjoyed. With a subsistence economy, no global market for the produce from the region, and little benefits from tourism, a majority of the population is forced to suffer grinding poverty.[1]

At the other end of the spectrum is the growing strife between humans and wildlife. Villagers often stray into the protected area in search of fish or honey and are killed or injured by tigers. They do not receive compensation, as these are restricted areas for them. On the other hand, there are regular cases of the big cats straying into villages and killing or mauling humans and cattle. Some of these tigers have been found to be old and infirm, which makes hunting their regular prey such as deer and wild boar an extremely difficult task in the swampy lands of the region; humans and their habitations offer an easier prey base.

With the region's shrinking ecosystem, the competition for survival is no longer restricted between humans and the tiger. Even predators high up in the food pyramid are found to be fighting between themselves. On an August morning in 2011, a forest patrol discovered a half-eaten body of a Royal Bengal Tiger. The post-mortem of the dead beast revealed a bloody over 10-hour long fight between it and a crocodile. "We have never seen anything of this kind. Tigers swim the rivers all the time and crocodiles avoid them. Now, it seems that their desperation has increased," said Subrat Mukherjee, the field director of Sundarban Tiger Reserve, who has been working in the area for over 25 years.

A KEY CARBON SINK

According to a 2011 scientific paper, the forests of Sundarbans play a critical role as a carbon sink; trees and soils in forests can trap and store carbon dioxide (CO_2) from the atmosphere, a process known as carbon sequestration. Forests, when destroyed, lead to release of the stored carbon: tropical deforestation is reportedly responsible for about 20 per cent of the world's annual CO_2 emissions. The study says that Sundarbans might actually be a more effective carbon sink than even the Amazon forests. Overall carbon storage in these islands is estimated to be 21.13 million tonne, with 5.49 million tonne sequestered in the soil (up to a depth of 30 cm). The region stores 0.41 per cent of the total carbon stored in Indian forests (6,621 million tonne). It uptakes 2.79 million tonne annually, which is 0.55 per cent of the annual fossil fuel emissions (504.6 million tonne carbon per annum) of India.[1]

Carbon capture rates vary by tree species, soil type, regional climate, topography and management practices. In the Sundarbans, carbon capture and storage in live biomass is greater than in the Amazon forest by 35-48 per cent. In Amazon, the carbon intake rate stands at 2.59-3.24 kilotonne per hectare (ha) per annum, whereas in the Sundarbans it is close to 6.54 kilotonne per ha per annum. This is despite the fact that live biomass is about four times lower in the Sundarbans compared to the Amazon (between 167 ± 7.1 kilotonne carbon per ha and 149 ± 6 kilotonne carbon per ha).[2]

Naturally, carbon accrual in the Sundarbans is faster than in the Amazon. The Amazon will need about 50 years to sequester the same amount of carbon that Sundarbans can sequester in just 10 years.[3] This also points to the advantage that mangroves have over terrestrial forests in terms of rapid carbon sequestration. At the current global price of forest carbon, which is about Euro 5 (or about Rs 350) per tonne, the carbon value of the Sundarbans can be estimated to be in the range of Rs 737.4 crore, while the annual uptake of carbon can be valued at Rs 97.3 crore.[4] This is without pricing the other ecosystem services and livelihood opportunities that the Sundarbans provides to over four million people.

Population: how much more can the region hold?

Before 19th century, Indian Sundarbans had no human population or habitation. In 1771, British collector general Clod Russell initiated a plan to divide the forest land into plots and lease them out to prospective landlords[6]. At stake were timber and the collection of land revenue. These lease-holding landowners encouraged poor farming communities from other parts of Bengal as well as from neighbouring states (present day Odisha, Bihar, Jharkhand and Chhattisgarh) to come and settle in the Sundarbans. These people were put to work on clearing the forests and developing the land.

This exercise of forest clearing began in 1781, and was initiated by Tillman Henkel, the then magistrate of Jessore district, currently in Bangladesh. Initially, the forests were cleared mostly in the northern parts, closer both to Kolkata and Dhaka. By 1873, the blocks of Hasnabad, Bhangar, Haroa, Hingalgunj, Minakhan (North 24 Parganas) and Canning, Joynagar, Mathurapur and Sagar (South 24 Parganas) had been fully or substantially cleared of forests.[7]

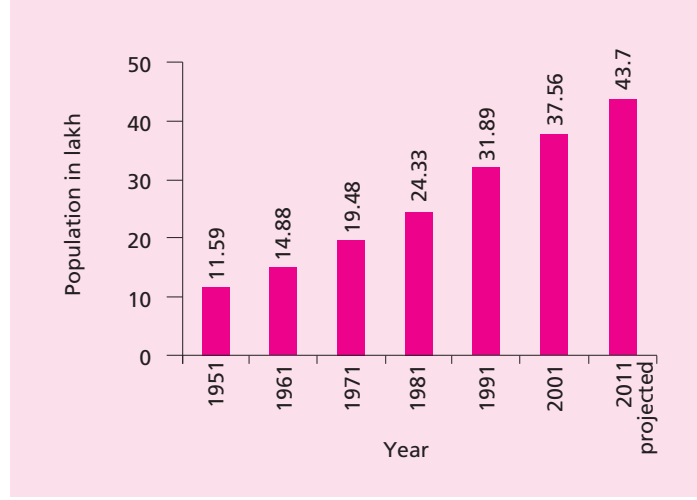
The migrants were also made to erect embankments to make the place habitable by blocking ingression of saline water. Apart from the lure of paid work, these poor farmers were also offered the bait of small pieces of land by the lease-holders. The initial provisions and some cultivable land of their own made a majority of these migrants stay back in the Sundarbans.[8]

Migration continued in the later periods from Midnapur in the west of Bengal as well as from the east (now Bangladesh).[9] Over the years, the population of Indian Sundarbans has increased dramatically – from 11.59 lakh in 1951 to 37.57 lakh in 2001, or almost 224 per cent over half a century. The decadal increase between 1991 and 2001 was close to 18 per cent, which is equal to the population growth in the entire district of South 24 Parganas (see Graph 1: *Galloping population*).[10]

At the time of going to press, no precise estimation of current population (as of 2011) was available. This report is, therefore, relying on the district-wise provisional data derived from the Census of 2011. A weighted average has been calculated, using the percentage increase of population in the two districts, to get a provisional population for the 19 blocks of Sundarbans. According to it, the approximate population of Sundarbans can be estimated at around 4.37 million (43.7 lakh) people.[11]

What is the economic status of this population? While this question has been dealt with in detail in the next section, it is important to mention here that people in Indian Sundarbans, by and large, are poor and vulnerable, with extremely limited access to resources, services or facilities. The region is labouring under a severe 'development deficit', brought along by the official machinery's almost complete disregard for its (or its people's) well being. Add to this the galloping population, and you get the already fragile world of the Sundarbans being stretched to breaking point. After all, how many more can this ecosystem accommodate with the current rate of population growth?

Graph 1: Galloping population



Source: Anon 2009, *District Human Development Report, South 24 Parganas*, Development and Planning Department, Government of West Bengal

Table 1: Population and literacy

Blocks	Area (in sq km)	Population	Population density	Literacy rate
Canning I	187.86	2,44,627	1,302	61.23
Canning II	214.93	1,95,967	912	52.72
Joynagar I	131.01	2,19,090	1,672	66.67
Joynagar II	186.25	2,09,145	1,123	60.09
Kultali	306.18	1,87,989	614	60.81
Basanti	404.21	2,78,592	689	58.12
Gosaba	296.73	2,22,822	751	69.67
Mathurapur I	147.3	1,64,650	1,118	66.00
Mathurapur II	227.45	1,98,281	872	68.94
Kakdwip	252.74	2,39,326	947	71.35
Sagar	282.11	1,85,644	658	78.92
Namkhana	370.61	1,60,627	433	79.38
Patharpratima	484.47	2,88,394	595	73.44
Minakhan	158.82	1,68,965	1,064	58.65
Haroa	152.73	1,82,522	1,195	62.82
Hasnabad	153.07	1,77,521	1,160	63.45
Sandeshkhali I	182.3	1,40,476	771	58.45
Sandeshkali II	197.21	1,36,318	691	59.31
Hingalganj	238.8	1,56,400	655	70.07
Total	**4574.78**	**37,57,356**	**906.4**	**Average: 65.26**

Note: Literacy rate in Indian Sundarbans is high, and is higher in blocks where there are opportunities of further studies and technical education. CSE researchers found that locals perceived primary education futile in the absence of opportunities for higher education that will offer employability. Of the five blocks – Sagar, Gosaba, Kakdwip, Namkhana and Patharpratima – which stand out in terms of literacy, all except Sagar have both a degree college and a technical institute.
Source: Census of India 2001

Economy: development deprived

On land and livelihood

The economy of the Sundarbans is based on agriculture, fishing and collection of non-timber forest produce (NTFP), all natural resource-based activities. Agriculture offers livelihood to about 60.32 per cent[12] of the population, consisting of both cultivators as well as daily wage labourers. About 17 per cent are engaged in fishing[13], which includes those who own their boats and nets and those who work as daily labourers in the fishing trawlers. The other organised and unorganised sectors – which include people with regular employment such as petty jobs with the government, labourers and the self-employed (like artisans and hawkers) – make up 22.3 per cent of the workforce. Of this, just about 9 per cent on an average work in the organised sector, such as at petty government jobs with the public distribution system or the post office. About 6 per cent hold regular jobs in the unorganised sector, such as in cottage industries.

The highest percentage of employment in the organised sector is in Joynagar I block: a mere 12.46 per cent of the total working population. This is because landlessness in Joynagar I (about 70 per cent) is the highest among all the blocks; people have little option but to look for alternative sources of employment (see Table 2: *Occupational patterns*).

Land, in fact, is a key resource, and is at a premium. Indian Sundarbans suffers from an acute state of landlessness – about 47.55 per cent of the households do not own any land. This denies close to half the people the option to grow food. Only about 25 per cent of those who depend on agriculture are cultivators themselves (see Table 2: *Occupational patterns*). However, the income they derive is meagre, as per capita land-holdings and land available for cultivation for every worker is miniscule, at 0.084 hectare (ha) and 0.41 ha, respectively.[14]

There are some blocks which are relatively fortunate with respect to land: those with the least number of landless households include Patharpratima (30.66 per cent), Kultali (31.25 per cent), Sagar (31.61 per cent) and Gosaba (35.59 per cent). The better landholding in these blocks is due to various reasons, such as their political or religious importance (Sagar, for example, hosts the annual *Gangasagar Mela*) and effective initiation of land reforms in them.

Poor is the word

Livelihood opportunities have shrunk over the years: this is evident from the quantum jump in the number of marginal labour – those who worked less than 183 days in the year – between 1991 and 2001.

Table 2: Occupational patterns

Blocks	Households with no land	Daily/ agricultural/ other physical labourers	Cultivators	Self-employed rural artisans/ hawkers/those who do not employ others	Labour oriented regular jobs in the unorganised sector	Others (jobs in the organised sector)
Canning – I	58.92	49.93	19.76	10.53	7.93	11.85
Canning – II	55.86	61.56	24.81	5.11	3.63	4.89
Joynagar – I	69.38	53.51	14.57	10.24	9.24	12.46
Joynagar – II	52.09	44.45	23.31	13.39	11.01	7.83
Kultali	31.25	47.45	36.67	5.76	4.92	5.19
Basanti	43.97	49.44	32.69	5.98	4.69	7.2
Gosaba	35.59	41.54	36.19	5.05	6.26	10.95
Mathurapur – I	61.65	55.97	16.77	9.58	6.12	11.56
Mathurapur – II	51.7	58.42	21.47	6.46	4	9.66
Kakdwip	56.58	54.93	20.39	4.72	8.8	11.16
Sagar	31.61	54.97	29.45	3.86	4.15	7.58
Namkhana	39	58.54	23.64	5.42	3.87	8.52
Patharpratima	30.66	48.84	30.56	4.05	5.43	11.1
Average	**47.55**	**52.27**	**25.4**	**6.93**	**6.15**	**9.22**

Source: Anon 2009, *District Human Development Report, South 24 Parganas*, Development and Planning Department, Government of West Bengal

This number is a direct indicator of how economically vulnerable people are. It also points to whether an area is able to sustain and support livelihoods.[15]

Between 1991 and 2001, while the population of Sundarbans increased from 31.89 lakh to 37.57 lakh[16], the number of marginal labour jumped from 49,429 to 4.15 lakh, an increase of almost 739 per cent (or over an eight-fold jump). The number of main workers in these 10 years remained almost constant, from about 15.27 lakh in 1991 to 15.30 lakh in 2001. This means that the additional workforce failed to find gainful employment and was relegated to fringe jobs to survive: an indicator of an overstretched, constrained economy, and of worse times to come in 2011(see Table 3: *The working population*).

Naturally, blocks in the Sundarbans are far poorer than those in the rest of the districts of North and South 24 Parganas. There is no reliable data on the per capita income at the block level. In the absence of this data, the average poverty ratio – or the number of households below poverty line – becomes the main indicator of poverty in the 19 blocks of the two districts that make up the Sundarbans. This is 43.51 per cent, which, in the context of India's rural areas, means living below the poverty line (or living on less than Rs 26 a day). The poverty ratios in the remaining blocks in these two districts are much better, at an average of 22.41 per cent in North 24 Parganas and 24.43 per cent in South 24 Parganas.

In comparison, in blocks in the Sundarbans such as Basanti, almost two-thirds of households (about

Table 3: The working population

Blocks	Male 1991			Male 2001			Female 1991			Female 2001		
	% of Main Workers	% of Marginal Workers	% of Total Workers	% of Main Workers	% of Marginal Workers	% of Total Workers	% of Main Workers	% of Marginal Workers	% of Total Workers	% of Main Workers	% of Marginal Workers	% of Total Workers
Canning I	48.05	1.15	49.2	40.58	10.56	51.14	2.95	1.81	4.76	6.68	5.96	12.64
Canning II	49.06	0.25	49.31	40.4	8.08	48.48	2.81	1	3.81	4.11	7.05	11.16
Joynagar I	45.7	1.2	46.91	41	8.34	49.33	2	1.65	3.65	6.12	4.74	10.85
Joynagar II	45.27	0.67	45.94	40.06	9.19	49.25	1.89	1.34	3.22	5.1	9.3	14.4
Kultali	46.75	0.8	47.55	40.35	11.01	51.36	1.31	2.45	3.76	2.92	6.84	9.75
Basanti	49.23	1.13	50.36	39.19	11.53	50.73	2.82	5.48	8.3	3.97	8.38	12.35
Gosaba	51.55	1.73	53.28	41.03	15.01	56.04	4.91	12.59	17.5	3.99	16.41	20.4
Mathurapur I	45.21	1.57	46.77	34.26	14.18	48.44	2.08	1.95	4.04	2.96	2.64	5.6
Mathurapur II	48.9	1.02	49.92	42.36	10.48	52.84	2.48	3.5	5.98	4.2	6.72	10.92
Kakdwip	48.36	1.37	49.37	41.39	11.22	52.61	2.55	5.57	8.12	4.52	11.72	16.24
Sagar	46.7	1.15	47.86	40.86	11.86	52.72	1.58	3.83	5.41	4.51	23.16	27.66
Namkhana	49.7	5.38	55.08	44.74	11.21	55.96	5.36	28.11	33.47	6.14	22.89	29.03
Patharpratima	48.44	2.84	51.28	43.73	11.26	54.99	3.09	9.85	12.94	8.73	20.87	29.6
Average	47.91	1.55	49.44	40.76	11.07	51.83	2.75	6.08	8.34	4.91	10.82	16.2

Note: 1. Percentage of total & marginal workers in the population in Sundarbans blocks of South 24 Parganas.
2. The population of Sundarbans was 31.89 lakh in 1991 and 37.56 lakh in 2001. The number of marginal labour @1.55% of the population in 1991 thus comes to 1.55% of 31.89 lakh, which is 49429. Similarly, the percentage of marginal labour in 2001 was 11.07 which means the number of marginal labourers were 11.07% of 37.56 lakh, which is 4.15 lakh. Thus the number of marginal labour increased from 49429 to 4.15 lakh or an increase of 739% or over eight folds. Similarly, the number of main workers in 1991 was 47.91% of 31.89 lakh, which is 15.27 lakh. The same number for 2001 was 40.76% of 37.56 lakh, which is 15.30 lakh. The increase is merely of 3000, the number of main workers stayed constant.
Source: Census of India 1991 & 2001

65 per cent) are BPL; in Sandeshkhali I and II, about 60 per cent households fall in this category (see Table 4: *People and poverty in Sundarbans*).

Another indicator of poverty is the state of food security. In the 13 Sundarban blocks of the South 24 Parganas, only about 12.47 per cent people face no shortage of food: an overwhelming 87 per cent thus have no food security. Close to almost 21 per cent of the population (more than one person in every five), do not get food even once a day on a regular basis. In blocks like Basanti, this figure is as high as 37 per cent (or one in every three) (see Table 5: *Food insecurity*).

In terms of housing, only about 30 per cent of the families in almost the whole of the Sundarbans live in *pucca* or partially *pucca* houses (Joynagar is the only exception). In blocks like Basanti, Gosaba, Canning-II and Patharpratima, this number is not even 10 per cent[17].

According to Tushar Kanjilal of the Tagore Society for Rural Development, an NGO that has done extensive work in the Sundarbans, the region has seen increasing marginalisation of the workforce because of fragmentation of land. "The government did not think beyond land-based livelihoods. In the second and third generations, the land allotted reduced substantially which no longer offered viable livelihood option to people," he says.

Says Anurag Danda, Sundarbans programme in-charge for the World Wide Fund for Nature (WWF): "Land was used as a political tool and released in a staggered manner before elections, which is why almost half of the households do not possess any land."

Table 4: People and poverty in Sundarbans

Blocks	Poverty ratio (% of BPL households)
South 24 Parganas	
Canning I	31.05
Canning II	50.32
Jaynagar I	39.57
Jaynagar II	42.6
Kultali	46.36
Basanti	64.89
Gosaba	38.03
Mathurapur I	34.43
Mathurapur II	39.59
Kakdwip	34.91
Sagar	44.46
Namkhana	48.17
Patharpratima	49.13
North 24 Parganas	
Minakhan	38.42
Haroa	33.73
Hasnabad	28.69
Sandeshkhali I	58.29
Sandeshkali II	59.7
Hingalganj	44.5
Average	**43.51**
Rest of South 24 Parganas	**24.43**
Rest of North 24 Parganas	**22.41**

Source: Anon 2010, *District Human Development Report, North 24 Parganas*, Development and Planning Department, Government of West Bengal; Anon 2009, *District Human Development Report, South 24 Parganas*, Development and Planning Department, Government of West Bengal

Economists and natural scientists working in the region feel that the lack of planning has hurt the region's economy severely. "There has not been any revenue incentive for the government from Sundarbans. As population kept on increasing, alternative livelihoods were never thought of and now we have a situation where that subsistence economy itself is threatened," says economist Rabindranath Bhattacharya who has worked on the region for over 20 years. According to Debal Roy, chief environment officer, government of West Bengal, "The area no longer has the carrying capacity for so many people. We need to take a drastic call soon enough."

In 2005, the government of India introduced the National Rural Employment Guarantee Scheme in the region, for ensuring employment and income for 100 days in a year for the rural population. The impact

Table 5: Food insecurity

Blocks (South 24 Parganas)	Less than one or one square meal a day	No food shortage
Canning I	13.73	17.63
Canning II	20.77	7.6
Joynagar I	19.98	18.87
Joynagar II	18.97	10.8
Kultali	15.21	11.08
Basanti	36.93	6.54
Gosaba	15.42	17.52
Mathurapur I	16.96	10.41
Mathurapur II	20.4	13.69
Kakdwip	16.35	18.15
Sagar	28.3	8.97
Namkhana	22.55	9.91
Patharpratima	27.37	11.06
Average	20.99	12.47

Source: Anon 2009, *District Human Development Report, South 24 Parganas*, Development and Planning Department, Government of West Bengal

of the scheme on marginal labour in the Sundarbans can be known only after the 2011 Census Report comes out (not available at the time of going to press). Hopefully, it will give a better understanding of whether the vulnerability of the people has increased further in the last decade.

Administering the Sundarbans

The Sundarbans' plight has often been attributed to the fact that the region's administration is handled by multiple agencies, which tend to work at cross-purposes or duplicate work in the absence of a specific development plan or strategy. "Even today, the Sundarbans does not have a development master plan, despite two planning agencies, the Sundarban Development Authority and the Sundarban Development Board having been set up for the task. Over the past 25 years, all they have achieved is small-scale project implementation," says Tushar Kanjilal.

Multiple agencies, duplication of tasks

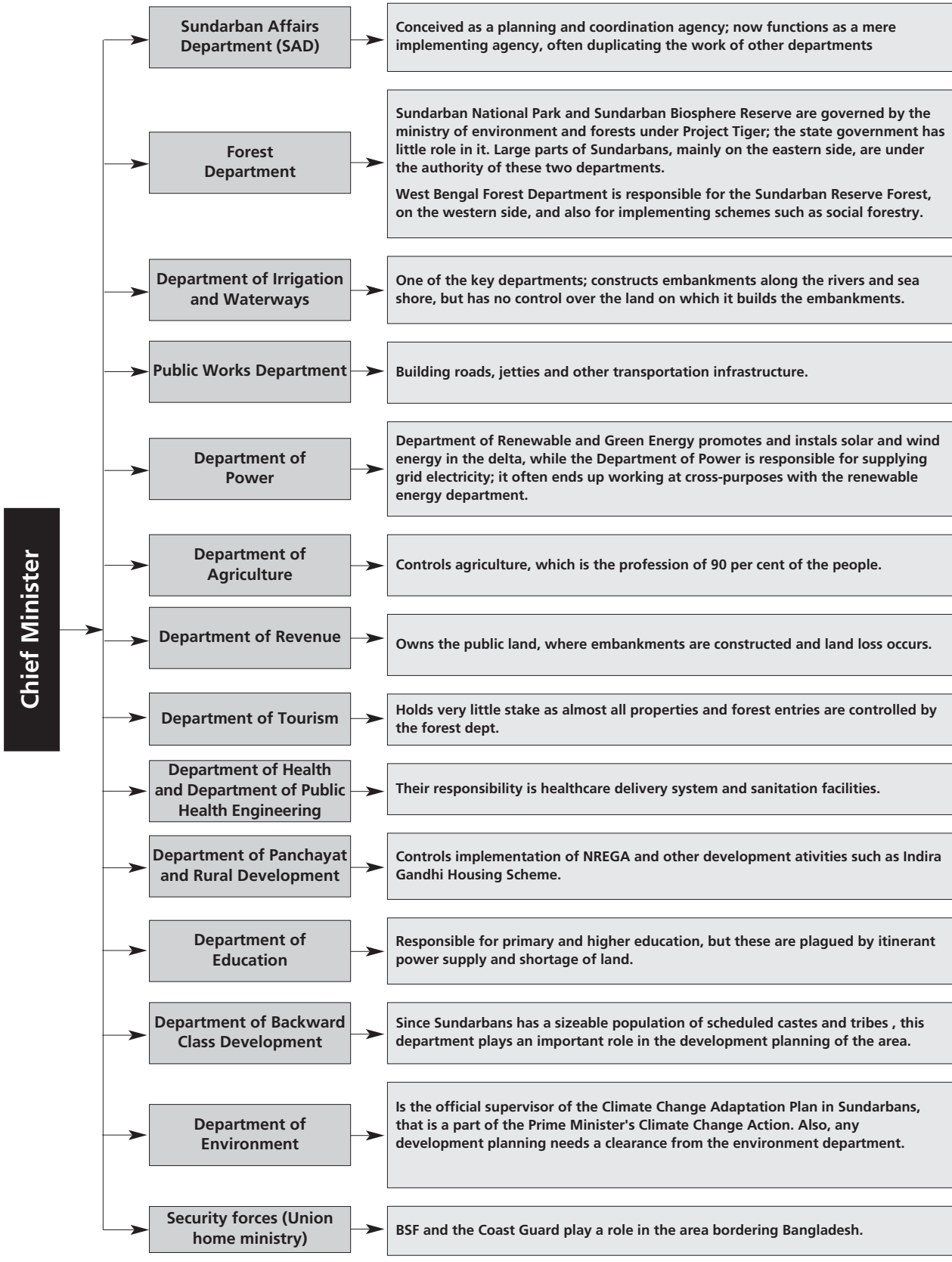
In line with the state government's policy of entrusting planning and coordination of development activities in backward regions to specified agencies, the Sundarban Development Board (SDB) was set up in 1973 under the Development and Planning Department of the West Bengal government. Constitutionally, it is a distinctive agency guided by the decisions of a board comprising of elected representatives (MLAs/*sabhadhipatis*), administrators (district magistrates of the two districts), social workers, representatives of NGOs, and representatives of state government departments. Functionally, however, it is a directorate, previously under the Sundarbans area branch of the Development and Planning Department, and since 1994, under the new Sundarban Affairs Department (SAD).

The SDB was entrusted with a coordinating role in implementing government policy in Sundarban. Its mandate included:

(a) Formulation of an integrated programme for effective utilisation of the resources placed at its disposal from various sources,
(b) Coordination of execution of plans for the development of the region,
(c) Supervision of the execution of any project for the development of the region,
(d) Review and evaluate the progress of implementation and make adjustment in policies and measures as the review may indicate.

However, the SDB seems to have missed its mandate; it presently carries out smaller development projects such as construction of brick-paved roads, culverts, jetties and bridges and sinking of tube-wells – thus duplicating the work of the Public Works Department (PWD) and the Public Health and Engineering Department (PHED). Similarly, it duplicates the work of other agencies such as the forests, fisheries and agriculture departments and is involved in everything from social forestry, tree planting and fisheries to agricultural extension programmes – mainly seed distribution to small and marginal farmers. Areas of critical planning and research, aspects that the SDB was mandated to perform, remain neglected.

Chart 1: Administrative maze: who is responsible for what in Indian Sundarbans



The state's departments in charge of fisheries, forests, agriculture, irrigation, *panchayats* and rural development, disaster management and power are working at cross-purposes in the region, further confusing responsibilities and duplicating execution. Take the case of the forest department: it controls forest resources, including collection of non-timber forest produce (NTFP), prawn seedlings and timber. It undertakes a wide variety of development work independently, but its decisions and prohibitory orders can leave immediate impact on what is perceived as the domain of other departments such as fisheries and irrigation, which builds embankments. Similarly, the agriculture department distributes seeds, fertilisers and pesticides, but does not have a say in the construction of embankments or management of the freshwater aquifers that make cultivation possible.

As a result of the multiple agencies and the lack of coordination between them, development suffers. Often, decisions are taken based on political gains. Sagar Isalnd, important as a pilgrimage site, was brought under grid electrification despite having sizeable solar energy projects running successfully. At an investment of Rs 100 crore, electric poles were erected over the creeks of the Muriganga river. Compared to the high cost, the initiative seems to have helped only a small section of people.

Lack of planning

The failure of the SDB to evolve as a nodal and coordinating agency between the various state departments has led to chaos. Officials of the agencies working in this area complain of inordinate delays and lack of clarity in taking up development projects.

According to P K Vyas, director, Sundarban Biosphere Reserve: "There is no synergy in the planning and implementation stages. We need serious research in the area to be carried out to understand how climate change will impact the region. Unfortunately, there is none happening at the moment except individual efforts of dubious quality." Vyas suggests creation of a central agency with an overarching mandate to implement existing development strategies effectively and plan further to mitigate the damages to and destruction of lives and livelihoods.

Tushar Kanjilal would like to see a pooling of intellectual resources with adequate government support. He says, "Sundarbans perhaps has attracted the maximum number of researchers after the Amazons. But nobody wanted to learn or put all these into a knowledge pool. The government was never interested in learning what they were doing wrong and what could be done right, despite no dearth of research. The administration could have promoted local research to find out localised solutions."

CHAPTER 3

Impacts: Aila and the others

On May 25, 2009 a tropical cyclone hit the Sundarbans in India and Bangladesh with a wind speed of 110 km/hr. Over 8,000 people went missing and about a million were rendered homeless in the two countries. About 300 people were killed in the Sagar island alone in Indian Sundarbans[1]. The Aila, as it is called, was categorised as a severe cyclonic storm. Casualties would have been far higher if the cyclone, instead of hitting the land on a Monday afternoon, had its land-fall the previous night. Locals claim that the meteorological warnings never reached them; they still shiver at the thought of what could have happened had Aila arrived a few hours earlier.

Such extreme weather events are now becoming more frequent and powerful, and experts are drawing linkages between them and the changing climate. The Intergovernmental Panel on Climate Change (IPCC)

PRASANTA BISWAS / DRIK INDIA / MAJORITYWORLD

Extreme devastation: In the Sunderbans islands, this used to be the boy's home. Aila flattened it

– the global body that monitors and studies the risks of human-induced climate change – has estimated that the atmospheric concentration of carbon dioxide has increased from about 280 to 379 parts per million between the years 1750 and 2005 and is presently increasing at a rate of 1.9 parts per million each year. This is expected to lead to an increase of the global average atmospheric temperature by 1.8 to 5^0C by 2100[2].

Global sea level rise is one of the clearest outcomes of global warming; several climate models project an accelerated rate of sea level rise over the coming decades[3]. Sea level rise and temperature increase are impacting the Sundarbans, in most cases at far greater intensities and scales than the global averages, and in some cases faster than that recorded in other some parts of India. The Arabian Sea, for example, is warming at a much slower rate compared to the Bay of Bengal. Climate change is altering rainfall patterns and monsoon timings as well as increasing the intensity and incidence of cyclonic events in some regions. Some of these changes are often pronounced in the tropical countries and India's entire environment, especially the nation's water resources, sea level, and biodiversity, will be grossly affected by these changes.

Temperature: warmer times are coming

The Sundarbans is ringed by the Bay of Bengal in the south with all its rivers and estuaries draining into it. The temperature of the water in the Bay has been consistently increasing over the past three decades. The increase in this sea surface temperature (SST) has been much higher than the global average, and even higher than the increase in SST in the Arabian Sea on the western coast of India. The SST is the water temperature close to the oceans' surface. The exact meaning of surface varies according to the measurement method used, but it is between 1 mm (0.04 in) and 20 m (70 ft) below the sea surface.

At least three independent studies have confirmed this phenomenon, which also agree that SST in the Bay has increased at the rate of 0.5^0C per decade since 1980. While the globally observed SST warming rate is 0.06^0C per decade between 1970 and 1999, that for the Indian Ocean for the same is 0.2^0C per decade[4].

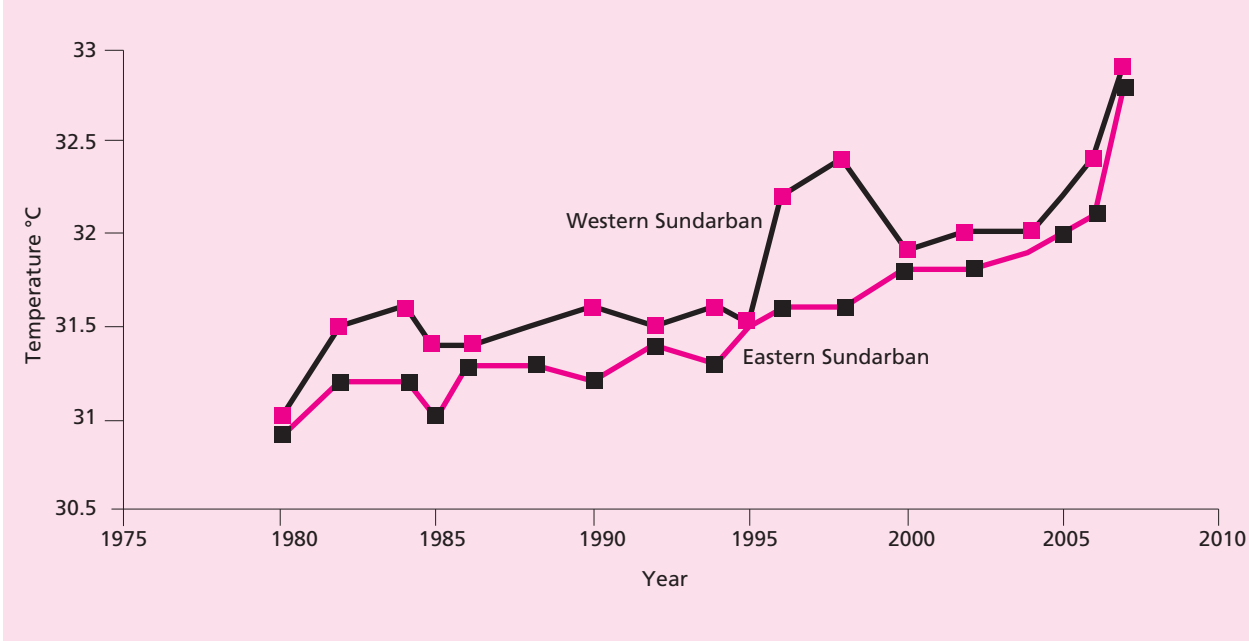
The first of the studies in Sundarbans on SST trends, carried out by the Indian Meteorological Department (IMD) in 2001, noted an increase in SST of 0.5^0C in the eastern part of Sundarbans[5].

In 2009, a team of researchers from Massachusetts Institute of Technology and University of Calcutta jointly studied SST change in the Sundarbans. They found the average temperature to have increased from 31^0C to 32.6^0C between 1980 and 2007 in the pre-monsoon periods[6], an increase of 0.5^0C per decade. This study demonstrated an increase in SST in both eastern and western Sundarbans (see Graph 1: *Increasing surface water temperature*) despite completely different levels of human interference between the two. The eastern part, being a protected reserve forest and a national park, has seen negligible human intervention while the western sector is overloaded with human habitation. A similar spike in the SST in both the sectors indicates that increase in SST was not influenced by human intervention and can thus be attributed to climate change.

In 2009, an Indian Meteorological Department (IMD) study analysed increase in SST in Sundarbans – this time for all three seasons, pre-monsoon, monsoon and winters. They found that the SST in all three seasons in the Bay of Bengal were significantly higher compared to that a few decades earlier – especially during 1981-1990 and 1991-2000[7].

A higher SST affects the ecology in many ways. Warmer waters is already affecting the entire hydrological cycle of the region – a process that includes evaporation from the sea surface, condensation of clouds and rainfall. Sea surface temperature increase can even have links with cyclone frequency in the region, something which researchers are working on at the moment. These changes will eventually lead to a shift in the monsoon patterns, making life difficult both for farmers and fisherfolk[8].

Graph 1: Increasing surface water temperature



Source: A Mitra, A Gangopadhyay, A Dube, ACK Schmidt and Kakoli Banerjee 2009, 'Observed changes in water mass properties in the Indian Sundarbans (northwestern Bay of Bengal) during 1980-2007', *Current Science*, Vol 97, No 10, pp. 1445-1452

Water, when heated, expands in volume. Thus warmer seas cause thermal expansion of water. Sea level is rising because of climate change globally and additional thermal expansion of water will only add to the extent of its increase.

Plants and animals are also affected in warmer waters as they are more sensitive to temperature change than humans. Increase in SST directly affects life cycles, habitat and distribution of aquatic plants and animals such as fish stocks, crab, coral reefs and plankton. While they try to adapt to the changes by shifting to sites with favourable temperatures, in cases when they fail to, they succumb, leading to imbalances in the ecosystem.

In the surface air temperature, there is no reliable data on trends in the Sundarbans, the only observation is recorded in one study using data from a monitoring station in Haldia, an industrial, critically polluted town. This study shows that an increase in the air temperature has taken place at an average rate of 0.1058^0C per year between 2002 and 2009 which translates to about 1^0C increase per decade. However, the authors admit that this phenomenal temperature increase in Sundarbans can be attributed to the formation of a local heat pool because of the industrial hub in Haldia[9].

Sea level: rising inexorably

Sea level rise[10] has also been higher than the global average in Sundarbans, much like the steep increase in the sea surface temperature. A recent report of the School of Oceanographic Studies of Jadavpur University, Kolkata puts the increase at 17.8 mm/year between 2000 and 2009[11]. However this report is yet to be peer reviewed and published. The last published research conducted by the National Institute of Oceanography, Goa, dated 2006, indicates an increase of 5.7 mm/year between the year 2000 and 2004[12].

Earlier, during 1991 and 1999, sea level rise in the Sundarbans was 3.14 mm/year[13]. This means that over the years, sea level rise has become more pronounced in the region.

The current rate of sea level increase in Sundarbans is far higher than the global average rise in sea level which was in the range of 1.7 mm/year between 1870 and 2000 and 3.27 mm/year between 1993 and 2010[14]. In some other large deltas of the world, sea level rise varies from 1-5 mm/yr (in the deltas of the river Nile), up to 10 mm/yr (in the Mississippi Delta)[15], but these have been found to be largely because of land subsidence.

In the Sundarbans, sea level is measured using tidal gauges (see Box: *Tidal technology*), installed and maintained by the Kolkata Port Trust at four locations – Diamond Harbour, Tribeni, Haldia and Sagar Island. The sea level rise of 17.8 mm/year between 2000 and 2009 was recorded from the tide gauge data of Sagar, the largest island in the delta, and also the westernmost point of the Sundarbans.[16]

The significant increase of sea level in the last decade has put its average rise – while considering the record of last 25 years across all four locations of the tidal gauges, to 8 mm/year and the same for the period between 2002 and 2009 to 12 mm/year for all observation stations.[17] Even in the Hooghly river estuaries, the sea level increases between +0.76 mm/year and +5.22 mm/year at different locations in the Sundarbans.[18]

According to A S Unnikrishnan, senior scientist, National Institute of Oceanography, Goa, the sea level rise was far higher in the Bay of Bengal around the Sundarbans. "This is true for all the tidal gauges in the area and in Bangladesh. In our study, the sea level rise came to about 5.7 mm/year between the year 2000 and 2004 where we used the tidal gauge of Diamond Harbour. The current data, from 2004-06 is being processed and we will know in some time how much has it been in the later part of the decade," he said.[19]

Even this 5.7 mm/year was far higher than the global average, he added. "There is a particular cause of worry in the Sundarbans area by the Bay of Bengal is because the threat is not merely from sea level rise but from land subsidence as well. The combined effect is felt on the rise in the sea level. The instability of the land mass and sea level rise influence each other and the outcome is far more severe as it affects the stability of the land itself. This is also one of the reasons behind the high levels of erosion," says Unnikrishnan.[20]

The joint impact of the global sea level change plus the intense subsidence of deltaic deposits determines the extent of sea level rise which reaches 10-20 mm/yr in the seaward part of the delta of the Ganga and Brahmaputra rivers.[21] The 10 most vulnerable islands in the Sundarbans are on the seaward side.

Slow tectonic sinking of the entire Bengal basin and rather intense land subsidence (more than 15 mm/years in some areas of the delta) caused by compaction of loose deltaic deposits often results in the depletion of the deposited sediment height.

The rise of sea level has already had and will continue having an egregious impact on the region. Sea level rise is a major factor contributing to recent losses and projected future reductions in the area of valued coastal habitats, including mangroves and other tidal wetlands, increasing threats to human safety and minimising damages from coastal hazards[22].

Sea level rise and subsequent erosion have inundated four islands fully in the Sundarbans over the past two decades. About 6,000 families from Bedford, Lohachara, Kabasgadi and Suparibhanga in South 24 Parganas district of the Sundarbans have been rendered homeless. It is predicted by marine scientists that one of the largest islands – Sagar – will lose at least 15 per cent of its habitat area by 2020[23]. Ten of the most vulnerable sea facing islands are expected to lose between 3 and 32 per cent of their land mass by 2020. Assuming current sea level rise predictions and local conditions do not change, in the next 50 to 90 years, 50 per cent of the critical land mass across India and Bangladesh

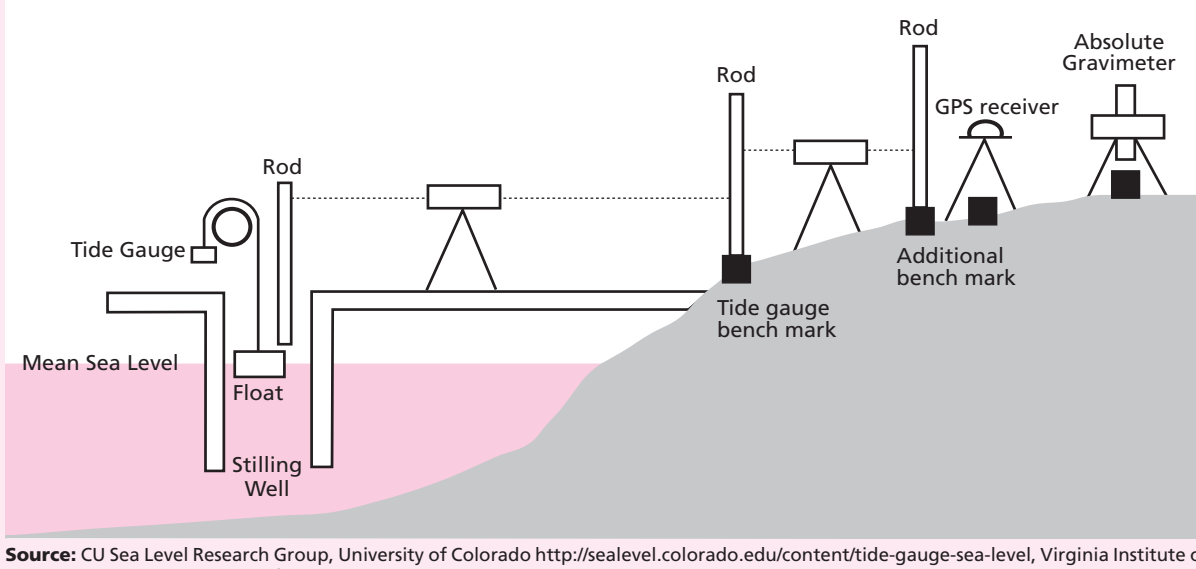
TIDAL TECHNOLOGY

Tide gauges, usually placed on piers, measure the sea level relative to a nearby geodetic (the science of measurement of the earth) benchmark. The figure below shows the most commonly used tide gauge measurement system, a float operating in a stilling well.

Differences in global sea level estimates from tide gauge data usually reflect the investigator's approach in considering these vertical crustal (relating to the crust of the earth) movements. Tide gauges also monitor meteorological factors that affect sea levels, such as barometric pressure and wind speed, so that these variable factors can be eliminated from long-term assessments of sea level change. Although the global network of tide gauges comprises of a poorly distributed sea level measurement system, it offers the only source of historical, precise, long-term sea level data. Tide gauge data show that global sea level has risen approximately 10-25 cm during the past century. Most of the investigators reported that the estimated values were sensitive to the choice of record length and the tide gauges selected.

Mechanical devices for recording water level are being replaced now by acoustic water level meters that measure and record data electronically. The data can even be transmitted by cell phones. Unlike the mechanical gauge that featured a spring-loaded pulley and wire leading down to a cylindrical float inside a vertical stilling well, the acoustic devices utilise an acoustic "shock-wave" sent down a vertical wave-guide. After striking the water surface, the wave is reflected back to a transducer and microcomputer that converts travel time to distance based on the speed of sound in air. While acoustic instruments don't have moving parts to jam or become fouled, they do require compensation for the effects of temperature change on sound speed to maintain their high standard of accuracy.

Diagram: Schematic diagram of a tide gauge measurement system



Source: CU Sea Level Research Group, University of Colorado http://sealevel.colorado.edu/content/tide-gauge-sea-level, Virginia Institute of Marine Sciences, The College of William and Mary http://web.vims.edu/physical/research/TCTutorial/tidemeasure.htm?svr=www

Sundarbans will be inundated[24]. Geological Survey of India estimates that one metre rise of sea level will inundate about 1,000 sq km area of the Sundarban deltas[25].

Sea level rise makes tidal waves higher. This causes frequent breaches in embankments vital for human settlement and agriculture in the villages. This not only leads to higher damage to lives and livelihoods but also puts an incremental cost to repairing and reconstructing embankments every year. Ingression of higher level of saline water in the soil makes it less productive for agriculture which also has an adverse effect on the people. The aggravated erosion leads to loss of land.

Rainfall: changing intensity

While it is well recognised that rainfall patterns will be altered under the influence of global warming, the exact nature of this change is not very clear in Sundarbans as yet. The first few studies had observed an increase in rainfall during the monsoon. The IMD classified the Bay of Bengal as a zone where rainfall has 'significantly increased', with a marked increase in rainy days as well as intensity of rains and risk of flooding in 2007[26].

An analysis carried out by the School of Oceanographic Studies, Jadavpur University in 2009 found that rainfall intensity has increased over the Bay of Bengal at a rate of 0.0041 mm/hr resulting in marginal increase in the average annual rainfall in the Bay of Bengal area. It did not observe any change in total rainfall over the land area[27].

However, statistical analysis of rainfall pattern in the Sundarbans by two scientists from the IMD in 2009 indicates a more complex situation[28]. While analysing impact of increase in SST on rainfall patterns, the scientists found that the total frequency of low-pressure systems that cause rainfall have neither increased nor decreased significantly. However, the duration of these rain-bearing systems have increased significantly without actually culminating into rainfall.

This study broadly supports the earlier IMD report of 2007 on the increase in rainfall. This, they say, was a direct result of increase in the SST that led to higher evaporation. However, they have also found that increase in SST beyond a certain threshold now is not favourable for rain. This, in turn, goes with the findings of the Jadavpur University study of 2009, which did not find any significant increase in the rainfall over land. The IMD study concludes that the unabated increase of SST is not allowing formation of depressions from low-pressure systems, which lead to rainfall. This means increase in SST beyond a certain threshold has started impacting rainfall negatively[29]. This is leading to longer but drier monsoons where single rainfall events are becoming more intense. This is supported by long range projections carried out by the IMD for the region as well[30]. Also, changes/reduction in unseasonal rains were also observed in 2010 by the IMD[31].

While we need better projections, erratic rainfall that is not well distributed through the monsoon season will have negative physical and economic impacts on the economy, particularly for the farmers who depend on a certain pattern of rain for their crop. There is a higher disaster risk with more frequent and intense cyclones and higher damages to infrastructure, both personal and those built by the state. Pre and post-seasonal rainfall is harmful for agriculture. Productivity of the main crop as well as cash crops and vegetables suffer.

Cyclones: growing fury

Pre- and post-monsoon storms are more violent than the storms of the monsoon season. Life span of a severe cyclonic storm in Indian seas averages about four days from the time it forms until the time it enters the land. Severe cyclonic storms over the Bay of Bengal have registered a 26 per cent increase over the last 120 years, intensifying in the post-monsoon period[32].

Table 1: Cyclones in the past decade

Events 1999-2009	Date	Speed (km)	Nature of Storm
	28 October, 1999	>140	Super Cyclonic Storm
	28 October, 2000	<40	Cyclonic Storm
	19 May, 2003	<60	Severe Cyclonic Storm
	17 May, 2004	<60	Severe Cyclonic Storm
	2 October, 2005	<40	Cyclonic Storm
Mala	24 April, 2006	>120	Super Cyclonic Storm
Not given	13 May, 2007	<60	Severe Cyclonic Storm
Sidr	15 November, 2007	>120	Super Cyclonic Storm
	28 June, 2007	>120	Super Cyclonic Storm
Rashmi	26 October 2008	>40	Cyclonic Storm
Nargis	27 April, 2008	<120	Very Severe Cyclonic Storm
Bijli	16 April,2009	<60	Severe Cyclonic Storm
Aila	24 May, 2009	<60	Severe Cyclonic Storm

Source: S Hazra, K Samanta, A Mukhopadhyay and A Akhand 2010, 'Temporal Change Detection (2001-2008) Study of Sundarban', School of Oceanographic Studies, Jadavpur University, Kolkata

The actual incidence of storms has actually gone down in the last decade. However, their intensity has gone up (see Table 1: *Cyclones in the past decade*). The decadal frequency of storms in the Bay of Bengal from 1891 to 1961 as per the 1964 records of the IMD indicates that 56 cyclones occurred during 1921-1930, while 32 storms were reported for the period 1951-1960[33]. However, the intensity of these events appears to be increasing, possibly as a result of rising sea surface temperature[34]. Studies have shown that frequency of high to very high intensity cyclones in the past 120 years has increased by 26 per cent in Sundarbans[35].

The way forward

There is an urgent need to understand the complex relations between temperature (air and water), rainfall, sea level rise, erosion and cyclones with changing climate. At the moment, Sundarban's heightened vulnerability to climatic changes is clearly demonstrated from the few studies that have been carried out. However, the exact nature of the impacts remains unclear. Also the complexities about the way each of these impacts influence one another, for example SST's influence on rainfall, needs to be much better understood[36].

Studies have also thrown up contrasting data and observations. While the study by IMD in 2001[37] has shown a 26 per cent increase in severe cyclonic events over the Bay of Bengal over the past 120 years, others have suggested that in the recent decades (1990-2010) the incidence of cyclonic events have reduced. However, they seem to be more intense because of warmer SST.

The Sundarbans is a low lying area and the interaction between sea level rise, salinity, erosion and land loss lead to a complicated set of outcomes that jeopardise the stability of the area and livelihoods of the people. The east coast of India has already been proved to be more vulnerable to sea level rise in comparison to that of the west coast[38].

ADITYA GHOSH / CSE

Pucca houses came up after Aila, which had washed away the islanders' mud buildings. But with the increasing intensity of cyclones, how long will these future homesteads stand?

In the island system of Indian Sundarbans delta, some islands are fast vanishing from the map rendering thousands of people permanently homeless and displaced from their original habitat. What is clear is that we need extensive monitoring and reliable data generation on various land and meteorological parameters. We urgently need more structured studies to design better and foolproof adaptation strategies.

CHAPTER 4

Land: the bone of contention

Land is at the heart of the crisis in the Sundarbans. Being an active delta, the contours of the land changes constantly anyway through a natural process of erosion and accretion. Erosion and increasing salinity of soil has made these islands less hospitable, while human intervention – in the form of dams built upstream and embankments created to block saline water – has exacerbated the problems.

Erosion-accretion: the net loss is more

The Ganga-Brahmaputra system carries a suspended sediment load amounting to more than one billion tonne per year.[1] Near the confluence of the riverine system and the sea, some of this enormous amount of silt is deposited on the river bed depending on the slope of the rivers and the velocity with which the water travels. A large part of the sediment is also pushed back into the rivers and on to the surrounding islands by the high tides, thereby raising the height of the land.

PRADIP SAHA / CSE

Hanging on the edge: severe erosion in the sea-facing islands has even eaten up *pucca* houses including schools and police stations

Table 1: Land loss in south Sundarbans

Sl. no.	Islands	2001 (in sq km)	2009 (in sq km)	Loss (in sq km)	% Loss
1	Dakshin Surendernagar	44.336	42.015	2.324	5.23
2	Sagar	244.434	239.091	5.343	2.18
3	Namkhana	150.155	145.488	4.667	3.1
4	Mousuni	28.283	28.283	0.64	2.28
5	Ghoramara	5.339	4.564	0.774	14.52
6	Dalhousie	36.084	34.28	1.904	5.26
7	Dhanchi	67.101	62.201	4.9	7.3
8	Bulchery	26.915	23.287	3.628	13.45
9	Bhangaduani	31.316	26.159	5.157	16.44
10	Jambudwip	6.242	4.979	1.263	20.19
Cumulative land loss for ten islands				**30.6**	

Note: Cumulative land loss in ten most erosion prone islands: 30.6 sq km. This amounts to 69 per cent of net land loss, which is 44.042 sq km in the entire Sundarbans.
Source: S Hazra, K Samanta, A Mukhopadhyay and A Akhand 2010, *Temporal Change Detection (2001-2008) Study of Sundarban*, School of Oceanographic Studies, Jadavpur University

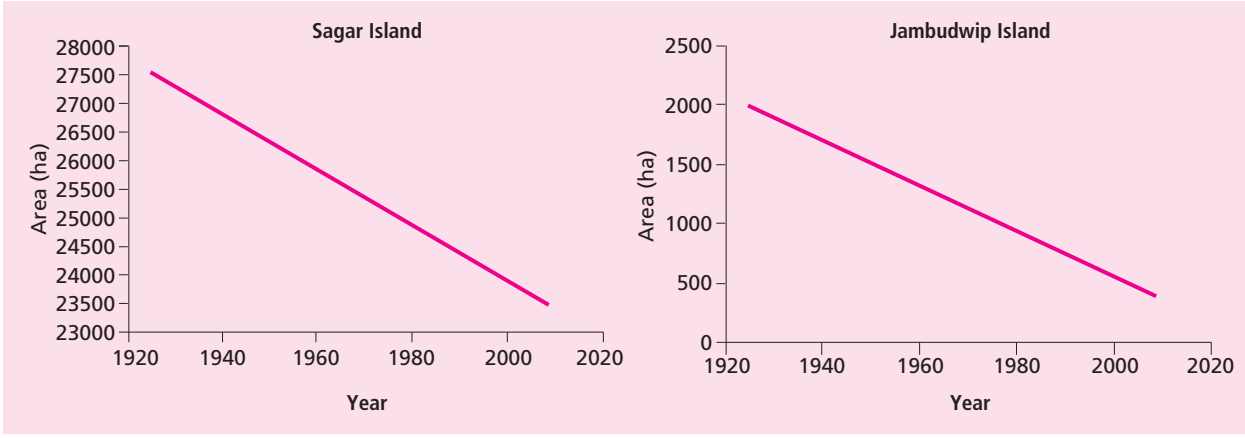
This accretion is a part of the natural delta forming process; so is erosion. In fact, over the past 80 years, there has been no significant gain in land in Sundarbans. On the contrary, there has been a net loss. The rate of erosion after 2000 has almost doubled compared to that in the 70 years between 1930 and 2000.[2] In 1930-2000, almost 283.58 sq km was lost to erosion, while 83.97 sq km was gained.[3] This points to a loss of approximately 2.85 sq km a year. Between 2000 and 2008, the total land lost was 64.162 sq km, and that gained was 20.120 sq km. The net erosion thus was 5.5 sq km per year – the rate of land loss had doubled. The net land lost in the Indian Sundarbans was thus 44.042 sq km a year, an area which is almost equivalent to 45 football grounds![4]

The 10 sea-facing islands in southern Sundarbans – Sagar, Ghoramara, Jambudwip, Namkhana, Mousuni, Dakhsin Surendranagar, Dhanchi, Dalhousi, Bulchery, and Bhangaduani – are the most vulnerable. Together, they account for 69 per cent of the land lost to the sea. Islands like Bhangaduani in the east and Jambudwip in the west lost 16 to 20 per cent of their land area between 2001 to 2009 (see Table 1: *Land loss in south Sundarbans*).

The reasons for this land loss varies between the eastern (forested) and western (inhabited) parts of Sundarbans. In the western part, building of dams such as the Farakka Barrage on the river Ganga has led to an increase in the velocity of water in the Hooghly channel, making it a powerful agent of erosion. After an average 135-mm rainfall for five days in 2011 between 10-15 August, 80,000 cusec, 1,10,000 cusec and 5,000 cusec water was released per day from the Panchet dam and Durgapur barrage (on Damodar river) and Maithon dam (on Barakar river), respectively[5]. This massive volume of water drained into the main Ganga-Bhagirathi-Hooghly channel in western Sundarbans, and led to erosion on Sagar, among other places. In the last 90 years, Sagar Island has lost 20 per cent of its land, while Jambudwip is one-fourth of what it used to be in 1920 (see Graph 1: *Sinking shores – Sagar and Jambudwip*).

According to Kanailal Sarkar, a resident of Satjelia and author of a history of the Sundarbans, one of the reasons behind the changing water course and increase in erosion in the western sector is the

Graph 1: Sinking shores: Sagar and Jambudwip



Note: Between 1920 and 2010, the land in Jambudwip Island has shrunk from about 2,000 hectares (ha) to less than 500 ha and that in Sagar has gone down from 27,500 ha to about 23,000 ha
Source: Data obtained from Forest Department, Govt. of West Bengal

incomplete construction of the Hooghly channel carried out by the Port Trust of India. The port authority, in a bid to increase the navigability of West Bengal's largest port Haldia, had plans to construct seven walls to divert the Hooghly river. However, after construction of three such walls in 2003-04, the plan was abandoned as a new port in Sagar was conceived. These three walls – feel locals and fisherfolk – have increased the strength of the water currents and aggravated erosion.

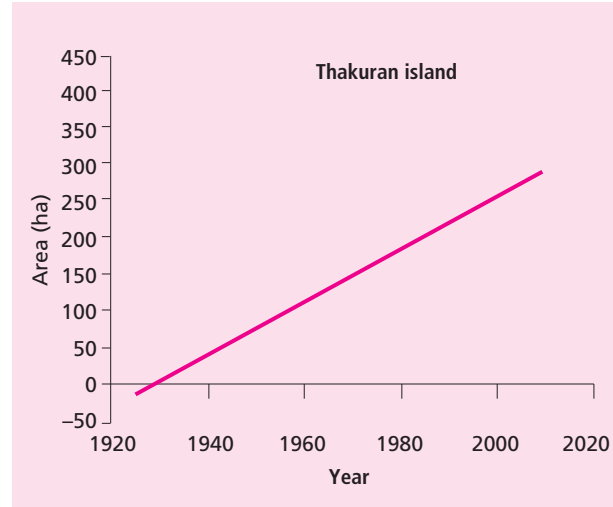
In the eastern sector, on the other hand, siltation has resulted in the drying up of distributaries such as the Thakuran, Matla, Bidyadhari, Gosaba and Haribhanga, leading to a loss of sweet water sources. Embankments, built for the settlers, are often responsible for this siltation. During high tides, seawater enters with force into these rivers, increasing their salinity.

On the other hand, because of the narrow width of these channels, tidal inflows often flood the land and weaken the embankments. "The tidal inflow transforms into tidal bores which have the power to breach the embankments and aggravate land subsidence," says Kalyan Rudra, a river scientist and an expert on the region.[6]

When the embankments do not allow the water to widen their channels and erode the banks, the water strikes the banks on the opposite sides, which, in the case of the eastern sector, are mostly forested islands without embankments. Thus, these islands also erode at a greater rate. The subsidence from all these islands leads to thicker sedimentation and increases sea levels further. This results in a higher and stronger tidal force.

However, there is accretion taking place as well in central Sundarbans. In Thakuran island, for example, about 300 ha of new land has been formed in the period 1920 to 2010 (see Graph 2: *Gradual accretion*). This is because the siltation and clogging of the Bidyadhari river: the sediment carried during high tide from the Bay of Bengal is deposited here due to low freshwater flow.

Graph 2: Thakuran, a gradual accretion



Source: Data obtained from Forest Department, Govt. of West Bengal

Embankments: a management failure?

The Sundarbans was made habitable initially by building earthen embankments to block ingress of saline water. These embankments run for about 3,500 km in this region.

The first attempts at reclamation in the region were made by the British in the eighteenth and early nineteenth centuries, a time when Sundarbans extended till the fringes of Kolkata. These were unsuccessful. Clearing of forests did not immediately facilitate the beginning of agriculture on the flood plains, which remained submerged under saline water during high tides. Sir Daniel Hamilton, a Scottish businessman who made a fortune out of his shipping business in Kolkata, put forward the idea of constructing embankments to block the tidal waters.

Thus came the embankments to Sundarbans, with a majority of them being erected between 1873 and 1939. Viewed as an absolute necessity at that time, as they allowed people to settle down on the islands, these structures are now being severely criticised for the role they play in unsettling the land and its people. Says Kalyan Rudra: "It is a Catch-22 kind of situation as these structures seriously impede delta formation process, and aggravate erosion and sea level rise locally. But without them, there cannot be human settlements in the region."[7]

Earthen embankments are breached regularly, and have to be repaired. It is a difficult task, especially as the pattern of water hitting the land varies from island to island and from shore to shore. For example, in the eastern parts where the rivers have largely dried up, the inflow of seawater into the river channels is much stronger compared to the western sector, where the river flow is more.[8] Tidal patterns vary as well: tidal amplitude (height) varies between 2 and 5.5 metre in different parts of Sundarbans.[9] This variation leads to changes in the way erosion happens in different places, calling for different solutions while

ADITYA GHOSH / CSE

Every year, around the monsoon, embankments are erected around villages to protect them from flooding and inundation. It lasts a year, maximum two, and takes homes and land along with it.

ADITYA GHOSH / CSE

The way to manage the embankments is at the core of the physical adaptation strategy for Sundarbans

repairing or designing embankments. The way to manage the embankments is at the core of the physical adaptation strategy for Sundarbans.

Kanailal Sarkar explains: "All the embankments in every part of Sundarbans are exactly similar. No one tried to understand the way water in the river or the sea was working and what was the actual cause of erosion. The irrigation department constructed the embankments in exactly the same fashion as the previous one that was washed away. The massive incremental cost of constructing embankments every year or every two years kept increasing. Without a holistic management plan involving engineers, river scientists and social scientists, the problem can never be sorted."[10]

While embankments have managed to bring down land submergence, they have also halted the process of sedimentation on these lands. Instead, the sediments have started settling on the river bed, raising the relative water levels. In fact, water levels around many embanked areas remain at least two metres above the adjoining flood plains during high tide, which makes them flood prone[11]. Currently, the overall height of most areas in Sundarbans is less than three metres above the mean sea level[12].

Silt deposition on the river bed has made the river channels shallow, reducing their water-holding capacity. This has led to drying up of rivers, particularly the distributaries in the eastern parts.

In the western sector, however, despite the channels becoming narrower, water volume has remained constant because of the dams upstream. In these rivers, high volumes of water strike the banks with greater force now, trying constantly to broaden the channels by eroding the banks. When embankments stop the water, its level rises because of higher river beds, escalating flood risks. When these embankments eventually give in, large chunks of land is lost to the river.

These threats became a destructive reality during the super cyclone Aila, that struck Sundarbans in May 2009. The cyclone's waves were higher than many of the embankments, and the water could not recede back due to these same barriers. This caused high levels of salinity in the soil rendering it unfit to cultivate for two consecutive years.

Says Kalyan Rudra: "The only solutions are embankments with wider spill areas of water, something that the Netherlands is building now in order to reduce the hydrostatic pressure on embankments and make them more stable," (see Box: *Will the Dutch design work here?*).

WILL THE DUTCH DESIGN WORK HERE?

In 2001, the Netherlands announced a change in its water management policy. In a report titled 'Water Management Policy in the 21st Century', the writers said the rethinking was required in the wake of sea level rise because of climate change. The new policy was based on the principle that there was a need for relinquishing space to water, rather than winning space from it.[1] The idea was to keep a spillover area in the wake of tides, instead of constantly battling the waves in an effort to hold on to land.

In 2008, a special commission of the Dutch ministry of infrastructure and environment presented a new delta management plan, addressing the issues of climate change. The Delta Committee overseeing the plan realised that trying to save some of the areas from inundation would be financially non-viable. It recommended that some of the land which would inevitably face flooding could be put to better use in helping to protect other, more valuable land. In times of especially high flooding, these areas could take on some of the excess water, easing the burden on the country's dykes and preventing floods in other parts of the country. In subsequent years, this was achieved by clearing and widening the flood plains by moving the dykes further back from the river and constructing water retention and storage areas.[2]

Another technique followed in the Netherlands is known as beach nourishment. In this process, sand from the sea floor is spread along the coast. The Netherlands is using some 15 to 20 million cubic metre of sand just to keep the coastline static. With gradual nourishing, dune grasses and other plants can colonise the beaches, strengthening them against storms and waves.[3]

These approaches may appear to be simple, but aren't, because the costs involved are very high; moreover, these costs are to be borne by the public. The cost of climate change adaptation in the Netherlands is assessed at Euro 9 billion or Rs 63,000 crore.[4] This is equivalent to what the National Highway Authority of India plans to spend over the next 20 years on the country's highways.[5]

On other counts too, the Dutch model may not be the panacea for Indian Sundarbans. Kalyan Rudra, river scientist, warns against blind adoption of the Netherlands model. "They have studied their regions extensively and have better projections to work with. We are yet to fully understand the nature of water flows in Sundarbans. There are critical differences between two regions. For example, the sediment load carried annually by the Ganga-Brahmaputra system into the Bay of Bengal is more than a billion tonne and this is more than four times the load carried by all European rivers put together. Also, the maximum possible tidal amplitude in the estuaries of the Netherlands is less than 3.5 metre and those are classed as meso-tidal, while many estuaries of the Sundarbans are said to be macro-tidal having a maximum tidal amplitude close to 5.5 metre."[6]

He also points out that the estuaries of the Netherlands are aligned in an east-west direction, but those of the Ganga are aligned north-south and allow easy invasion of tides far inland. The off-shore currents in the Netherlands flow parallel to the coast, while the Coromandel and Martaban currents of the Indian Ocean flow northwards and strike the southern face of the Ganga-Brahmaputra delta.

Salinity: slow poison

For Kanailal Sarkar, the increasing soil salinity is a key greatest cause of worry. It is, after all, about growing food. "Salinity is slowly poisoning the entire region – the crop, the potable water, and the flora and fauna," he says.

There was a time when the embankments managed to stall seawater flooding the land. But a hundred years after, as the embankments collapse, sea levels are increasing, tidal surges are going up, and cyclones are devastating the region. In some areas, salinity has increased beyond the safe threshold for agriculture (for growing rice, the safe limit is 4-6 parts per thousand, or PPT). The northern part, which is a low salinity zone, witnesses salinity of up to 8 PPT, while the southern part contends with 8 to 20 PPT. A normal or good monsoon helps dilute the salinity of the soil. But irregular precipitation patterns have put an end to any such possibilities.

Post-Aila, soil tests carried out by the European Commission of Humanitarian Aid (ECHO) found that salinity had reached a depth of about 1.5 metre in most areas. This has hit paddy cultivation (winter crop) even two years after the cyclone (see Table 2: *Top soil salinity*).[13] In a study conducted in Bangladesh on the impact of climate change-induced salinity on crops, it has been shown that

Table 2: Top soil salinity

No	Sundarban islands	Salinity (in psu)
1	Kachuberia (western)	1.67
2	Sagar South (western)	11.39
3	Frasergaunge (western)	12.19
4	Sajnekhali (central)	13.33
5	Jharkhali (central)	13.88

Note: 1. Salinity of ocean water is 35 practical salinity units (psu)
2. Safe limits for rice cultivation: 4-6 psu
3. Top soil salinity measured during winters of 2010 in the Indian Sundarbans

Source: Department of Marine Sciences, University of Calcutta

ADITYA GHOSH / CSE

A study from Bangaldesh has predicted that sowing for rice will be possible only after the first spell of monsoon, when salinity is diluted

rice crops will be affected, particularly as high salinity affects their germination. The study also predicts that sowing will now only be possible after the first spell of monsoon when the salinity gets diluted.[14] Investigations into the loss of rice production in a village of Satkhira district in Bangladesh showed that in 2003, the village produced 1,151 metric tonne less than that in the year 1985, of which 23 per cent was directly because of yield loss related to increased salinity.[15]

Land use: changing contours spell trouble

There is no 'free land' available anymore in the Sundarbans except the embankments which are owned by the government or the *panchayats*. Added to the severe erosion in the region is the problem of growing population. This has resulted in a rise in the settlement area from 1,226 sq km to 1,666 sq km between 2001 and 2009 (see Table 3: *Land use change*).[16] Unfortunately, this increase has been at the expense of available agricultural land which has reduced from 2,149 sq km in 2001 to 1,691 sq km in 2009 (see Table 3: *Land use change*).[17] This conversion seems to have happened largely at the level of families who lost their homes and converted a part of their available cultivable land into settlements. Explains Noorjehan, resident of Baliara village, Mousuni *gram panchayat*: "After the first erosion, we resettled on a part of our own agricultural land. So our landholding reduced. The second time we lost the house as well as the entire land we had so we had to settle on the embankments." (see Box: *A place for Noorjehan*)

Forest land has also decreased by 72.89 sq km in these years, from 404 sq km in 2001 to 332 km in 2009. However, a majority of it is due to coastal erosion of forested islands.[18]

As agricultural land gives way to settlements, food production has dwindled. So have incomes of families (agriculture is the predominant economic activity). Also, shrinking forest land has hit the subsistence economy, leading to greater poverty and food insecurity in the region. Brick-kilns have started making their appearance in the region, damaging land in the process (see Box: *Aquaculture to brick kilns*).

Table 3: Land use change

Sl. no.	Land use/land cover	Data for 2001 (in sq km)	Data for 2009 (in sq km)
1	Dense forest	1655.878	1651.3275
2	Degraded forest	404.887	332.0008
3	Saline banks	38.93	74.7965
4	Settlement with vegetation	1226.334	1666.43
5	Agricultural land	2149.615	1691.246
6	Agricultural farm	603.603	649.1
7	Waterbody	232.888	250.6531
8	Mudflats	23.897	12.6135
9	Sand	8.0835	8.7664
10	Reclaimed land from forest	14.512	12.644
11	Swamp	14.847	20.41
	Total	**6373.4745**	**6369.9878**

Note: Changes in the land use patterns and land cover classes in Sundarbans between 2001 and 2009
Source: S Hazra, K Samanta, A Mukhopadhya & A Akhand 2010, *Temporal Change Detection (2001-2008) Study of Sundarban*, School of Oceanographic Studies, Jadavpur University, Kolkata

A PLACE FOR NOORJEHAN

Noorjehan Bibi and her family lives on the embankment. The household of this 50-year-old lady, a resident of Baliara village, has 10 members. Her three sons work as daily wage labourers in agricultural fields and also double up as fishermen. The typical daily income is about Rs 150 to Rs 210 per male member.

They have been forced to make their home on the embankment. After losing their homes twice over the past 10 years, there is no land left for the family to move to. So the family members pooled their resources and start living as a joint family to share the expenses. Now, waves of the raging sea lash at the doorsteps of Noorjehan Bibi's small hut. Behind, lies someone else's land.

The family does not have the resources to buy land and resettle, nor to migrate out. Technically, Noorjehan still has a choice: she can apply to the government for rehabilitation. But the wait for the outcome will be agonisingly long. "Where will we live till then?" she asks. Also, government land will be available only in Sagar Island, the neighbouring island block separated by sea. The small piece of land the government gives cannot sustain a family of 10. Hence, the younger members of the family will need to move out in search of work.

Noorjehan refuses to move to a government refugee camp and cannot afford to move out of Sundarbans yet. The embankment, therefore, is her only option. But she knows how precarious it is, because this embankment is her last line of defence as it is for the island of Mousuni. Another round of erosion, another breach in the embankment, and her home will be washed away yet again. As she counts the waves that strike the embankment in a destructive rage, she is also counting days. "I do not know where else we can move except hell," she rues.

ADITYA GHOSH / CSE

Habitation on the edge of the embankment. The sea has advanced engulfing large parts of the village. Dependent on fishing as their livelihood, they have been pushed back to the fringe of the paddy fields and they know there is no room to move back.

AQUACULTURE TO BRICK KILNS

A still unpublished land use 'change detection analysis' reveals that areas put to aquaculture in Sundarbans increased by at least 45.5 sq km between 2001 and 2009. But these were later converted illegally into brick kilns, in contravention of the West Bengal Land and Land Reforms Act (Amendment 1972), a law that protects rural populations from conversion of land from agricultural use to industrial use. Satellite images have revealed the conversion trend clearly, claims the report. These brick kilns "can be seen in the major parts of Minakhan, Hasnabad, Sandeshkhali I and II and Haroa," observes the report.[1]

Tiger prawn aquaculture had attracted many investors between 1990 and 2000. The boom resulted in the conversion of large swathes of land from agricultural use to aquaculture. However, by 2007-08 most of these farms had folded up because of a disease outbreak. This industry needs strict norms and levels of health and hygiene. After one season, the entire water has to be pumped out, the land treated and regenerated. This is expensive. The industry also suffered because prawn prices fell. Also, West Bengal did not have a single farm for prawn hatchlings, the seed for prawn farming; these had to be imported from Tamil Nadu, which raised the costs further.

These abandoned aquaculture farms subsequently started getting converted into brick kilns. Both sides of the Basanti Road, a main arterial road that connects Sundarbans with Kolkata, are now dotted with these kilns that feed the housing boom in Kolkata.

"The lure of quick money was irresistible. As the demand for bricks grew, the farm owners set up these kilns. Investment is low, labour being largely unskilled. They get far lower wages compared to shrimp farming. The soil that is excavated is sold. Thus, profit margins are large, risks are far less compared to tiger prawn farming. So it is a win-win for the landowner," says Subhash Acharya, a senior office bearer of the Sundarbans Development Authority. He also claimed that these brick kilns were leaving the ecosystem severely damaged because the deep digging made the land unusable for any kind of production for at least two years.

ADITYA GHOSH / CSE

Aquaculture ponds across Sundarbans are being converted into brick kilns, rampantly violating the law of land use conversion. These are on Basanti Road, Minakhan, North 24 Parganas. Besides the two here, there are at least eight such kilns in close vicinity.

SAYANTA BERA / CSE

Smaller pieces of land are now making it more difficult for all families in the subsequent generations to sustain themselves

After the first wave of land reforms in West Bengal called *Operation Barga*, when parcels of land were handed over to sharecroppers, the land has got fragmented in the subsequent generations. A piece of land, for example, remained constant while its heirs multiplied over the preceding generations. Since no alternative livelihood was promoted, dependence on land remained high. Smaller pieces of land are now making it more difficult for all families in the subsequent generations to sustain themselves.

Social maladies such as dowry force many to sell part of their land, therby reducing the landholding size. Almost all the villagers interviewed in the course of the CSE survey claimed that their families had to sell land for the marriage of their daughters. Tarapada Mondal (67) of Satjelia, Gosaba block, is a well-off farmer. Of his original holding of 5 bighas (2 hectares), he has been left with about 2 after selling off 2 to get his daughter married. Erosion has taken away over 1 bigha.

All these factors have reduced the sizes of per capita land holdings significantly in the Sundarbans: at 0.084 hectare (ha),[19] it is one of the lowest in the country (the national per capita operational land holding is 1.33 ha).

Needed: a new land policy

A new land and embankment policy is urgently required to stop or reduce further deterioration in land quality and quantity as well as to adapt to the changing climate.

There is a proposal from the state irrigation department to take over some 6,880 ha or close to 70 sq km of land for constructing stronger, weather-proof and long-lasting embankments. The government claims that these embankments will make the islands more secure, but where will this land come from? The

second biggest challenge for the administration will be how to rehabilitate the people who would be displaced if this land is taken over.[20]

But experts agree that to save the Sundarbans, the embankments need to be stronger. The new engineering must include three levels of protection within the embankment including natural mangrove buffers, retired embankments with flooding areas and a final line of stronger embankments. “We still have to think about how best the embankments can be strengthened, but this is the minimum that is needed,” says Sugato Hazra, head of marine sciences department of Jadavpur University in Kolkata.

However, it would be a near impossible task for the administration to take over the land. “There will be major upheaval and resistance from the people, and it will lead to an almost war-like situation,” says Subhash Acharya of the Sundarban Development Board.

CHAPTER 5

Survival archipelago

After migrating from the neighbouring district of Midnapore to Brajaballavpur in Patharpratima block of the Sundarbans, Radhakanta Mahakal and his father used to cultivate a small piece of land for a living. The returns were just about enough to provide for the family.

However, with changing climate, Mahakal's terms of livelihood changed, as it did for many others like him. He now had to 'multi-task' to survive. Half his land was lost to the rivers due to erosion. Mahakal began to fish for food, and he also started accompanying groups of people to the forest to collect honey to supplement his meagre income. He also had to shift to a new location after losing his home to the river, and start life afresh.

With his daughter's marriage, another part of his land had to be sold. The miniscule 0.26 hectare (ha) of land was not enough to sustain eight people, which included two of his sons and their families. Steep competition from mechanised fishing also cut him out from his catch. In the end, the family had to turn

SUNITA NARAIN / CSE

Setting sail for a catch: People have been shifting to fishing as returns from agriculture have started dwindling because of climate change

to the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) for daily wage employment. But there was never enough work and his young sons, without a school leaving certificate, failed to find any other options of livelihood in the Sundarbans.

Then came Aila in May 2009; it ravaged the delta and eroded more chunks of earth from Mahakal's land. His sons joined the scores of people leaving the island and their homes in search of sustenance. Finally, they got jobs as daily wage labourers in a potato firm in Hooghly district up north. Now with remittances coming in, the family could again afford two square meals a day.

Mahakal still has to look after his daughters-in-law and grandsons, as his sons don't earn enough. "I have to keep working here, but there is just isn't enough resources to sustain us all. The weather has changed over the years and we are at its mercy," he says.

Isn't the family missing the sons? "Sure we do. But we can't live without food, can we? We migrated here to defy poverty 50 years ago and today my sons are doing so again. The poor cannot afford to have the luxury of permanent homes. For us, home is where the food is," says Mahakal.

Subsistence living

Mahakal's life resonates that of others in Sundarbans: it is the story of 4.5 million poor citizens living in this fragile ecosystem. Government policies and their implementation over the decades have not been able to ameliorate poverty despite Sundarban's proximity to Kolkata.

The average poverty ratio – or the percentage of households below the poverty line – in the 19 Sundarban blocks in North and South 24 Parganas is 43.51 per cent. In comparison, the average poverty ratio in the

ADITYA GHOSH / CSE

The landholding of Radhakanta Mahakal of Brajaballavpur has steadily decreased; agriculture is not viable anymore

remaining (non-Sundarbans) blocks in these two districts is much lower: 22.41 and 24.43 per cent, respectively.

The primary occupation of the people here is mono-crop agriculture. It contributes close to 77.55 per cent of the entire economy directly or indirectly[1]. However, due to the low returns from agriculture, people turn to fishing – both subsistence as well as the more formal, structured pisciculture (the latter also being an employment source for the people). There are 70,000 active fisherfolk in Sundarbans; another 270,000 are engaged in fishing, but are not exclusively dependent on it.[2] In the non-cultivation season, for instance, people shift between collection of non-timber forest produce (NTFP) and fishing.

These are the marks of an economy where access to natural resources is the key to survival. This is the real measure of poverty, where environmental degradation leaves the poor debilitated and hamstrung for livelihood options.

In a clear sign of things to come, large swathes of Sundarbans now depend on remittances sent by migrants, who are essentially environmental refugees fleeing the effects of climate change and shrinking resources. There is no reliable quantification yet of the total remittances towards Sundarbans. A 2010 study conducted by the Kolkata-based Jayprakash Institute of Social Change as also the CSE survey have noted that about 75 per cent families have one or more members living and working outside the state. Even a conservative estimation thus points to 12-15 lakh migrants sending anything between Rs 500 to Rs 2,500 per head per month home as remittances. Thus, the total figure could be in the range of Rs 720-4,500 crore annually.

Livelihood options for Sundarban's residents are shrinking. Overdependence on natural resources for livelihoods and rapid increase in population in an ecosystem under siege from the effects of climate change has jeopardised even this subsistence economy. "As population kept on increasing, alternative livelihoods were never thought of and now we have a situation where that subsistence economy itself is threatened," says Rabindranath Bhattacharya, economist, who has studied the region for over 20 years.

Agriculture: on the wane

About 85 per cent of Sundarban's population depends on agriculture[3]. The productivity of paddy is very low and fails to offer decent returns to the farmer – 1.5 to 2 tonne per hectare (ha) against a national average of 3.28 tonne per ha[4] (see Table 1: *Paddy productivity*). According to local farmer Arup Mondol in Mousuni, the income is to the tune of Rs 6,000 per acre against an investment of Rs 4,000 per acre each sowing season. There are three dominant reasons why agriculture will remain subsistence in Sundarbans. Firstly, the land holdings are small. There is also land loss to deal with. Finally, there is a limited potential to develop irrigation facilities, which means multi-cropping cannot be practiced extensively.

The growing population has been exerting tremendous pressure as well. Between 2002 and 2009, the land available to agriculture had shrunk from 2,149.615 sq km (2,14,961.5 ha) to 1,691.246 sq km (1,69,124.6 ha). With the rise in population, settlements have also

Table 1: Paddy productivity

Sundarban blocks of South 24 Parganas	Tonne/hectare
Canning I	1.723
Canning II	1.712
Basanti	1.777
Gosaba	2.732
Mathurapur I	1.600
Mathurapur II	2.311
Joynagar I	2.021
Joynagar II	1.551
Kultali	1.919
Kakdwip	2.057
Namkhana	2.522
Sagar	2.243
Patharpratima	2.319
Average	**2.037**

Note: Data from 13 Sundarban blocks in South 24 Parganas
Source: District Statistical Handbook, South 24 Parganas, 2009

Table 2: Land and agricultural workforce relations

Blocks	Net area under cultivation (in ha)	Rural population	Total agricultural workers	Relative availability of cultivable land (ha per capita)	Cultivable land per agricultural worker (in ha)	Agricultural workers as % of total workers
Canning I	15,862	2,44,627	29,359	0.065	0.54	37.13
Canning II	15,748	1,95,967	43,863	0.08	0.359	73.93
Joynagar I	9,402	2,14,026	22,209	0.044	0.423	33.78
Joynagar II	15,539	2,09,145	36,698	0.074	0.423	54.08
Kultali	19,923	1,87,989	42,135	0.106	0.473	71.61
Basanti	26,151	2,78,592	66,004	0.094	0.396	74.02
Gosaba	17,000	2,22,822	63,277	0.076	0.269	73.53
Mathurapur I	11,980	1,64,650	21,303	0.073	0.562	46.73
Mathurapur II	17,878	1,98,281	40,558	0.09	0.441	62.54
Kakdwip	15,973	2,39,326	44,487	0.067	0.359	53.26
Sagar	17,436	1,85,644	55,683	0.094	0.313	73.95
Namkhana	16,910	1,60,627	43,895	0.105	0.385	63.81
Patharpratima	36,429	2,88,394	80,887	0.126	0.45	65.84
Average				**0.084**	**0.41**	**60.32**

Note: Data from 13 Sundarban blocks in South 24 Parganas
Source: Anon 2009, Human Development Report, South 24 Parganas, Government of West Bengal

increased from 1,226.334 sq km to 1,666.43 sq km[5]. The average land holding is 0.82 hectare[6] per family and about 0.084 hectare per capita (the national average of operational landholdings is 1.33 ha per capita)[7].

In Sundarbans, a farmer who owns agricultural land between 0.13 and 0.27 ha (1-2 *bigha*) is considered marginal, while one with land between 0.27-0.67 ha (2-5 *bigha*) is perceived as small. Households with less than 0.13 ha (1 *bigha*) of agricultural land are considered practically landless[8]. Of the total land owning families, small and marginal farmers account for 85.22 per cent[9]. This is a higher figure compared to the West Bengal average of 43.48 per cent[10].

In 13 Sundarban blocks of 24 South Parganas, about 47.5 per cent households are landless and another 41 per cent own land measuring 1 acre or less.[11] Essentially, landholdings are just too small in Sundarbans to allow for livelihood improvements based on agriculture (see Table 2: *Land and agricultural workforce relations*).

On top of it, there is a dearth of adequate and efficient irrigation facilities. Only about 64 per cent of the agricultural land has some kind of groundwater-based irrigation support. But even this faces serious challenges because of non-availability of electricity that does not allow the operation of pumps. There are ownership and access issues as well: a farmer on whose land a pond is excavated may not allow other villagers to access the water. The nature of farming is different in Sundarban as segments of land are not conjoined, which makes the fair distribution of water a problem. Also, paucity of sweet water in the region poses a major problem for irrigation. Most of the cultivation of land thus remains mono-cropped because all that farmers can depend upon are the monsoonal rains.

Apart from all this, there are governance deficits and institutional shortcomings that do not allow farmers of Sundarbans to get a better price for whatever little they produce. Development of rural infrastructure with proper marketing and storage facilities is a necessary pre-requisite for successful rural agro-based industries. Ease of transportation is an integral part of proper infrastructure. In the Sundarbans, this infrastructure is minimal.

This lack sometimes leads to huge losses for the cultivators. For example, Kakdwip and Sagar are known for their excellent watermelons, while chillis from Patharpratima are especially savoured for their quality. With no proper storage, transport, credit and marketing facilities, their producers do not get any opportunity to sell these non-foodgrain crops in distant places at competitive prices. There is only one cold storage in the entire region: located in Kakdwip, this storage serves the fishing community.

Changing climate compounds the crisis

Farmers in Sundarbans also have to contend with climate change. A majority of the crops they cultivate are highly sensitive to changes in temperature or unseasonal rainfall. Tarapada Mondol, a farmer of Satjelia island, provides interesting insights into how agriculture is being affected. One of these is that the region witnesses much higher levels of heat after a spell of rain: this is disastrous for cash crops such as watermelon and betel, which are more sensitive to changes in temperature and rainfall. This has been corroborated by scientific research – an Indian Institute of Tropical Meteorology[12] study says there is 'overheating' after rainfall events.

When CSE surveyors visited the region in July 2011, farmers reported the loss of their watermelon crop in blocks such as Patharpratima, Namkhana and Kakdwip due to inclement weather. Following major losses of the crop between 2005 and 2008, farmers in Mousuni, Brajaballavpur and Satjelia had stopped cultivating watermelon.

To adapt to the changed circumstances, farmers need guidance, new products and institutional support. They need to know which rice varieties would suit the soil conditions, when they need to sow these varieties and what other crops they can cultivate. Since conventional cash crops have failed, they need alternative cash crops. They also need more reliable weather forecasts to decide on the sowing time.

It is also necessary to resurrect traditional knowledge. There were six varieties of salt-tolerant rice that used to be cultivated historically in Sundarbans which, from the time of the Green Revolution, slowly went out of cultivation. Today, with salinity increasing again, these varieties would have helped farmers cope better; after a prolonged search, the National Bureau of Plant Genetic Resources (NBPGR) was able to trace only two of those varieties, *Matla* and *Hamilton*[13].

Towards downward adaptation

The lack of enabling choice is evident in the agricultural sector in Sundarbans: farmers do not have options that will enable them to practice agriculture that will generate sufficient incomes. The continued deprivation binds them down. The farmer, in order to compensate his declining income, gives a part of his land to a money lender. This is his own way of adapting to his changed circumstances. However, this leads him into a debt trap. He can never repay if he continues to depend on income from agriculture. So he starts working elsewhere as well to supplement his income and repay the debt. However, this puts him back further, in what can be termed as a 'downward' adaptation of his needs. This is how a great majority of the farming households are continually adapting downwards across Sundarbans[14].

Naturally, agriculture is no longer a preferred livelihood option for the younger generation. The assets created by the father has little value for the son, who has to start his struggles all over again. For this, he either has to migrate or get trained in a skill that will help him earn a livelihood. They have little freedom to choose from available career options.

True enough, neither of the two sons of Tarapada in Satjelia could or even wanted to opt for agriculture. While the younger son started a roadside eatery after training himself in making sweetmeats, the elder son supplies feed to the crocodile park started by the state government and looks after the little land they are left with.

Fishing: drying up

Fishery is the second biggest source of employment in the Sundarbans. On an average, around 4,000 individuals fish daily. With an average catch of 1.5 kg per fisherfolk per day, the annual fish catch amounts to 66,995 tonne. Though fishing activities continue throughout the season, production starts increasing at the onset of monsoon and reaches its peak during winter (November-January)[15].

Ecologically, the Sundarbans mangroves act as a nursery, the breeding and feeding grounds for 90 per cent of coastal aquatic fauna that are found along the east coast of India. These aquatic species, because of favourable water temperature and other environmental conditions, use the ecosystem as their spawning and nesting sites. A healthy aquatic and mangrove ecology in the Sundarbans is thus the key to the biodiversity for the entire East Indian coastal fishery down to Andhra Pradesh.

The two main types of fishing activities in Sundarbans that have substantial commercial value and need capital investment are aquaculture (aquafarming) and marine fishing. Apart from this, the other major economic activity, more like a cottage industry, is collection of prawn seedlings, mainly handled by women. But this is often classified as a non-timber forest produce, rather than a fishery activity.

The other types of fishing activities are largely at subsistence levels. These include brackish water fishing (*nona-ghery/bheri*), tank and *bilse* (water pods within paddy fields), fishing in the rivers, fishing in the forest and winter migratory bag-net fishery – where migratory fish and seedlings are trapped in the shallow estuaries using a hand-held triangular net attached to three bamboo poles.

ANIL AGARWAL / CSE

Repairing the fishing gear on the edge of the river. Many fisherfolk cannot even afford to buy their own nets

ADITYA GHOSH / CSE

Large fishing trawlers anchored off Namkhana. These trawlers are owned by a select few who bag the largest pie of the profit. Fisherfolk who operate these trawlers and take them to the high seas, work on daily wage basis which are as low as Rs 70

Over-exploited

Both commercial and subsistence fishing are now threatened: over-exploitation is one of the major causes behind dwindling fish resources. This is a direct outcome of the increase in the number of people moving towards fishing. The diminishing returns in agriculture prompts many farmers to shift to fishing. There is also competition to deal with from foreign shores, which makes it tougher to make a living.

Popular species such as the *Hilsa* have perhaps borne the biggest brunt of overfishing. These species are not allowed regeneration time and the catch has declined drastically. While data in India is not very reliable and authentic, in Bangladesh, the *Hilsa* catch dropped by about 60 per cent between the years 1999 and 2002[16].

In the Sundarbans, raising capital for fishing and getting licenses can be a struggle. Licences are issued by the forest and fisheries department. These permits, called Boat Licence Certificate or BLC, have stayed constant over the past 20 years according to the district forest office of South 24 Parganas. Neither department has any plans to increase them. In total, 3,793 BLCs have been issued catering to at least 24,000 fisherfolk. Under BLC, owners of the boats can carry out permitted activities, which include collection of non-timber forest produce, besides fishing. But because of high demand, owners often sublet these BLCs to groups of people who go fishing with the license. These groups, apart from paying the 'rent' of the license, also have to cover the cost of fuel. After they sell the catch, the profits after covering all the costs is equally divided within the group which generally comprises of six-seven people. Thus, the returns are not very high individually.

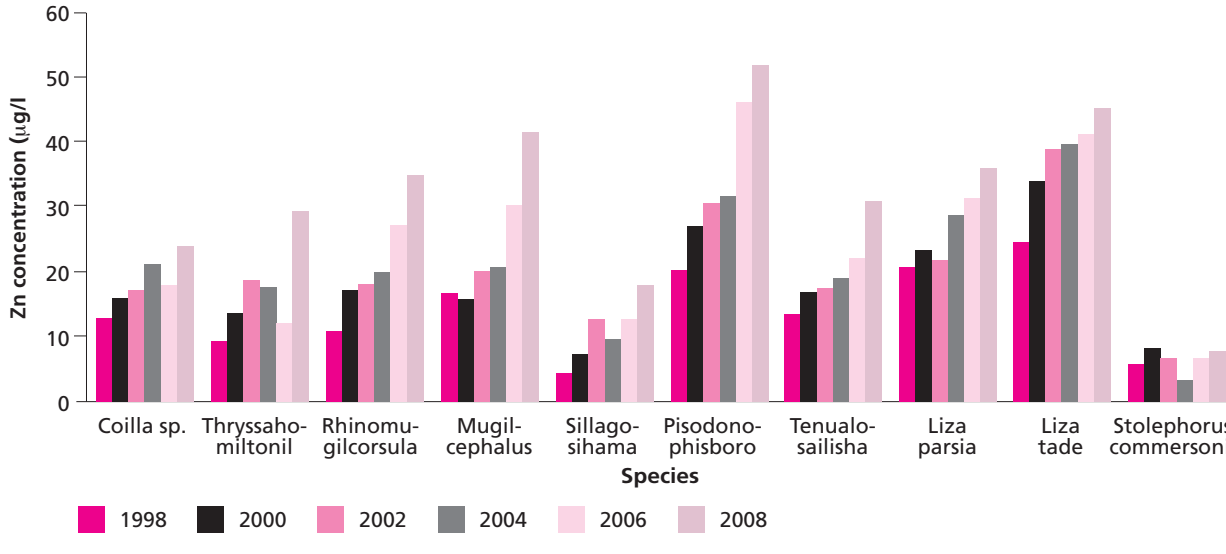
There is also an ongoing conflict between fishing and forest protection as no fishing is allowed in the protected Project Tiger zones in the eastern sector of Sundarbans. Illegal fishing, however, continues because of livelihood constraints and poverty.

CONTAMINATION IN FISH

Data from the marine sciences department, University of Calcutta shows that for all fish species, levels of heavy metals have increased significantly between 1998 and 2008. A time series analysis of heavy metal accumulations (Zn, Cu and Pb) showed significant variations in case of zinc (Zn) and copper (Cu) over time. While copper and zinc may not be grave causes of concern for human consumption as human tolerance for both the metals is quite high, concentration of lead (Pb) is a serious concern. In all the samples in 2008, the concentration of Pb was higher than the World Health Organisation safety limit of 2µg/gram. In some species (four out of 10 tested), even the copper concentrations were higher than WHO prescribed safety levels of 10 µg/gram.

High levels of pesticides were also found in fishes; these sometimes exceeded the safety limits, particularly in the case of hexachlorocyclohexane (HCH) family of pesticides and endosulfan[1]. Exposure of HCH in humans can lead to blood disorders, dizziness, headaches, and possible changes in the levels of sex hormones in the blood. Both these pesticides are under the group of persistent organic pollutants (POP) that are in the list of pesticides to be banned under the aegis of Stockholm Convention because of the harm that they cause to human health. Some countries have already banned them.

Graph: Zinc (Zn)



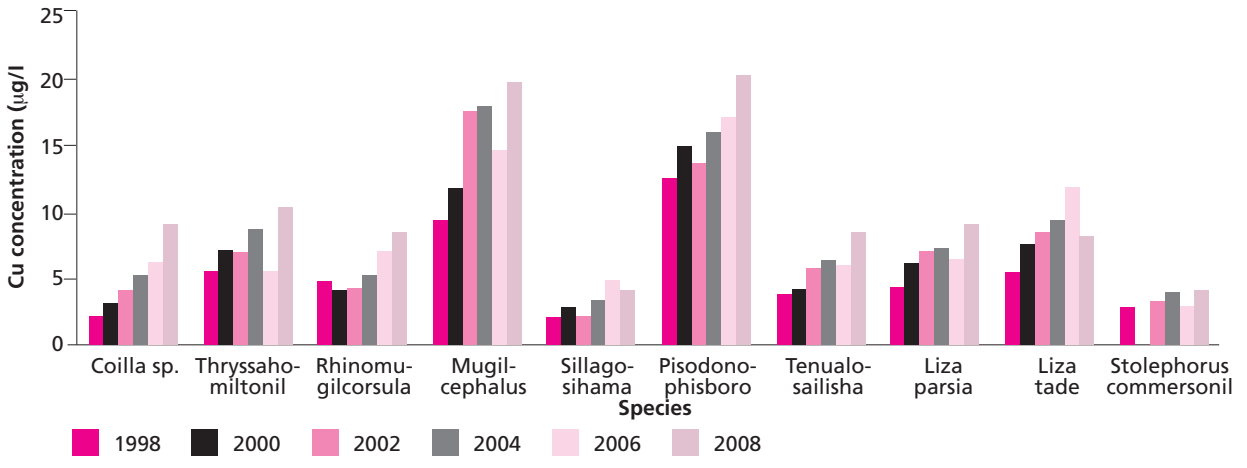
Note: Variation of bioaccumulation of Zn (µg/g) in the muscle of different fish species during the period of 1998 – 2008

Fish diversity and stock have been affected negatively over the years, forcing fisherfolk to venture into the deep seas. This translates into much higher fuel and equipment costs as well as greater risks for the fishers. There is also ever increasing competition from foreign trawlers, particularly from Thailand, Sri Lanka and Indonesia.

In case of aquaculture, the economic benefits of captive fishing (or *bheris*), such as cultivating tiger prawns, are concentrated in the hands of a small group of people who own the farms. "There has been little institutional support for marginal and poorer communities to set up businesses such as small cooperatives to run commercial aquaculture, or for that matter, even to buy a boat," says Tushar Kanjilal. Besides, the prawn aquaculture industry has more or less collapsed in the Sundarbans, with many aquaculture farms having been converted into illegal brick kilns (see Chapter 4).

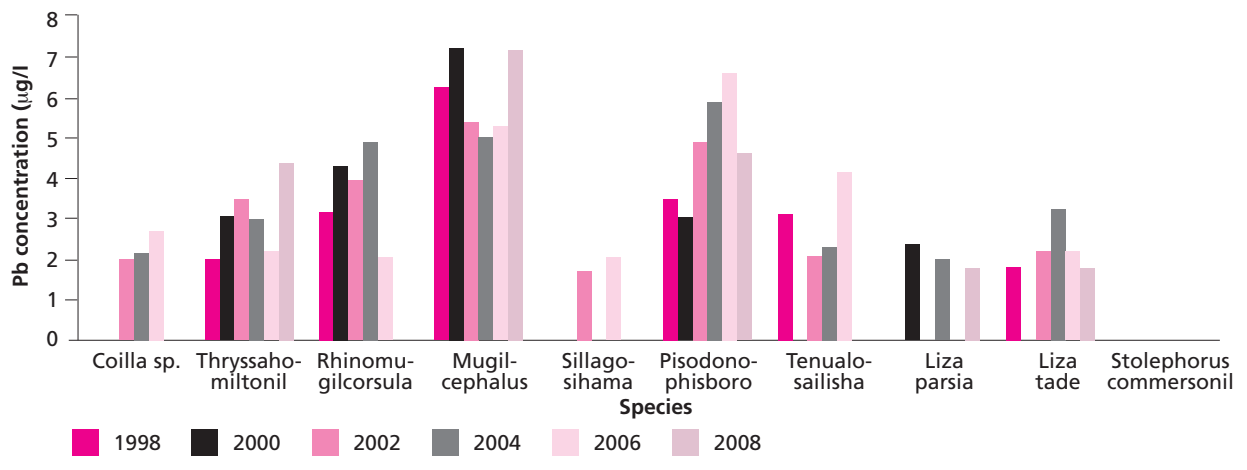
Apart from all this, pollution and heavy metal concentration in fish has also emerged as a serious concern (see Box: *Contamination in fish*).

Graph: Copper (Cu)



Note: Variation of bioaccumulation of Cu (µg/g) in the muscle of different fish species during the period of 1998- 2008

Graph: Lead (Pb)



Note: Variation of bioaccumulation of Pb (µg/g) in the muscle of different fish species during the period of 1998-2008

Climate change is impacting stocks and availability

A rise in sea surface temperature in the Sundarbans area is expected to affect fish stocks. Fish are extremely sensitive to water temperature – any change can force a fish species to change its life cycle, or shift to a different level or depth of water. It can also lead to loss in swimming ability of a fish, thus affecting the ability of the species to get food[17]. Thermal effects on muscle function determine the success of a particular species to survive and multiply. As the surrounding water warms up, fish metabolism speeds up – they digest food more rapidly, grow more quickly, and have more energy to reproduce. But fish need more food and more oxygen to support this higher metabolism if there is not enough food, all of a fish's available energy goes to fuelling its high metabolism, and less energy is available for growth and reproduction.

A recent study titled 'Vulnerability of Indian Marine Fisheries to Climate Change' carried out by the Central Marine Fisheries Research Institute observes that some species such as the Indian mackerel *(Rastrelliger kanagurta)* show a shift in the depth of distribution and are now caught only by bottom

trawlers. This might explain unavailability of certain fish species in certain depths, as many respondents reported in the survey conducted by CSE.

The fish density in shallow waters seems to have reduced as well, if local fisherfolk are to be believed. They claim that they have to now venture into the deep seas to get adequate catch. The average number of fishing days in the deep seas have gone up, and so have the costs. This has led to a consequent decrease in income. "A few years ago, trips on an average would last about seven days, but now they have to fish for 10 to 12 days to generate similar catch," says Saikh Rustam of Mousuni village. Rustam had to shift to fishing from agriculture after he lost his land to erosion.

Fisherfolk in Baliara village claim that the sea has become more dangerous with higher and stronger tidal currents coupled with greater wind speeds. Along with competition, altered tidal patterns and water temperatures have affected the availability of fish in the shallow waters, they say (see Box: *Shifting distribution of fish stocks*).

SHIFTING DISTRIBUTION OF FISH STOCKS

To understand the current distribution of fish in Sundarbans, a survey was conducted by the department of marine sciences, University of Calcutta in two segments in 2011: on July 21-24 and August 9-12 in the western and central parts. The survey reflects a shift in the composition of fish in response to ecological conditions. The difference in salinity in the aquatic subsystem has caused the compositional variation, compared with the consolidated results of earlier studies conducted by the same department during 1990-2010.

SAYANTAN BERA / CSE

Laying out the net for what is dwindling stocks

Non-timber forest produce

The mangrove biomes of Sundarbans provide some of the essential components of livelihood of the forest-dependant island villagers of the area. These people collect a wide variety of non-timber forest produce (NTFP)including tannin bark (most Sundarban species like *Ceriops decandra*, *Ceriops myrobalans*, *Phoenix paludosa* yield around 30-42 per cent tannin); *Nypa fruticans* (Golpata), natural honey from *Apis dorsata*, cultured (apiary) honey (*Apis indica*) and bees wax; fuelwood and small poles and boles; fish, prawn, crab, shrimps; and lime (manufactured from *jorgran*, *kastura* and *jhinuk*)[18]. In some areas of Sundarbans, the contribution of NTFP to total household income is quite high (see Box: *Income from NTFP*).

There is also a constant conflict between protection of forests and collection of NTFP. Sundarbans is a biosphere reserve and a protected area under IUCN's Category 1A; hence, there are several restrictions for the collection of the NTFP from its forest areas. These restrictions range from number of permits

The catch composition, segregated between commercially important and trash fishes, reveals that the proportion of trash fish has jumped from 25 per cent in 1990 to 63 per cent in 2011 (the current survey) in central Sundarbans (*Stolephorus sp.*, *Thryssa sp.*, *Harpodon nehereus*, *Trichiurus sp.*). In the western sector as well, the proportion of trash fish in the whole catch has increased from 35.4 in 1990 to 40 per cent in 2011 (see Table: Variation of fish catch). A gradual increase in catch of commercially important fishes (*Tenualosa ilisha*, *Polynemus paradiseus*, *Sillaginopsis panijus*, *Pama pama*, *Arius jella*, *Osteogeneiosus militaris*) in the western sector was observed compared to the central sector. This significant difference between the two sectors could be due to the increased dilution factor in the west owing to barrage discharges from upstream.

Table: Variation of fish catch

Year	Western Sundarban		Central Sundarban	
	Commercially important	Trash fish	Commercially important	Trash fish
1990	3.1	1.7	2.6	0.9
1995	2.9	1.6	2.4	1.2
2000	2.3	1.4	1.9	1.3
2005	1.7	1.2	1.2	1.4
2011	2	0.8	1.1	1.9

Source: *University of Calcutta, Department of Marine Sciences*

The study clearly indicates a distinct dissimilarity between the western and central sectors in terms of fish diversity. The diversity of commercially important fish species has not altered significantly over the years in western Indian Sundarbans, but in the central sector the diversity has reduced due to hypersaline conditions. The trash fish diversity, however, has increased. This study indicates that fish composition in different parts of Sundarbans are changing and trash fish are increasing as against commercially important ones.

The change in composition of fishes can be attributed to both climatic changes and human-induced ones. As pollution increases and water temperature changes, trash fishes can cope and survive better compared to commercial fish which are more sensitive to such as changes. Trash fish survives better in polluted waters, says Abhijit Mitra, head, department of marine sciences, University of Calcutta. "But it can also be because of climate change, which needs further exploration and scientific study that will reveal how the diversity was changing," he adds.

The data in the table represents Fish Diversity Index, calculated as Shannon Index, which is one of several diversity indices used to measure diversity in categorical data. The advantage of this index is that it takes into account the number of species and the evenness of the species. The index is increased either by having additional unique species, or by having a greater species evenness.

INCOME FROM NTFP

In a recent survey[1] in three villages of Sundarbans, Bali II, Anpur and Dulki, the contribution of non-timber forest produce (NTFP) to the total annual household income was found to be between 76-92 per cent (Rs 57,000-Rs 1.02 lakh). The total contribution of NTFP in the annual average household income of all three villages combined was Rs 75,000 (see Table: *Average annual household income*), which is 79 per cent of the total household income. Income from other sources like agriculture and labour was approximately 12 per cent and 8 per cent, respectively.

Among the various types of NTFP, fish contributed the highest (Rs 64,885, about 46 per cent of the household income), followed by tiger prawn seedlings (Rs 56,000, or 42 per cent of the household income approximately). Honey and bees wax contributed around Rs 4,500 (3.5 per cent) (see Table: *Average annual incomes*).

However, value of prawn seedlings collected has declined by 95 per cent. The closure of the Bangladesh market has contributed to higher prices of prawn seedlings in adjacent blocks. Economic and environmental causes have also resulted in deterioration of fisheries and consequent decrease in seedling demand. The quality of seedlings has also declined. Higher mortality and lesser growth rates, susceptibility to contract diseases are common complaints.

Table: Population involved in NTFP collection

Occupational categories	% of population involved		
	Bally II	Bulki	Anpur
NTFP collection	6.35	6.98	9.54
Agriculture	7.30	10.23	9.05
Agricultural labour	79.05	72.53	66.40
Household industry	0.35	.52	5.05
Other occupation	6.95	9.75	9.97

Notes: 1) 6.3-9.5 per cent population involved in NTFP collection
2) 66-79 per cent agricultural labour involved in NTFP collection
3) In NTFP, there was equal distribution in households collecting honey, wax and firewood on one hand; fish and prawn collection on the other
Source: A Singh, P Bhattacharya, P Vyas and S Roy 2010, 'Contribution of NTFPs in the livelihood of mangrove forest dwellers of Sundarban', *Journal of Human Ecology*, Vol 29, No 3

Table: Average annual incomes (in Rs)

Village	Honey	Wax	Prawn Seed	Crab	Fish	Total contribution
Bally II	5,697	1,633	72,527	4,453	1,34,080	2,18,390
Dulki	3,181	441	63,945	5,489	44,114	1,17,170
Anpur	4,412	584	23,404	8,400	39,109	75,909
Average	3,886	680	56,040	6,443	64,885	1,31,934
% of household income from NTFP	2.94	0.5	42.47	4.88	49.17	

Table: Average annual household income (in Rs)

Villages	NTFP	Agriculture	Labour	Service	Total
Bally II	1,25,691	19,265	20,067	14,400	1,31,168
Dulki	60,577	9,972	3,474	0	74,023
Anpur	57,964	5,658	9,160	0	71,434
Overall average	75,032	11,530	7,703	327	94,156

Source: A Singh, P Bhattacharya, P Vyas, S Roy 2010, 'Contribution of NTFPs in the Livelihood of Mangrove Forest Dwellers of Sundarban', *Journal of Human Ecology*, Vol 29, No 3

HONEY AND WAX

Honey production needs sunny days and optimum intermittent rains, not storms, cyclones, high tides or floods. A changing climate might affect these parameters, which in turn may impact the production of honey.

The collection season extends roughly between the fourth week of March and the first week of June, that is before the onset of monsoon. The bulk of the honey is produced and collected in the first phase; that is between March and May. Quality-wise too, honey collected during the first phase is the best[1].

The forest department issues about 1,000 permits every year to groups of three to five members. Permit holders are allowed to access only the buffer zone of the Sundarbans Tiger Reserve. The honey collectors are required to sell the entire quantity of honey and wax collected to the forest department at a price prescribed by the latter. The rates are revised annually. The Forest Development Corporation of West Bengal buys honey and wax at Rs 48 and Rs 50 per kg, respectively.

According to the forest department, the average current yield is about 30 tonne annually, which is a sharp decline from about 55 tonne a few years ago. "High risks and decreasing outputs are responsible for the decline in NTFP collection," said Subhendu Bandyopadhyay, district forest officer, South 24 Parganas.

There are institutional challenges as well. The number of BLCs has remained constant over the past 20 years. The forest department does not have a structured and efficient marketing system. Thus, fetching the right price for Sundarbans honey, especially against competition with popular brands, is difficult. The market for honey itself is small, according to Bandopadhyay. Honey has little cultural acceptance as a food product in the state and mass scale production often fails to find markets within West Bengal. In the absence of unrestricted access and a large market, scope of honey collection as an alternative livelihood remains largely unviable.

issued to not allowing access to the core forested area inside the Sundarbans Tiger Reserve (STR). However, certain relaxations have been made for the collection of a few specific NTFP, which are mostly animal-based, such as honey, fish and crab.

In general, NTFP collection practices are highly area-specific. They are more prevalent in eastern and central Sundarbans. The collection of NTFP is a daunting task, which involves risks from man-eating tigers. There is no insurance coverage and compensations are often delayed in case of an accident. Also, if the accident takes place in a protected area, no compensation is paid. There is no government help for the groups which venture into the forests to collect NTFP. Many NTFP gatherers take the help of local *tantriks* or witchdoctors, who tell them when to enter the forests. All the interviewees of CSE's household survey said that given a choice of an alternative livelihood, they would prefer not to collect NTFP because of the risk and the physical labour it involves.

CHAPTER 6

Development deficit

Using a mobile phone in the remotest corner of Indian Sundarbans is not a problem. Getting safe drinking water and life saving medicines is. Private phone companies have reached where the government, with all its bulk and mandate, has failed to for over 50 years. Despite the absence of electricity, even remote islands in Sundarbans today have mobile towers of multiple service providers that enable call delivery, short messages and even email. But there are no roads, electricity penetration is a mere 17 per cent (up from 6 per cent in 2001), and just one in every 10 people has access to a bank. In many areas, there is just one doctor for at least 50,000 people, and only one institute of higher education covering an area of 250 sq km.

ADITYA GHOSH / CSE

An NGO sponsored solar mini-grid in Lahiripur in Gosaba block which is supplying power to about 500 families. Sundarbans, however, suffers from acute power crisis: only 17 per cent of its total households have grid connectivity. Renewable energy, therefore, is a key alternative

While the residents charge their mobile phones at innovative 'community charging stations', a diesel generator-run facility operated commercially, they still take hours to reach a hospital and are often forced to resort to quacks. Such infrastructural shortcomings have made it impossible for the people of the Indian Sundarbans to effectively cope with the daily strife that life in the delta offers them. This chapter examines the acute 'development deficit' that plagues the people of Sundarbans.

Power: connecting, but in fits and starts

Only 1.2 lakh households (17 per cent of the total) in the Sundarbans are electrified through the grid. In the blocks in South 24 Parganas, only about 13 per cent of households have connectivity, while in North 24 Parganas, the figure is close to 26 per cent (see Table 1: *Grid electrification status*).[1] This is a marked improvement from 2001, when a mere 6 per cent of the households (about 41,000) had access to any form of electricity in the 13 blocks of South 24 Parganas. The lowest penetration of electricity was reported in Kultali (0.15 per cent) and the highest was in Joynagar I (15.21 per cent); Basanti, Gosaba, Kultali, Sagar and Patharpratima were the predominantly unelectrified blocks.[2]

The improvement in status between 2001 and now can be attributed to the Rajiv Gandhi Gramin Vidyutikaran Yojna (RGGVY). In 2005, adhering to the provisions of the National Electricity Policy, the Union ministry of power introduced the RGGVY to electrify all unelectrified villages by 2012. The scheme provides for free electricity to people below the poverty line, and at rates as low as Rs 3.5 per unit to the rest. For a village to be deemed electrified, at least 10 per cent of the households in it are expected to receive a unit of electricity per day. There are plans to cover 3.53 lakh households with financial support from the Yojana and the concerned state government.[3] In the Sundarbans, RGGVY is being implemented by the West Bengal Green Energy Development Corporation Limited (WBGEDCL).

However, till 2010, only 57 villages in the Sundarbans were fully connected to the grid under the Yojana. The work continues in 838 villages. The fate of 100 odd villages are still undecided. In the rest, either the work has just begun or the villages have been brought under RGGVY very recently (see Table 2: *Electrification at the village level under RGGVY*).

Apart from grid connection, Sundarbans is also using renewable energy to power its villages. In all, 16

Table 1: Grid electrification status

Areas	No. of households (Census 2001) (in lakh)	No. of households electrified (grid) (in lakh)	Households electrified (in percentage)	No. of BPL household (in lakh)
North 24 Pgs	2.04	0.53	25.98	0.87
South 24 Pgs	4.90	0.67	13.67	3.36
Total	**6.94**	**1.20**	**17.29**	**4.23**

Source: Anon 2011, 'Improving Energy Infrastructure in Indian Sundarbans', West Bengal Green Energy Development Corporation Limited, Govt of West Bengal

Table 2: Electrification at the village level under RGGVY

Total number of villages	Completely grid electrified	Ongoing grid electrification	Proposed under DDG (renewable)	To be considered	Not planned
1076	57	838	39	104	5

Source: Anon 2011, 'Improving Energy Infrastructure in Indian Sundarbans', West Bengal Green Energy Development Corporation Limited, Govt of West Bengal

Table 3: Annual electricity supply

Sources	Installed capacity peak load (MW)	Proportion in installed capacity (percentage)	Consumption (million units/year)	Proportion in total supply (percentage)
Grid supply in North 24 Parganas	33.1	40.2	78.0	29.7
Grid supply in South 24 Parganas	38.4	46.7	174.0	66.2
Generation from RE power plants (mini-grids: solar + wind-diesel)	4.3	5.2	3.8	1.4
Generation from solar home systems	4.8	5.8	4.1	1.6
Generation from diesel gensets	1.7	2.1	2.9	1.1
Total supply	**82.3**	**100**	**262.8**	**100**

Source: Anon 2011, 'Improving Energy Infrastructure in Indian Sundarbans', West Bengal Green Energy Development Corporation Limited, Govt of West Bengal

solar photo-voltaic mini-grids (local renewable energy generating stations) are in place, besides some solar home lighting systems, two wind and wind-diesel plants, and three biomass gasifier plants: these generate a total of 10.8 MW at peak rates (see Table 3: *Annual electricity supply*). There are about 120,000 solar home systems (about 100,000 installed by the government, the others provided either by non-government organisations or purchased directly from the market) in the Sundarbans.[4]

In addition, Sundarbans also has 114 diesel generator sets, each of 10-25 kW capacity, run by private operators, which serve mainly small markets and commercial loads.[5]

The per capita electricty consumption in Sundarbans is less than 50 kwH/year. This is one-fourteenth of the average per capita electricity consumption of the entire country. About 96 per cent of this electricty is supplied through grid, and the remaining 4 per cent is from renewable sources (see Table 3: *Annual electricity supply*). About 1,2 lakh households are grid connected whereas 1.1 lakh get some electricty through renewable sources. Those connected to renewable energy systems, get four to six hours of electricity sufficient to operate two CFL bulbs and one fan.

The grid and its problems

According to estimations done by the Sundarban Development Board in 2010, the demand for electricity in the region is expected to grow 10 to 20-fold between 2010 and 2020. Where will the power come from?

Off-grid renewable energy (RE) power plants had been first introduced in these islands in the 1990s by the West Bengal Renewable Energy Development Agency (WBREDA), at a time when none of the villages in the Sundarbans were electrified. Between 2000 and 2007, as many as 10 solar photo-voltaic mini-grids were up and running in Sagar island alone. This emerged as a model for RE schemes in the rest of the country, with Sagar becoming an exemplar of decentralised power supply in remote areas (see Box: *Sagar's tryst with power*).

But faced now with a growing demand for more power, the West Bengal government is planning to extend grid-based electricity to most areas in the Sundarbans: about 1,076 villages are supposed to be covered under this plan. For the state, the coming of the RGGVY scheme at this time has been a real boon. However, grid-based power supply has its obstacles and pitfalls.

To begin with, extending the grid across the whole of the Sundarbans, particularly to the disparate islands separated by large rivers and creeks, is an extremely trying proposition. In this inter-tidal deltaic and cyclone-prone region, it is difficult to extend and maintain electrical transmission and distribution (T&D)

SAGAR'S TRYST WITH POWER

Sagar has been an unqualified success story of renewable energy in the country and is often touted as a model to bring electricity to remote areas. The island, which is the largest one of those that comprise the Indian Sundarbans, has a population of 200,000; every year, over a million people flock to it to celebrate the festival of Makar Sankranti.

A combination of solar photo-voltaic cells and wind-diesel hybrid systems currently generates the power that the island needs. The island has 11 solar stations, each of which on an average generate 25-100 KW. The collective generation is close to 800 KW for a consumer base of 1,400 households and commercial establishments. Apart from this, the stations also provide solar home lighting to about 7,000 consumers.

The generation cost of the solar power is about Rs 10 per unit; consumers buy at Rs 7, with the difference of Rs 3 borne by the West Bengal government. The wind-diesel hybrid has about 600 consumers and generates 300 KW at a cost of Rs 6.

All this, however, may come to naught very soon, with the state government planning to connect the island to the primary grid. This, when the project was rejected by the Rajiv Gandhi Gramin Vidyutikaran Yojana as financially non-viabile. Worse still, the solar project and its decade long investment could become redundant.

The government's plans are threatening to make the investments in the solar project redundant. Shaktipada Gon Chaudhuri, former director of the West Bengal Green Energy Development Corporation Limited which had executed the solar project, claims that the money which will go into connecting Sagar to the grid can be better utilised to light up villages which have not been electrified yet. He says: "The capital investment of Rs 100-crore towards providing grid electricity undermines the earlier subsidies. The capital cost, transmission loss and the generation expenses, when rounded, would be far greater which the government will eventually need to pay as subsidies. Instead, far lesser subsidy was required to spread solar connectivity and generation. The government could have been wiser had it sought Central help to extend the solar movement in Sagar. This would have had a huge potential to electrify the entire island at much lesser cost."

Other activists feel that the case of Sagar is a prime example of a skewed and politically expedient policy at play. "It (Sagar) is of religious significance because of the Gangasagar Mela. Hence, the decision. The ecological footprint of this scheme would be massive with all these electric poles across the river. The cost is also prohibitive," says Anshuman Das of Sabuj Sangha, an NGO that has been working in the Sundarbans for over 10 years.

lines from the mainland to the islands due to the wide water channels. Further, the small and dispersed nature of the electric loads can result in long transmission lines and hence, in relatively higher T&D losses.

Another problem with grid-based electricity is its irregularity and unpredictability. Even though the grid accounts for almost 87 per cent of the total installed capacity, it connects only 17 per cent of households and supplies power at almost 35 per cent below the declared voltage level. Moreover, of the villages that do receive power, 85 per cent face daily power cuts for four-nine hours and around 14 per cent for more than nine hours, says a primary survey conducted by the WBGEDCL in March 2010 (see Table 1: *Grid electrification status*).

Sundarbans also has a high percentage of households belonging to the below poverty line (BPL) category: this, along with the dispersed nature of the settlements and non-availability of large commercial loads, results in low revenues for electricity distributors. A major challenge, therefore, is securing investment and ensuring long-term sustainability of electricity infrastructure in the region.

Research indicates that in the sanctioned schemes for grid electrification, only Rs 15 lakh has been allocated per village by the state government for laying out the distribution lines and connecting households. It is estimated that a medium-sized village of around 400 households in this region requires around Rs 35 lakh for this kind of connectivity. This leaves a gap of Rs 20 lakh per village. Thus, an estimated Rs 180 crore (considering there are 900 villages) would be required to achieve 100 per cent household electrification in the Sundarbans during 2010-2015.[6]

As mentioned in the earlier section, there are other bottlenecks: low returns or revenues for a distributor coupled with high costs of distribution. Long feeder lines and non-availability of an adequate number of distribution transformers are also factors that lead to poor quality of electricity.

There is, therefore, a dire need to have a planned and integrated approach, based on socio-economic and financial viability, towards the development of the islands. The approach of the West Bengal government is anything but this; its misguided initiative in Sagar is a clear example.

Renewable energy: pushed back

Since 1996, solar home lighting systems (SHS) have been a major source of electricity in the Sundarbans. The WBREDA has provided more than 100,000 SHS at a subsidised rate to households in unelectrified remote villages.[7] The highest concentrations of SHS are in Sagar, Patharpratima, Gosaba, Hingalganj and Namkhana blocks. In addition, another 20,000 SHS have been provided through NGOs and private sellers. Taken together, all the solar home systems generate more power than the cumulative generation from the solar power plants or mini-grids (see Table 3: *Annual electricity supply*).

The WBREDA runs 21 renewable energy (RE)-based power plants or mini-grids (see Table 4: *Renewable energy power plants*).[8] These plants supply electricity for four-six hours in the evening. On an average, a household is supplied 15 kWh of electricity per month, and the average tariff for this electricity varies from Rs 6/kWh for power from biomass gasifier power plants to Rs 8/kWh for that from solar power plants. The WBREDA is responsible for the maintenance and major repairs of the

Table 4: Renewable energy power plants

Technology	Location	Capacity (kW)
Solar PV Power Plant	***South 24 Parganas***	
	Kamalpur	26
	Mritunjoynagar	26
	Khasmahal	25
	Gayenbazar	25
	Mahendranagar	25
	Natendrapur	28.5
	Uttar Haradhanpur	32.5
	Mandirtala	28.5
	Koylapara	120
	Rudranagar	20
	Bagdanga	55
	Baliara	110
	Rakhalpaur	110
	Indrapur	100
	Pathankhali	60*
	North 24 Parganas	
	Daudpur	95
Wind Power	***South 24 Parganas***	
	Fraserganj	8 X 250
	Sagar (Wind-diesel)	Wind (4 X 55) + Diesel 150
Biomass Gasifier Power	***South 24 Parganas***	
	Gosaba	5 X 100
	Chotomollakhali	4 X 125
	Herambagopalpur	2 X 100
Total capacity (kW) of RE power plants		**4306.5**
Total capacity (MW)		**4.3065**

Note: *currently non-functional
Source: West Bengal Renewable Energy Development Agency http://www.wbreda.org/success.htm

systems and for capital investment. Maintenance is a key challenge, as there is very little local capacity for it.

Under RGGVY, there is a proposal to provide renewable energy-based power to 39 un-electrified villages in South 24 Parganas. These villages have remained deprived because connecting them to the grid is not considered a viable option. The proposal is under consideration at the REC[9] as a part of the decentralised distributed generation (DDG)[10] scheme under RGGVY.

Besides, there are 36 villages that are being covered under the remote areas village electrification programme by the Union ministry of new and renewable energy. This programme attempts to provide electricity to un-electrified villages till the time the grid reaches them.

Renewable solutions feasible?

The investment of Rs 1,246.43 crore required to reach electricity to the islands will not ensure availability of power in every household as the definition of electrification[11] itself does not stipulate that (see Table 5: *Investments for electrification*). This definition only makes it incumbent upon the state government to extend the grid, without ensuring that every household gets power: something that the state agency WBSEDCL can do relatively easily by 2015. Incidentally, the sum of Rs 1,246.43 crore is only the transmission and distribution cost. It excludes the additional generation cost of electricity (from conventional sources such as coal) that is needed to fully electrify the region.

But extending the grid can have severe environmental impacts. "The land is soft and setting up large and heavy transmission poles may lead to greater erosion, and change the tidal patterns when installed in the rivers and creeks. These transmission lines will also be vulnerable to cyclones that hit the region regularly," says Shaktipada Gon Chaudhuri, former director of WBGEDCL.

The Sundarbans has a potential of generating 2,250 MW of solar power; this would need about 45.75 sq km of land. There is also an additional 450 MW potential of wind energy in the region between off-shore

Table 5: Investments for electrification

Scheme	Investment requirement (Rs in crore)	Source of funds
Already sanctioned for electrification	198.31	RGGVY, REC
Additional scheme for intensification of electrification in the villages that are proposed to be connected through grid electricity	198.12	RGGVY, REC
Gap in funding	180	Not yet identified
DDG investment in approved scheme for 39 villages to be executed through WBGEDCL	110	RGGVY
Villages to be considered by WBSEDCL but with no announced scheme so far	200	Not yet identified
Capacity building and equipping the new corporation (say, Sundarbans Electricity Supply Corporation)	10	Not yet identified
Investment for upgrading the electricity infrastructure in the already electrified villages.	100	Not yet identified
Tailend wind power plants	250	Not yet identified
Total investment (only for transmission and distribution)	**1246.43**	

Source: West Bengal Green Energy Development Corporation Ltd 2011, *Improving Energy Infrastructure in Indian Sundarbans,* Government of West Bengal

POWERING THE SUNDARBANS WITH RENEWABLE ENERGY: WHAT WILL IT COST

Scenario 1: *Entire Sundarbans is powered by solar PV, supplied through mini-grids.* There is enough potential to meet entire local demand. The cost of installation, generation and distribution of solar PV mini-grids would be about Rs 5,721 crore (see Table1 : *Estimation of electricity requirement in the Sundarbans*).

Scenario 2: *Entire Sundarbans is powered by solar home-lighting systems (SHS).* SHS are available only on 37 Watt-peak (Wp) or 74 Wp modules. If provided to all households, as per 2010 prices, the total investment needed will be around Rs 1,254.8 crore; including free power to all BPL households at 74 Wp at a cost of Rs 578.5 crore (see Table: *Investment needed for decentralised solar home systems*). In 2010, the cost of a 37-Wp home lighting system was Rs 11,000 and that of a 74-Wp system was Rs 19,000. In the case of APL households, the user can share 10 per cent of the cost (as per guidelines of the MNRE).

Scenario 3: *All villages powered by a hybrid combination of renewable energy, by modelling and extrapolating the expenses incurred to electrify 39 villages under RGGVY.* In these 39 villages, a mix of renewable energy options has been proposed: this includes solar photovoltaic, biomass boiler turbine generators, biodiesel gasifiers and biomass gasifiers. The cost of this project is Rs 110 crore.[14] If we take this as a model, the approximate cost to electrify Sundarbans (with 756 unelectrified villages) through a mix of different RE technologies can be pegged at of Rs 2,500 crore.

So in different scenarios, using renewable to supply electricity ranges between Rs 726 crore (from Scenario 2) to Rs 5,721 crores (from Scenario 1). The policy makers here will have to make a choice and correct combination of different kinds of RE installations depending on the sites and population served which demands greater ground level data and research. There is a question of 'right' as well between the APL and BPL families and how much they should consume. This needs to be addressed as well.

Table: Estimation about electricity requirement in the Sundarbans

Category	No of households	Maximum supply per household (Watt)	Hours of consumption	Annual requirement (kWh)/household	Total requirement (MU)
Below Poverty Line	304,500	60	6	131.4	40.0113
Above Poverty Line	395,500	300	12	1314	519.687
Annual energy requirement					559.6983

Note: Assumptions: • 8.2 lakh total number of households in 2010 • 1.2 lakh total electrified household 2010 • A BPL family must have a single point electricity connection which translates to 60 W consumption (as per Govt of India stipulation). The supply is used for 6 hours peak a day. • An APL family should have 300 W consumption (as per REC norms) operating it for 12 hours peak a day. • The calculation for annual consumption per household = load x hours of consumption x number of days in a year, • The solar energy requirement to meet this demand = Annual Energy requirement/plant load factor for solar pv X number of hours in a year :: 559.6983/0.19 X 8,760 • Thereby, solar power required to meet the annual energy requirement is 336,276.3158 kW. To meet the additional total requirement of electrifying all the households in the Sundarbans exclusively from solar energy would need an investment of Rs 5721 crore (assuming capital cost/kW to be Rs 1.69 lakhs, and additional operating and maintenance cost of Rs1030/kW).

Table: Investment needed for solar home systems

Technology	Price in 2010 (Rs)	No. of BPL households	Funds for BPL households (Rs in crore)	No. of APL households	Funds for APL households (Rs in crore)	Total funds (Rs in crore)
37 Wp module	11,000	304,500	334.95	395,500	391.55	726.495
74 Wp module	19,000	304,500	578.55	395,500	676.31	1254.855

(in the waterways) and on-shore (on land) utilities. The WBGEDCL has plans to invite private participation for development of 40 MW. This electricity would be fed into the main grid[12].

Renewable energy therefore, say experts, might hold the key to the region's power concerns. "The costs will, in fact, be far cheaper compared to the grid generation and distribution combined," says Gon Chaudhuri. According to him, the best way forward would be to look for hybrid solutions. "The islands should have decentralised power from renewable sources, while the areas connected to the mainland should have grid connections," he says.

Power and adaptation

Absence of electricity hurts adaptive capacities in various ways, from affecting health services and educational facilities to impacting productivity at the household and commercial levels. For instance, none of the high schools and colleges in Sundarbans teach any science subjects because the lack of electricity do not allow laboratories to function! Educational levels in families that have no access to electricity are low as their working hours shrink and remain confined only till the daylight lasts.

Many villagers, during this survey conducted by CSE, claimed that absence of electricity leads to large number of cases of snake bites which could potentially be fatal. In Satjelia island, even tiger attacks were attributed to unavailability of street lights.

Unavailability of power also affects livelihood options like agriculture and fisheries. Absence of cold storages is a major constraint for farmers and fisherfolk alike; they are unable to access better markets or get the right kind of price for their produce or catch.

Public health: at its very basic

Sundarban's public health infrastructure is in as bad a state. The problems range from non-availability of safe drinking water to poor sanitation and collapsing infrastructure. While the lack of sanitation and drinking water escalate the risk of health hazards such as diarrhoea, poor health system delivery ensures that the people have no chance to seek medical attention for these conditions. This puts the people under considerable stress – poor health conditions mean less available man-days for families and less income. At the same time, higher expenditure on health leads to lesser savings.

The only source of drinking water in the islands is deep tubewells; there is a limited and rudimentary piped supply system in the areas connected to the mainland. The region suffers from an acute arsenic problem in its groundwater. Close to 58 per cent of the habitations have no access to safe drinking water. The incidence of diarrhoea in the district is alarmingly high, with 1.27 lakh cases being treated on an average every year.[13] About 88 per cent of households face food shortage of some kind, with about 21 per cent without the assurance of even one square meal a day (see Table 6: *Health conditions in women and children – 2006-07*).

Sundarbans, in fact, has the poorest healthcare facilities compared to any other part of the state of West Bengal. In many cases, primary health centres (PHCs) exist only on paper or are merely structures of cement and concrete, without the requisite staff. According to the Union ministry of human resource development (MHRD), the ideal doctor-patient ratio in the country is 1:1,000; the national average ratio is 1:1,722[14]. In Sundarbans, some blocks such as Basanti do not have a doctor for a population of one lakh. Canning has three doctors to serve a population of two lakh, while Gosaba and Patharpratima have a doctor-patient ratio of 1:44,682 and 1: 41,152, respectively (see Table 7: *Health infrastructure*).

One in every three persons in Sundarbans does not have any access to institutional healthcare. As of 2011, there is a deficit of 62 PHCs across 13 blocks of Sundarbans in the South 24 Parganas, which

Table 6: Health conditions in women and children – 2006-07

Block (Sundarban)	Full coverage drinking water (%)	<1 or one square meal a day, which may fails (%)	No Food Shortage (%)	Unsafe Deliveries (%)	Infant Mortality (Per 1000 live births)	Malnutrition in Children (%)	Anemia in Pregnant Mothers (%)
Canning I	19.3	13.73	17.63	24.84	13.91	55.6	NA
Canning II	20.9	20.77	7.6	24.15	29.03	60.7	NA
Jaynagar I	80.3	19.98	18.87	12.74	21.17	58.1	NA
Jaynagar II	29.7	18.97	10.8	24.51	15.11	60.9	NA
Kultali	52.4	15.21	11.08	24.17	23.61	56.9	NA
Basanti	38.6	36.93	6.54	29.5	15.61	51.2	NA
Gosaba	38	15.42	17.52	23.85	11.01	50.2	NA
Mathurapur I	46.2	16.96	10.41	26.47	31.75	55	NA
Mathurapur II	52.5	20.4	13.69	32.62	16.89	50.8	NA
Kakdwip	39.5	16.35	18.15	25.73	8.5	50.9	NA
Sagar	40.5	28.3	8.97	56.3	18.73	57.3	NA
Namkhana	42.9	22.55	9.91	3.65	46.4	46.4	NA
Patharpratima	24.6	27.37	11.06	16.35	52.6	52.6	NA
Average	**40.41**	**20.99**	**12.47**	**29.06**	**17.3**	**54.3**	**51.58**

Sources: Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal and Anon 2009, 'Health on the March', Department of Health, Government of West Bengal

Table 7: Health infrastructure

Name of Blocks	Beds per 10,000 Pop	Doctors per lakh population	Doctor: Patient Ratio
Canning I	3.19	6.54	1:15290
Canning II	1.28	1.53	1:65359
Jaynagar I	2.1	3.2	1:39250
Jaynagar II	2.49	4.3	1:23255
Kultali	2.82	5.32	1:18796
Basanti	1.18	0.72	1:138000
Gosaba	1.39	2.24	1:44682
Mathurapur I	2.9	3.82	1:26178
Mathurapur II	4.48	5.46	1:18315
Kakdwip	4.85	10.45	1:9569
Sagar	4.42	4.85	1:20618
Namkhana	2.68	6.23	1:16051
Patharpratima	2.12	2.43	1:41152

Note: Data from 13 Sundarban blocks in South 24 Parganas
Source: Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal

translates to a gap of 67 per cent of what is required according to norms of Union ministry of health and family welfare. As per the ministry, there should be one PHC for every 20,000 people in remote areas (such as Sundarbans). A deficit of 62 PHCs thus, indicates 124,000 (12.4 lakh) people have no access to primary, institutionalised healthcare across the island (see Table 8: *PHC infrastructure*).

Apart from a massive capacity constraint, the quality of care in PHCs is also abysmal. In all the surveyed areas, PHCs were found to open twice a week for four hours. Thus, access to institutionalised healthcare is limited to eight hours a week. Many of these PHCs have no electricity, safe water, and even access roads. People, naturally, seem to depend on quacks and religious leaders.

Majority of the doctors stationed to serve in this region hail from the cities, and avoid rural posts which are devoid of the basic infrastructure. The difficulties of transportation in the region act as a crucial deterrent. Almost all of them point to irregular medicine supplies, absence of basic medicine and hostility of the populace as other factors that work as negative incentives.
In the surveyed villages of Lahiripur in Gosaba block and Baliara *mouza* in Mousuni *gram*

Table 8: PHC infrastructure

Name of Blocks	PHC/3000 pop	Required No. of PHCS	Deficit in PHCS
Canning I	0.12	8	7
Canning II	0.15	7	6
Jaynagar I	0.27	7	5
Jaynagar II	0.43	7	4
Kultali	0.64	6	2
Basanti	0.32	9	6
Gosaba	0.27	7	5
Mathurapur I	0.23	9	7
Mathurapur II	0.49	6	3
Kakdwip	0.25	8	6
Sagar	0.48	6	3
Namkhana	0.75	5	1
Patharpratima	0.31	10	7
Total	**0.36**	**95**	**62**

Note: One PHC is supposed to serve 20,000 people in remote areas. A deficit of 62 PHCs mean that at least 20000x62=124,000 people do not have access to adequate healthcare facilities
Source: Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal

ADITYA GHOSH / CSE

Gates are shut at Brajaballavpur primary health centre. Medical services are not available when they are needed

panchayat, it was found that accessing institutional healthcare even in a medical emergency involved what amounted to be a cross-country endurance test. There is at least a three-hours journey to be undertaken in a cycle van, followed by a motorised three-wheeler, a boat, and a bus (or a motorised three-wheeler again) to reach the respective block headquarters. This, even for a caesarian delivery.

Respondents in the household survey claimed for most of their ailments, they have little choice but to visit the local quacks. In most villages, there are veterinary quacks as well, as livestock is an important part of livelihood for the people.

Public health and the changing climate

Public health is a subject of availability of right amount and quality of food, safe drinking water, a decent home protected against disasters, a reasonable income and good social and community relations[15]. Climate change is expected to affect all of these.[16] In the case of Sundarbans, absence of institutional support, poor health conditions and additional burdens such as snake bites, drowning etc are a major cause of concern, notes the Human Development Report for South 24 Parganas.

Sundarban's climate is especially favourable for the malaria-parasite bearing mosquito; recent research points to a possibility of increase in malaria incidence in the region due to changing climate. The National Physical Laboratory (NPL), New Delhi, in a study of the impacts of climate change on human health in India, has projected transmission windows for malaria. These are the months in a year when the malarial mosquitoes are active and spreading the disease. An increase of 3.8°C in temperature coupled with a 7 per cent increase in relative humidity by 2050 over present levels is projected to lead to transmission windows being open for all 12 months in nine states in India, that includes West Bengal. Simply put, malarial mosquitoes will now survive longer, breed more profusely even in the months when they are not active and invade areas where they weren't found earlier[17].

Poverty and other socio-economic factors would egregiously compromise health status of the poor. Improving adaptive capacity would necessitate bolstering the frail and inadequate healthcare infrastructure and delivery systems.

Education: leading nowhere

Educational facilities in Sundarbans do not lead to jobs. In all the surveyed villages, respondents clearly stated that education was a priority only if it provided employment. Since returns on investing in the education of children is very low because of lack of 'employable' instruction at the high school and college levels, many perceived it to be a negative incentive to send their children even to the primary schools. According to local experience, availability of only 'arts' or humanities subjects limited their choices at the high school and college/university level and many families could not afford educating their children till the age of 23 and face the unfortunate eventuality of unemployment afterwards.

There are some resourceful parents, though. Haripada Pahari of Brajaballavpur sent his sons to Howrah (a district near Kolkata) to get trained in stone polishing and cutting, which eventually led them to Gujarat. Both his sons earn Rs 500 a day now and the family feels that the skill that they acquired put them in good stead. "It is a boon that they can send us Rs 2,500 a month, else we would have had a very hard time," he said.

Another family in Lahiripur had sent their sons to Sonarpur, an urban hamlet between Kolkata and Sundarbans, to train as a teacher. "I want to keep my sons in Sonarpur for their education so that they can qualify in the School Service Examination (SSE) and come back to this village as teachers in some local school," said Asit Kumar Mondol, himself a school teacher in Lahiripur village.

High schools or colleges here do not teach science subjects. Lack of electricity means laboratories

Table 9: Upper primary and college infrastructure

Blocks	Upper Primary Drop Out Rate	Average population served (Upper Primary)	Area Served (Sq.Km) Upper Primary	Degree Colleges	Technical institute	Households with education beyond class X
Canning I	39.31	16,308	12.52	1		16.6
Canning II	57.11	19,596	21.49			7.91
Jaynagar I	33.85	9,525	5.69	1		16.52
Jaynagar II	42.83	11,007	9.8			13.71
Kultali	52.95	12,532	20.41			9.02
Basanti	45.61	12,663	18.37		1	9.88
Gosaba	35.51	5,570	7.42	1		20.7
Mathurapur I	46.86	6,332	5.66			17.64
Mathurapur II	40.64	6,396	7.33	1	1	15.63
Kakdwip	43.26	6,136	6.4	1	1	15.82
Sagar	34.85	5,988	9.1			15.98
Namkhana	27.4	7,301	16.84	1	1	15.7
Patharpratima	44.33	7,034	11.82	1	1	16.26

Source: Collated from data in: Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal

cannot be set up, while the lack of roads means skilled teachers are not available. The community, on the other hand, is not culturally attuned to study subjects like commerce; most of the respondents did not understand what could be its employment possibilities. The data available on higher education infrastructure for the Sundarban blocks supports this and even indicates to the kind of choices people want to have.

In most of the blocks, there is a high drop-out rate in the upper primary levels; in Namkhana, however, where there is an industrial technical institute (ITI), the drop-out rate at 27.4 per cent is considerably lower compared to other blocks (see Table 9: *Upper primary and college infrastructure*). But the facilities in five of the technical institutes set up recently in Sundarbans are abysmal; two of them do not have their own buildings either.

Careful examination of drop-out rates in different blocks reveals a miserable scenario. Drop-out rate at the upper primary level is very high in every block in Sundarbans and in many cases it is more than double the rate of drop-outs at the primary stage. Canning-II, an educationally backward block, has a drop-out rate of above 50 per cent in the upper primary level. The state Human Development Report describes the situation as "alarmingly high".

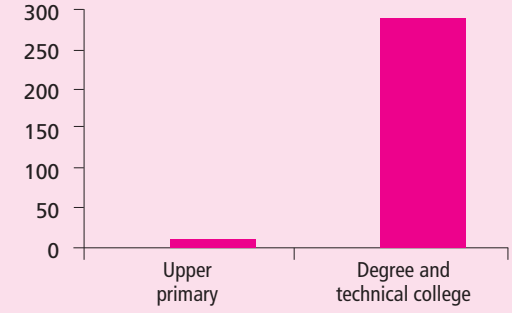
There are other reasons behind a high incidence of drop-outs as well. There is always pressure to leave school and join the work force as early as possible. For example, more than 90 per cent of students dropping out in Kakdwip block labour in their own homes or find work outside for a paltry income.

Inaccessibility to higher education is often cited as the cause behind non-enrolment and drop-out from the higher education system. The average area served by an upper primary institution in Sundarbans is 11.75 sq km (see Table 9: *Upper primary and college infrastructure*), while that for degree or technical institutes is a whopping 250 sq km (see Graph 1: *Higher education a distant dream*)! "...It is most

unfortunate that higher level education infrastructure is almost non-existent in many remote blocks of South 24 Parganas," notes the district's Human Development Report[18].

Apart from access, quality of education has been a major challenge, accepts Subhash Acharya, a former teacher and a senior functionary of the Sundarban Development Board. He blames poor instruction. Quality of teaching suffers with insufficient and improper physical infrastructure. The minimum required space of 7 square feet (0.65 sq m) per student is not available in many primary schools, which leads to overcrowding in classrooms[19].

Graph 1: Higher education a distant dream



Average area served per institute across 13 blocks in South 24 Parganas of Sundarbans

Source: Derived from: Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal

Another indicator, which points to the shortage of space and probably affects quality of teaching more adversely, is that in many schools, the number of rooms is less than the number of classes. As schools often have to absorb a large number of students and run separate sections in each class, the shortage of teachers acquires another dimension. Teaching tools such as computers are available only in 12 per cent of schools in Sundarban[20].

Education and adaptation

Primary education does not lead to much personal or household-level gains, though it does offer collective social benefits. But for people in the Sundarbans, social return from elementary education means nothing. Higher education that brings employability enables better levels of adaptive capacity, offers choices to people and reduces dependence on natural resources for survival and sustenance.

At present, on an average, only 14.72 per cent households across the 13 Sundarban blocks in South 24 Parganas have one or more member who have studied beyond secondary school[21]. This implies that for about 85 per cent households in the region, there is little option but to depend on natural resources or unskilled jobs. This seriously compromises their adaptive capacity.

Free movement within the country and access to job markets can be maximally exploited only when the people have the right skills and employability. The demand for more technical institutes instead of degree colleges teaching humanities, has gained salience because people clearly see more opportunities in the former.

Disaster management: still learning

Till cyclone Aila hit the Sundarbans in 2009, there was virtually no disaster management system in the delta. All the respondents in the household survey across Namkhana, Patharpratima and Gosaba said that the warning about Aila never reached them. All of them said that the fact Aila hit the islands around afternoon saved many lives as many islanders could escape; had the impact been in the night, casualties would have been far worse.

One would hope that the administration may have learnt its lessons with Aila. But that does not seem to be the case. Institutional response to disaster management and an early warning system is still absent in the islands.

The absence of Cyclone Warning Message Centres (CWMC) is a major reason behind the vulnerability in the delta. Among the seven extremely vulnerable blocks, only Basanti, Namkhana and Kakdwip have

early warning systems[22]. The Sundarbans fisherfolk are actually known to depend on Bangladesh radio for warning messages of inclement weather, crucial survival information for them. There have been cases when the warning messages from All India Radio (AIR) reached them after the disaster had struck. There is no community radio in the Indian Sundarbans and public announcements from the loudspeakers are the only way that the block office can inform fisherfolk. The Indian part of Sundarbans has not learnt the rudiments of disaster management from its Bangladesh counterpart (see Box: *Community radio in Bangladesh Sundarbans*).

After Aila, there has been a renewed vigour in taking up disaster risk reduction (DRR) projects in Sundarbans by international as well as local agencies. These piecemeal DRR projects, while contributing in small ways to the adaptive capacities of the people in these areas, do not address the inherent systemic failures that plague disaster planning. For example, post-Aila, the European Commission Humanitarian Aid and Civil Protection, with the help of local NGOs, has started constructing shelters and roads across Sundarbans. While this is one component of DRR and is of help, the issues of state's response and coordinated action have not been addressed. It starts from the vital element of communication to absence of electricity, roads, waterways and motorised boats, speed boats and lack of awareness about climate risks and disasters (see Box: *Disaster reduction: what ails the system?*).

There is already considerable confusion over the responsibility of different agencies pre- and post-disasters. Until the institutional mechanisms that can fix responsibility and address the problems of ownership and authority are in place, constructing a disaster shelter or buying life jackets would be of limited help.

Absence of institutional mechanisms in disaster management allows for manipulation and misappropriation, particularly in the post-disaster management phase. While efficient pre-disaster

BIJOYCHOWDHURY / DRIK INDIA / MAJORITYWORLD

Relief doled out post-Aila: Indian Sundarbans has still got lot of ground to cover in managing disasters of this scale1

COMMUNITY RADIO IN BANGLADESH SUNDARBANS

One of the most effective early warning systems is community radio (CR). In Bangladesh, it operates under their information ministry's Community Radio Installation, Broadcast and Operation Policy, 2008.

CR plays a significant role in disaster management through promoting preparedness, warning and rehabilitation programmes before, during and after any disaster in the coastal areas. In the pre-disaster phase, CR can promote social forestry. CR disseminates warnings, information on local weather situations, on first aid, emergency food, evacuation, gathering in cyclone shelter in particular space and on sanitation practice and facilities during emergency and before or afterwards[1].

All 14 agencies which have received CR licenses are developmental organisations working in cyclone, drought and flash flood prone areas. CR operates on FM Band, covering 17 km radius area of the radio station. Government in the next phase plans to facilitate setting up of one CR per district, and by 2021 one CR per *upazila* (block). In the first round of licensing of CRs, non-governmental organisations which received the licenses worked in cyclone and storm surge prone coastal areas and the flash flood prone Sylhet region. CRs could make a big difference in the way disaster risk reduction (DRR) and climate change adaptation (CCA) are handled in these areas. DRR and climate change adaptation and mitigation (CCA&M) require behavioural change, which would ultimately result in integration of DRR and CCA&M in the policy and programme design and implementation.

DISASTER REDUCTION: WHAT AILS THE SYSTEM?

Quantification: One inherent failure of the disaster warning system, according to the locals of Sundarbans, is the nature of warning, its language and content. For example, many islanders claimed that a mere announcement of a storm of a certain speed (which is a regular phenomenon in the region) does not mean anything to them. "How much damage a storm of a speed of 100 km per hour can cause needs to be explained in real terms to people. Otherwise people don't pay heed to the warnings even," Subhankar Goldar, a resident of Kakdwip who runs an NGO that works with the community to install sanitation facilities.

Lost in communication: The communication must be clear and concise and in a language that people understand. In Sundarbans, many reported that the government had resorted to short messaging services (SMS) through mobile networks in 2010, a year after Aila, for another storm warming that was named 'Laila'. But since the SMSs were in English, it was of virtually no help for the people. No wonder people find warnings issued in Bangladesh radio much more user-friendly!

Long lag periods: Aila could have been a great lesson towards the systemic failures that plague our disaster management system. The cyclone alert was generated on the Sunday of May 24 by Indian Meteorological Department in Kolkata and passed on to the state government. Being a holiday, no one received the message at the state secretariat or made a plan how to respond to the crisis, vital time was lost.

Jurisdiction: Between central relief agencies such as the army, coast guard and the state agencies, there is often a problem of ownership and responsibilities.

Absence of infrastructure: No roads, no electricity, absence of shelters, boats – all leads to a detrimental effect on the capacity of people to withstand risks from extreme weather events. In an ecosystem vulnerable to such events, it seems to be an insurmountable challenge to address all the areas effectively.

management systems that comprise early warning and evacuation facilities reduce the extent of damage in an extreme weather event, transparent post-disaster management ensures that compensation is distributed effectively.[23] After Aila, relief and compensation were distributed by various agencies of the government; in the absence of a strong authority or a formal management process, Aila intensified the marginalisation of people.

In West Bengal, disaster governance is aligned with local politics and power equations. Even NGOs that are supposed to operate in the vacuum created by state inaction[24], work as vehicles through which governmental power is consolidated[25].

Institutional banking: neglected

Absence of institutional banking and credit facilities is one of the major disabling factors for the delta residents[26]. The existing banking infrastructure covers only 4.5 lakh people against a population of close to 45 lakh, which means nine out of 10 people do not have access to institutional banking (see Table 10: *Sundarbans bank details*).

In case of inclement weather or during monsoons it can take days of waiting before one can get to a bank in the islands. On a regular day, it may take up to three hours. Many account holders have idle accounts; hence, visiting the bank is not a priority for them.

However, many government schemes presently in operation in the region necessitate the beneficiaries to have proper bank accounts. Poor banking infrastructure and lack of innovation in redefining or overcoming the problem of access and difficulties that the terrain involves has led to diminishing rate of participation in many of these government welfare schemes. An important scheme that has been negatively impacted because of absence of institutional banking facilities is the National Rural Employment Guarantee Scheme.

There is no system of mobile banking in the region. Elsewhere in the country, such as in some parts of Gujarat, mobile banking has been successful, particularly with women's self-help groups and cooperatives; representatives of banking institutions have been given hand-held devices to go to villages and collect as well as pay out money to subscribers/account holders.

But this region suffers from severe shortage of banking staff, owing to which payments get delayed. In a survey by the Kolkata-based Jayprakash Institute, that conducts social science and policy research, Mizanur Rahman, Pradhan of Boyermari I *gram panchyat*, was quoted saying that the banks often take 30 to 45 days to clear cheques issued by the Zilla Parishad (if the account is not from the same bank)[27].

Improving access to banking services can help ease the process of withdrawing remittances, on which a large number of families depend. As many Sundarban residents do not have active bank accounts, middlemen have devised an innovative way to earn money. "Someone else's account is used to transfer the money against a commission of around 10 per cent. Then the money is delivered at the doorstep of the recipient who does not have an account," says an employee of a public sector bank in the Sundarbans.

Insurance coverage is also extremely poor in the region. There is no crop insurance yet in Sundarbans, a critical protection that could help farmers tide over losses from climate-related damages. Locals believe that they urgently need not only crop insurance, but also insurance against natural disasters. Insurance is one instrument which greatly reduces vulnerability and enhances adaptive capacity, they feel. Insurance firms, however, are unsure. "It is very difficult to design products due to so many variables," says Anuj Kumbhat CEO and director of Weather Risk Limited, a climate risk management company.

Table 10: Sundarbans bank details

District	Block	Number of Bank Offices		Population Served Per Bank Office (Commercial and Gramin)	Net Small Savings Collection (in '000 Rs.)
		Commercial Bank	Gramin Bank		
1	2	3	4	5	6
South 24 Parganas	Basanti	5	3	28,000	12,000
	Canning-I	7	2	22,000	58,600
	Canning-II	5	3	19,000	12,400
	Gosaba	5	2	29,000	12,100
	Joynagar-I	8	4	15,000	34,800
	Joynagar-II	5	3	22,000	17,600
	Kakdwip	6	2	24,000	36,000
	Kultali	4	2	26,000	4,300
	Mathurapur-I	5	1	24,000	35,100
	Mathurapur-II	7	0	25,000	58,600
	Namkhana	6	2	17,000	9,200
	Patharpratima	6	6	20,000	13,300
	Sagar	5	3	19,000	23,600
	Total	**74**	**33**	**2,90,000**	**3,27,600**
North 24 Parganas	Haroa	4	1	30,000	41,638
	Hasnabad	6	3	17,000	72,244
	Hingalganj	1	3	36,000	15,032
	Minakhan	3	1	34,000	14,604
	Sandeshkhali-I	4	1	24,000	23,809
	Sandeshkhali-II	3	3	20,000	15,787
	Total	**21**	**12**	**1,61,000**	**1,83,114**
Total Sundarbans		**95**	**45**	**4,51,000**	**5,10,714**

Source: Data from Sundarbans Development Board, 2010

To help locals with financial instruments, some non-governmental organisations such as the Tagore Society for Rural Development have facilitated forming self-help groups to promote microfinance, often touted to be the panacea for poverty alleviation and local area development. Under microfinance programmes, in order to encourage entrepreneurship, small loans are offered to people who do not normally qualify for traditional banking credit. When operated efficiently, this can help large numbers of people in rural areas through cooperative action (see Box: *Microcredit under scrutiny*).

MICROCREDIT UNDER SCRUTINY

It is estimated that microcredit lifted 10 million Bangladeshis out of poverty between 1990 and 2008. Floods in 1998 and the food crisis of 2008 caused millions of families to fall below the $1.25 (Rs 70) threshold. However, even with these setbacks, nearly 10 million people rose above the poverty level thanks to the work of organisations like the Grameen Bank that helped families to raise their income above $1.25 a day, says the US-based Microcredit Summit Campaign in a report published in 2009 on the performance of micro-credit in Bangladesh[1]. The Grameen Bank and the brain behind it, Professor Muhammad Yunus were awarded the Nobel Prize in 2006 for their pioneering work.

However, blind adoption of the same model may not be warranted as in the recent times, micro-credit has come under scrutiny. Though there may not be serious harms to economic cycles for those who get these loans, specification tests (survey on the ground on the financial cycle of repayments and 'taking' loans for the villagers) do suggest that the instrumentation strategy (the way the microcredit products are designed) is failing[2].

In India as well, micro-credits have faced problems in the past. Banerjee e*t al.,* (2009) conducted a survey (trial) of microcredit in urban parts and after a year, they reported found that there were no significant trends of benefits; impacts of microcredit on basic human development areas such as health, education, and women's empowerment were negligible[3]. They also suggest that for the Indian Sundarbans, options and strategies must be clearly understood before plunging into micro-credit. Operations and conditions should be closely thought about, because benefits of micro-credit could remain really small. "Only 10 per cent of people have come out of poverty among all the participants in the Microcredit Summit Campaign report (for Bangladesh) leaving the other 90 per cent where they are. We cannot conclude that a whole lot has been achieved," said Dr Qazi Kholiquzzaman Ahmad, the chairman of Palli Karma-Sahayak Foundation (PKSF).

Serious charges emerged about microfinance borrowers taking on multiple loans and too much debt, coercive collection practices by microfinance staff, and even suicides among borrowers who were unable to meet their payments. India's multi-billion dollar industry was on the brink of a mass default until all the major banks in the country agreed to continue lending to microfinance firms[4]. It is consistently being challenged by highlighting the distinction between poverty alleviation and poverty reduction.

Poverty alleviation involves mechanisms which can help people get out of poverty – and stay out where secure savings should be the preferred financial instrument rather than credit. This again stresses importance of formal banking system for the people of Sundarbans.

Rural employment: not guaranteed

Despite having greater levels of poverty compared to other parts of the state, most local residents in Sundarbans do not sign up with the MGNREGS (Mahatma Gandhi National Rural Employment Guarantee Scheme). Apart from being seasonal and on an average offering not more than 20 to 30 days' work per person, the scheme has also met with cultural hindrances such as a preference for 'cash' over bank transfers. Data for past three years shows that since 2009 (when cyclone Aila hit the Sundarbans), the number of people employed under the scheme has gradually gone down (see Box: *Island dwellers reject government dole*).

Lack of faith

There is a serious lack of faith in the institution of the MGNREGS largely because of irregular payment of wages. The delay in some areas is reported to be more than seven-eight months; panchayat pradhans

ISLAND DWELLERS REJECT GOVERNMENT DOLE

The Mahatama Gandhi National Rural Employment Guarantee Scheme (MGNREGS) data for past three years reveals a steady decline in participation in the scheme. According to locals, the main reason of high participation in 2009-10 was because much of higher job generation in wake of Aila which necessitated a massive reconstruction, rebuilding and restoration of the destroyed infrastructure. While in 2009-10, 320,832 people were given work, in 2010-11 this figure dropped to 268,167, a decline of 18 per cent. In the six months of the current year, till September, only 94,995 people have been given work which is not even half the number that were given work in 2010-11.

Even though the people here are poor, and have MGNREGS job cards issued to them, they have stopped taking up the work. Even in the year when Aila struck, only half of the 632,712 people with job cards demanded jobs under MGNREGS. Next year (2010-11), while 8,561 more people were issued job cards and the total number of people with cards reached 641,273, less than half of them demanded jobs.

This clearly indicates the inherent flaws in operating this scheme. Locals point them out to be:

- There is a lack of jobs, which, various departments in charge of Sundarbans, collectively fails to ensure for people. Departments, it seem, are not proactive or ingenuous enough to initiate projects that will generate work.
- Procedural delays in payment are a major hindrance as payment often takes more than six months to come in.
- Absence of a culture of institutional banking where few have accounts coupled with pathetic banking facilities make MGNREGS a non-lucrative option for residents of Sundarbans.
- Political preference given in distributing jobs.

Table: Data on employment generated (2009-10, 2010-11, 2011-12)

Year 2009 – 2010										
Blocks	No. of Registered		Job Card Issued	Employment demanded		Employment offered		Employment Provided		
	House-hold	Persons		Persons	House-hold	Persons	House-hold	Persons	House-hold	Persons
CANNING-I	27,673	49,989	27,673	4,766	6,709	4,756	6,697	4,620	6,456	82,157
CANNING-II	24,213	37,823	24,213	4,800	5,410	4,800	5,408	4,797	5,404	89,972
GOSABA	42,706	98,821	42,706	16,403	29,963	15,142	27,842	16,014	29,594	3,43,575
JAYNAGAR-I	28,615	64,717	28,615	3,047	3,882	3,047	3,683	3,015	3,636	46,621
JAYNAGAR-II	29,142	62,988	29,142	3,050	3,613	3,050	3,613	3,035	3,589	45,582
KAK DWIP	30,638	61,808	30,638	6,095	8,347	6,094	8,345	6,072	8,310	1,04,723
KULTALI	37,181	84,252	37,181	7,821	10,830	7,860	10,876	7,769	10,743	1,34,924
MATHURAPUR I	23,838	53,806	23,838	4,595	5,520	4,595	5,519	4,600	5,533	55,769
MATHURAPUR-II	35,645	78,755	35,645	5,081	6,433	5,074	6,420	5,051	6,384	85,945
NAMKHANA	29,815	72,426	29,815	4,993	6,855	4,991	6,852	5,039	6,925	86,978
PATHAR PRATIMA	54,052	1,31,254	54,052	22,056	33,190	22,044	33,164	22,043	33,153	5,09,508
SAGAR	26,296	53,777	26,296	3,025	3,789	2,997	3,716	2,961	3,675	52,306
BASANTI	41,527	78,916	41,527	12,656	16,502	12,655	16,501	12,635	16,457	16,4770
HAROA	31,628	81,342	31,628	20,622	41,244	20,577	41,044	20,429	40,275	5,65,953
HASNABAD	40,132	84,017	40,132	22,451	31,868	22,394	31,716	22,566	31,978	4,69,118
HINGALGANJ	34,521	75,543	34,520	23,298	40,238	21,439	36,437	23,446	40,374	7,77,596
MINAKHA	39,785	71,191	39,785	17,643	24,072	17,554	23,902	17,608	24,002	4,12,638
SANDESHKHALI-I	26,159	52,113	26,159	13,964	21,360	13,937	21,288	13,992	21,349	4,05,004
SANDESHKHALI-II	29,147	52,279	29,147	20,214	28,155	20,010	27,809	20,714	29,080	4,59,331

Continued...

...continued

Blocks	No. of Registered		Job Card Issued	Employment demanded		Employment offered		Employment Provided		
	House-hold	Persons		Persons	House-hold	Persons	House-hold	Persons	House-hold	Persons
Year 2010 – 2011										
CANNING-I	27,822	50,407	27,822	3,218	4,295	3,251	4,328	3,213	4,279	71,064
CANNING-II	24,372	38,081	24,372	6,714	7,571	6,683	7,535	6,604	7,430	1,95,150
GOSABA	43,142	1,00,350	43,142	10,956	19,255	10,763	18,872	10,223	18,006	2,35,969
JAYNAGAR-I	28,865	65,186	28,865	1,889	2,306	1,888	2,280	1,884	2,260	33,335
JAYNAGAR-II	29,238	63,241	29,238	2,864	3,325	2,862	3,320	2,856	3,309	52,693
KAK DWIP	30,979	64,668	30,979	4,629	6,170	4,614	6,148	4,550	5,996	84,879
KULTALI	37,272	84,469	37,272	3,826	4,784	3,803	4,755	3,799	4,750	67,586
MATHURAPUR I	23,915	53,946	23,915	1,704	1,929	1,701	1,924	1,681	1,903	28,684
MATHURAPUR-II	35,822	79,140	35,822	3,074	3,720	3,096	3,742	3,080	3,690	50,458
NAMKHANA	29,881	72,584	29,881	6,881	9,307	6,836	9,225	6,762	9,039	1,12,159
PATHAR PRATIMA	54,723	1,33,148	54,723	19,936	28,449	20,096	28,664	20,055	28,519	4,21,281
SAGAR	28,783	59,207	28,783	4,334	5,526	4,334	5,326	4,268	5,151	89,233
BASANTI	42,512	80,638	42,512	7,250	10,228	7,236	10,184	7,188	10,108	1,62,657
HAROA	31,830	82,371	31,830	19,035	36,716	19,035	36,716	19,028	36,704	6,13,567
HASNABAD	40,458	85,276	40,458	23,112	34,050	23,109	34,036	23,089	33,987	6,65,096
HINGALGANJ	35,314	77,481	35,314	20,174	31,689	20,171	31,680	20,187	31,694	7,99,009
MINAKHA	40,214	72,238	40,214	13,227	17,397	13,220	17,385	13,208	17,365	3,98,317
SANDESHKHALI-I	26,699	53,517	26,699	13,312	17,542	13,301	17,531	13,343	17,581	4,07,112
SANDESHKHALI-II	29,432	53,156	29,432	17,100	24,525	17,096	24,516	17,237	24,680	5,15,505
YEAR 2011 – 2012										
CANNING-I	27,822	50,407	27,822	1,114	1,284	1,114	1,283	1,112	1,281	18,369
CANNING-II	24,372	38,081	24,372	2,410	2,669	2,410	2,669	2,402	2,659	47,354
GOSABA	43,142	1,00,350	43,142	5,938	10,766	5,936	10,760	5,677	10,300	1,13,441
JAYNAGAR-I	28,865	65,186	28,865	455	503	453	501	447	491	5,054
JAYNAGAR-II	29,238	63,241	29,238	1,403	1,570	1,402	1,569	1,406	1,572	19,915
KAK DWIP	30,979	64,668	30,979	1,574	1,915	1,524	1,859	1,524	1,859	19,334
KULTALI	37,272	84,469	37,272	325	444	325	444	324	443	5,365
MATHURAPUR I	23,915	53,946	23,915	428	477	427	476	427	476	6,470
MATHURAPUR-II	35,822	79,140	35,822	877	1,003	876	1,002	876	1,002	8,764
NAMKHANA	29,881	72,584	29,881	1,517	2,078	1,517	2,078	1,517	2,078	25,290
PATHAR PRATIMA	54,723	1,33,148	54,723	6,085	8,560	6,085	8,561	6,045	8,499	1,01,231
SAGAR	28,783	59,207	28,783	1,848	2,160	1,847	2,159	1,842	2,151	19,936
BASANTI	42,512	80,638	42,512	3,637	5,102	3,637	5,101	3,632	5,094	60,949
HAROA	31,830	82,371	31,830	7,910	12,366	7,909	12,364	7,879	12,289	1,21,229
HASNABAD	40,458	85,276	40,458	10,392	12,999	10,383	12,990	10,361	12,964	1,34,209
HINGALGANJ	35,314	77,481	35,314	8,730	11,879	8,730	11,878	8,729	11,879	1,41,513
MINAKHA	40,214	72,238	40,214	5,087	6,069	5,076	6,058	5,074	6,055	67,750
SANDESHKHALI-I	26,699	53,517	26,699	5,368	6,018	5,368	6,018	5,637	6,320	82,391
SANDESHKHALI-II	29,432	53,156	29,432	6,059	7,225	6,059	7,225	6,187	7,369	77,164

Source: Panchayat & Rural Development Department, Govt of West Bengal and NREGA Cell, Union ministry of rural development, Government of India

could not tell CSE surveyors confidently when the funds would be available. Due to this, no new MGNREGS work had been undertaken, while some existing projects remain incomplete. The CSE survey also found that very few respondents believed MGNREGS to be a viable employment option.

A survey conducted by the Kolkata-based Jayprakash Institute of Social Change revealed that on an average, only 10 per cent of the card holders in South 24 Parganas district demanded jobs under the MGNREGS scheme. The survey also revealed that women received only 24 per cent and 19 per cent person days wages in North 24 Parganas and South 24 Parganas respectively, of the total person days generated under the MGNREGS scheme between 2009 and 2011[28].

Many of the respondents claimed that their job cards were not in their possession and had been taken away by the secretary of the village development committee or some other *panchayat* functionaries on the pretext of updating the records. Most villagers were unaware that job cards are not to be handed over to any other person.

Procedural hassles

One of the reasons for delayed wages is the bottlenecks created by the government itself. Earlier, the approach was to incur expenses and submit an utilisation certificate to the Union ministry of rural development (MoRD) to be eligible for the next level of installment. But during 2010-11, the MoRD stipulated that work progress reports would be submitted online on its official website, following which an online utilisation certificate was to be issued. Next, the payments were to be made directly into the bank accounts of the beneficiaries and no cash transactions were to be allowed.

But in the Sundarbans, most people do not have access to banks; very few have bank accounts or feel the need to open one because of the lack of accessibility, as the respondents in the household survey recorded.

Thus, procedural changes by government actually binds down the residents further and leaves the field open for unscrupulous middlemen.

Choice of work

The lack of faith in the MGNREGS has also resulted from the nature of the work that is provided. The scheme has been relegated to *mati kata kaj* in local parlance, or 'work to dig the soil'. In this region, the work undertaken under MGNREGS has mostly been infrastructure development such as construction and repair of roads and embankments. However, this kind of work is not available all the time. In fact, many respondents claimed that it is only after heavy monsoons, storms, cyclones or embankment breaches (any event that qualifies as a disaster) that projects are taken up to restore status quo.

Almost all the respondents in the household survey claimed that availability of work was a major problem indicating to absence of proactive local area development planning and taking up projects that would lead to creation of jobs under the scheme and also benefit the area.

There is little ingenuity on the part of the managers to create sustainable fixed assets (such as water conservation structures) by using the scheme. No effort has been made to develop social forestry or horticulture, areas where women had the skill and could have been employed in large numbers.

Can MGNREGS be used as an adaptation tool?

The MGNREGS has often been touted by the government of India as a climate change adaptation tool. Experts such as M S Swaminathan has also pointed out to substantive adaptation co-benefits that MGNREGS can generate: at Rs 40,000 crore, it could easily qualify to be the most expansive and expensive adaptation programme in the world[29].

But the scheme can be used as an adaptation tool only if it is implemented properly and addresses the gaps in livelihoods and services that plague development in the country. The poor are the most vulnerable to climate change since their livelihoods are dependent on natural resources. With extreme climate events on the rise, there will be longer, severe droughts and water stress adversely affecting agriculture, water sources, forests, and coastal areas. Monsoonal variability has already started affecting many countries.

Works such as drought proofing, plantations, flood control and land development significantly contribute to provision of local environmental services. These environmental services could contribute to both mitigation as well as adaptation to climate change, by reducing vulnerability to climate variability and change as well as enhancing food and water security for the poorest of the rural population. But this has significant regional variations. This underlines the need for strategising locally.

The MGNREGS, by addressing some of the development gaps, could form responses to climate change and be an adaptation strategy for supplementing livelihood challenges in many areas. This could fit very well with its original mandate of poverty reduction.

CHAPTER 7

Migrating to survive

Monsoon is the only festival season in the Sundarbans. There is no Durga Puja – the quintessential Bengali festival – nor Christmas or Eid for the people here. With almost 75 per cent families here having their young ones working in states as distant as Kerala, Maharashtra, Gujarat and Andamans[1](see Box: *Migration survey*), monsoon is the only time families can meet their loved ones. Majority of these people work in the construction industry and monsoon is the time work stops. "There is no question of holidays in the post-monsoon and winters, work goes on in full swing and no one is allowed leave," said 19-year-old Md Shazahan, whom the Centre for Science & Environment (CSE) survey team met only because he was at home for his vacation.

SUNITA NARAIN / CSE

The employment opportunities are skeletal. Commerce is hostage to transportation and poor infrastructure. There is constant out-migration from this region, with 75 per cent families having relatives working outside Sundarbans.

In the CSE-surveyed areas of Mousuni (Namkhana block), Satjelia, Rangabelia and Lahiripur (Gosaba block), Brajaballavpur (Patharpratima block), there were hardly any households without migration. Explains Debal Roy, the chief environment officer of the Government of West Bengal, "The area has far too many people than its carrying capacity, so seasonal migration was a standard practice for the people here for many years. This practice has now become almost a rule after Aila, the super cyclone in 2009, and now because of climate related constraints[2]."

Population increase, failure of government in resource management and the expansion of livelihood opportunities, and climate change has affected almost all rural production systems. Thus local access to common resources on which the rural poor depend (eg. fisheries, forests, and river bank cultivation) has declined, driving the poor out further. After Aila in 2009, income from farming in the Sundarbans – assessed around Rs 520 crore annually – has reduced up to 20 per cent in 2010. Production in fisheries, which used to generate around Rs 100 crore every year, has also plunged[3].

Migration begets migration, feels Rabindranath Bhattacharya, an economist who has spent 20 years studying Sundarban's economy. "Once the youth starts working elsewhere and earn good money, they become a node in the chain of agents who supply cheap labour to different parts of the country for a commission. Living conditions and disposable cash in many cases improve for them which act as inspirations for others to follow suit," he said[4].

Shazahan, for example, has already helped others migrate to Thiruvananthapuram where he works as a mason. Previously, he had worked as a daily wage labourer for three years after leaving his home in Baliara village, Namkhana Block. "I went to Kerala with my uncle because there were not enough for all of us here, jobs or food. Our land shrunk consistently with erosion. One of my elder brothers thankfully found work in a local fair-price shop. But we have two sisters who need to be married off and one younger brother as well. I am definitely better off compared to those who stayed back. I can send my family money every month. I miss them and they miss me too but we cannot help. There is simply not enough for all of us to live here," Shazahan adds.

Who migrates?

If there are successful migration stories from the village to any part of the country, entire batches of young men follow suit and migrate to that particular state or city. "We cram about 12 to 14 people in one room so that we can save maximum and get back home in the monsoon when there is no work,"

MIGRATION SURVEY

Agency: Jayaprakash Insitute of Social Change, Kolkata, founded 1973.
Survey Period: September 2010 – January 2011
Scope: Implementation of MGNREGS and out-migration in the post-Aila Sundarbans
Total sample size: 500
Summary findings:

- 75 per cent respondents said that someone from their family migrated in search of work.
- 73 per cent respondents felt that lack of livelihood was key reason for migration.
- 73 per cent said that the migrating members regularly contacted their family members and 80 per cent of them sent remittances.
- 86 per cent said that migration increased post-Aila.
- 72 per cent respondents believe that wages received after migration is better than the local wage.
- There has been no initiative on the part of *panchayats* to address migration.
- 72 per cent respondents said that children of their villages go out to work as child labourers.
- 39 per cent respondents opined that employment opportunity in the region was 'very poor' while 34 per cent opined that it is 'poor'. At least 54 per cent of the respondents do not feel safe at home indicating the volatile situation prevailing in the villages. All these factors significantly contribute to migration by making their native place inhabitable.

said Shazahan. These men typically earn about Rs 250 a day which is much higher than what they can by staying back.

Apart from men who have been migrating out for a while now, women have also joined the trail, even preferring sex work to staying back in the villages. “Fringe jobs are all gone now. Employment as domestic workers is all that these women can depend on. Their vulnerability levels have reached or threatens to reach a tipping point,” said Subhankar Goldar, who runs Chetna Welfare Society, an NGO based out of Kakdwip which works in the area of trafficking.

With opportunities shrinking, there are many more traffickers, both men and women. “The nature of trafficking has changed as well. These agents target the poor parents, cajole them and even their daughters. They travel as far as Mumbai and Pune to work in the sex industry. Then when one of the sex workers come back to her village, narrates tales of good fortune and shows off her money, others are automatically lured into it. This woman then takes a fresh batch along with her and earns her commission,” he added.

Chetna rescues about 13-14 girls every year from Pathar Pratima and Kakdwip blocks only. “There has been a distinct change in the profile of girls being trafficked also, there is a higher tendency of trafficking school girls, mostly in the age group of 12 -18, even if they are not the drop outs from school,” Goldar said.

Yet another trend observed in the delta is when the family as a unit migrates, the children often get employed as child labour or domestic workers, especially the girls. In a study in 2010 conducted by the Kolkata-based Jayprakash Institute of Social Change, an NGO, 20 per cent households reported child migrant labourers[5]. However, cases of migration of the whole family are less frequent. It is restricted to the fringes of Kolkata such as Basirhat, Baruipur and Sonarpur. All the families with migrant members in other states reported that these people did not earn enough to migrate with the entire family, mainly because they were in unskilled jobs.

ADITYA GHOSH / CSE

Today’s resident, tomorrows migrant. Families living virtually on the embankment know that catastrophe is just a few feet away. Dependent on fishing as their livelihood, they have been pushed back to the fringe of the paddy fields. There is no more room to move back.

GENDER AND CLIMATE CHANGE

Women in the Sundarbans commonly experience many disadvantages with climate change. They have to work harder for a livelihood but have less control over income and assets. Being poorly represented in policy and decision making, their opportunities for human development are also gradually whittled away. Women also suffer when men migrate, left to run the households with meagre resources.

At least 50 per cent of the women here are anaemic due to pregnancy, lactation and inequitable food distribution within families. About 58 per cent girl children are underweight and 18 per cent malnourished. There has been a sharp rise in the number of women marginal labourers, from 6-10 per cent, between 1991 and 2001.

As competition for resources get tougher, it becomes more difficult for women to access them. For example, fry (prawn seedlings) collection, an economic activity that supplements household income, faces declining prices[11], increasing restrictions from the forest department, dwindling stock of fries, limited access to support services, resource opportunities and social exclusion. Women who engage in fry collection usually do so because of no other viable alternative. These women are considered to have low status and are often excluded from village functions.

Table: Crime rate against women

Sundarban blocks	2005	2006	2007
Canning I and II	98	170	215
Jaynagar I and II	60	82	118
Kultali	79	30	105
Basanti	22	52	66
Gosaba	17	14	21
Mathurapur I	28	30	44
Mathurapur II	20	43	34
Kakdwip	51	90	78
Sagar	50	53	86
Namkhana	20	49	46
Patharpratima	35	46	88
Total	**480**	**659**	**901**

Source: District crime data, Office of Superintendent of Police, South 24 Parganas, Alipore, Kolkata

The participation of women from this area in the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) is also far lower compared to men because of the nature of heavy jobs (hard manual labour) available under the scheme. This was confirmed by Mouslema Bibi of Mousini, a respondent in CSE's survey. Thus, women cannot access these income-earning opportunities. Women manage households and care for family members, which often limits their mobility and increases their vulnerability to sudden weather related natural disasters. Drought and erratic rainfall have forced women to work harder to secure food, water and energy for their homes. Girls are more likely than boys to drop out of school to help their mothers with these tasks and because of early marriages.

Some of these stresses have been documented in a 2009 study published by the United Nations Population Fund and the International Institute of Environment and Development on population dynamics and climate change. When it came to women, the impact of climate change was found to be exacerbated due to greater poverty, lesser power over their own lives, less recognition of their economic productivity and their disproportionate burden in reproduction and childraising.[12] These are true for Sundarbans as well.

A rather overlooked manifestation of the growing tension and uncertainty over lives and livelihoods is gender violence. Sundarban has a very high rate of crime against women despite high literacy rates among women compared to other areas of West Bengal. The higher incidence of crimes against women (CAW) in the Sundarbans has been consistent over the years where a temporal dimension is associated with block level CAW occurrence . Between 2005-2007, CAW in 13 blocks in 24 South Parganas has increased by 88 per cent (see Table: *Crime rate against women*).

ADITYA GHOSH / CSE

Going out in search of work, reaching the mainland from Gosaba. Majority of the families today depend on remittances

Remittances rule

It is very hard to get any authentic data on the total volume of remittances, but estimates put it into few thousand crores. "If you look at average remittances, they range from Rs 500 to Rs 2500. Even taking Rs 1000 as a ballpark, with the number of migrants close to a couple of lakhs, one can imagine the scale of contribution that it makes to the economy," says Bhattacharya.

In the CSE household survey, all the migrants or their families claimed that they were much better off after migrating. They also believed that the condition of the family members improved due to remittances. Parents almost always expressed the thought that their children deserved better lives than they had in the Sundarbans, struggling against nature and uncertainties. Majority of the islanders, almost entirely the wealthier households, emphasised that they did not want their daughters to be married to islanders. Saraswati Giri, a 42-year old woman in Brajaballavpur said: "Among families with daughters, it is almost like winning a lottery if the girl can be married to a boy from the mainland. We say here, at least one of us could escape and does not have to suffer like this anymore."

In the Sundarbans, the general feeling about migration and subsequent remittances is positive. Plenty of people are now successfully engaged in various trades all over India and their remittances have served as a key resource for their respective families. In Brajaballavpur, it was found that the youth have even gone to Saudi Arabia, Singapore and Indonesia to work as labourers in various projects[6].

Enabling options or escalating risks?

There are certain risks also associated with 'uninformed' or forced migration. Often families staying back in the villages do not have complete information on addresses of workplace and type of work. Because of

the nature of job which is largely unskilled, there remains apprehensions as all the migrations may not be 'safe' in nature. Stories of deprivation and hazardous working conditions are not entirely uncommon.

But increasingly, migration is being viewed as a valid coping mechanism for the heightened stresses and shocks that may result from climate change[7], if the uncertainties currently associated with migration are neutralised. Migration can in fact offset many additional burdens that plague the ecosystem today and are expected to exacerbate in the future with climate change.

Migration can help reduce pressure on the ecosystem and their better distribution. "People are migrating today anyway on their own volition, but mostly because all other choices. There is little choice or information available to them. Policies need to be bolstered to offer people a better range of choices. They may then decide whether to migrate or not. Even if they migrate to satiate their aspirations, and not be forced to move out, they still need to have a cushion if this move fails to yield positive results. Policies should be focused to improve household level resources," says Anurag Danda who heads the Sudarbans programme for the World Wide Fund for Nature-India[8].

Choice of migration destination and nature of work depends on resources available at the household level, social capital and skill that the migrant has. Higher the skill, greater the benefit or the bargaining power of the migrant in question. Also, right kind of social capital helps people find right kinds of opportunities and guidance. A balance between the investments and the expected outcomes can help a person decide whether to migrate or not. Threats are often greater than the benefits when the migration is 'agent'-based. It could be formal such as an agent who works for a commission to supply labour or informal such as a 'groom' who marries a woman from the area, which is followed by relocation.

Here role of institutional support and the right kind of policies which will not merely remain neutral to migration are necessary, points out Tushar Kanjilal, Secretary, Tagore Society for Rural Development a pioneering NGO in the Sundarbans. He cites the example of welfare services of the Union ministry of overseas Indian affairs as an example. "Services provided by the ministry of overseas Indian affairs is a policy tool that enables a prospective unskilled migrant to carefully weigh his options. Small self help groups of women who can manage credit effectively will also enable the wives who stay back to reduce their vulnerability that might arise from the absence of the man," he said (see Box: *Empowering services*).

Diminishing options

Impacts of climate change on migration are mediated by various drivers and any correlation becomes highly complex. Migration responses

EMPOWERING SERVICES

The Government of India, in 2006, started a special service — under the aegis of the Union ministry of overseas Indian affairs — for emigration recognising the fact that international migration is an important dimension impacting economic relations. The Emigration Policy Division of the ministry thus established is mandated to facilitate and empower emigrants from India, and deals with all policy matters relating to emigration of workers from India.

There are various welfare services that are offered by the division, an important one being insurance cover of a minimum sum of Rs 10 lakhs payable to the nominee or legal heir in the event of death or permanent disability of any Indian emigrant who goes abroad for employment after obtaining emigration clearance from the concerned Protector of Emigrants.

The division also counsels prospective emigrants on the jobs available, verifies the status of employers and the destination country.

Domestic migration on the contrary is informal but in many cases vulnerability is high because of lack of language skills in the region of migration and other kinds of exploitation. Some form of social security, worker registration or insurance would help the people.

TYPES OF ADAPTATION

There are two types of adaptation according to the definition by IPCC.

Autonomous adaptation is the spontaneous reaction that leads to certain action in people to changes in his/her surrounding s and to mitigate losses that might be a direct or indirect outcome of the changes. Here, governments, policies, administrations play little role to either minimise or mitigate the ill effects that the changes in the natural systems bring about. For example, a farmer would react autonomously to changing precipitation patterns and subsequently change crops or use different harvest and planting/sowing dates. Out migration is a form of autonomous adaptation here.

Planned adaptation however, is a measure of conscious policy options or response strategies, often multi-sectoral in nature, aimed at altering the adaptive capacity of people and help them design suitable coping strategies with the help of information, training, and institutional support. For example, deliberate crops selection and distribution strategies across different agri-climatic zones, substitution of new crops for old ones and resource substitution induced by scarcity.

to climate change are likely to include moves within countries, as well as across international borders, and may be non-linear, in the sense that migration becomes a learned behaviour within a population, developing specific traits, as a result[9].

Amidst constant threats to livelihood from various non-climatic and climatic factors, the administration in Sundarbans has not been able to help the populace in any way to restore their conditions or provide alternatives. The government bodies that manage the Sundarbans have never recognised the impermanence of the ecosystem, nor the fact that people depend on it. Constant land loss, threats of cyclone, erratic rainfall patterns because of climate change and absence of government intervention have led to heightened vulnerability of the people.

Thus, people have started adapting autonomously (see Box: *Types of adaptation*) and migration has emerged as the most popular choice because of lack of options. There too, the local governments have remained neutral and have not extended any institutional support. Peoples' disconnect with the administration is very high because of extremely limited interaction between governance and society. The state organisations and agencies are viewed with distrust making them all the more ill-positioned to effectively respond to the continuously changing situations. All this diminishes options for people who then have to migrate.

Demographically, societies in Sundarbans are highly dynamic and impermanence within its structure is also very high. With climatic risks as well as population increasing in the Sundarbans, the rural-urban flows will be further accelerated. The existing flows are already leading to increasing amount of pressure on the peri-urban areas such as Sonarpur or Baruipur closer to Kolkata, which were never prepared to (and still aren't) accommodate these many additional people. Cities can provide much better levels of safety and security to vulnerable people both in terms of livelihoods and in terms of physical safety. Migration can bring opportunities for coping with environmental change[10]. But there needs to be sufficient regional planning that includes physical, social and economic planning to accomodate people from Sundarbans.

CHAPTER 8

An agenda for action

For the residents of Sundarbans, climate change is now a part of their daily battle for survival. While global negotiations towards mitigation of climate change have remained inconclusive, sea levels have risen inexorably, cyclones have buffeted it, and rainfall patterns have kept changing for the worse, making lives more difficult and development of the area more expensive.

Much too often, however, the adaptation debate overlooks significant failures in development planning and strategies on the part of local and national governments. These failures are not only the root cause of the hardships that people are facing already, they do nothing to enhance the capacity of the locals to adapt to the additional burdens that climate change is posing now. In Sundarbans, people are left to their own devices. Till now, their only response has been migrating out of the region, which clearly underlines the absence of options and the poor adaptive capacity of the people.

SAYANTAN BERA / CSE

What does the future hold? With climate change a grim reality, Sundarbans and its people require decisive intervention to survive

A SNAPSHOT OF ADAPTATION CHALLENGES

Land management: How to ensure distribution and productivity of land where land resources is not only diminishing in size because of erosion but its quality is also deteriorating fast because of high salinity

Embankments: How can the embankments be effective in saving the land and people of Sundarbans

Cultivation: How should agricultural patterns be changed in wake of increasing salinity and land holding

Fishing: How can fishing be made more productive and less risky

Infrastructure: How to alleviate daily hardships of commuting, electricity, health facilities

Disaster management: How can information be disseminated faster, predictions be made more accurate and sufficient infrastructure is developed for communication, evacuation, rehabilitation and restoration

How climate change will affect the region: There is an urgent need to launch scientific inquiries into how various kinds of climatic changes will affect the lives and livelihoods. We know little and need to know more to effectively design policies for tomorrow

Information and communication: Knowledge generated needs to be circulated among people widely so that they can make informed choices. This is a cross-sectoral challenge that is letting people down today – people mostly clueless about physical changes taking place in their environment. They desperately need to learn about how climate change will affect SST, rainfall, sea level rise and how these in turn will affect agriculture, fishing, disasters and health.

Choice: How can it be ensured that people have a better level of choice than they currently are bestowed with? This issue has to be addressed creatively. These include making technical education available in the region to setting up mobile banking facilities.

Adaptation challenges in Sundarbans

The fragile ecosystem of the Sundarbans, and its unique biodiversity, must be protected and the remaining mangrove forests need to be nurtured. At the same time, the eventual impacts on the people will be determined by the manner in which global warming induced changes interact with the absence of development, social changes and governance deficits. Adaptation, for all practical policy and strategy purposes here, will be about tackling this culmination (see Box: *A snapshot of adaptation challenges*).

The job is two-fold, primarily:

Saving the ecosystem

Adaptation on the ground in Sundarbans thus becomes a complex challenge, one that demands conserving the ecosystem to ensure sustainability of people along the east coast of India who depend largely on natural resources. Sundarbans is a nursery for various kinds of animals, fish and plants found along the entire east coast of the country. It is important that this ecosystem and biodiversity is conserved and its resources managed efficiently, that will not push the people further into 'ecological poverty'.[1]

Saving people

While better resource management and conservation will help ameliorate survival struggles of the

people, it will certainly not solve it. An increaseing population (at a rate of 18 per cent and a density of around a 1,000) is in direct conflict with the task of conserving the ecosystem and ensuring a just benefit sharing mechanism. This brings us back to the threshold of an adaptation-development debate – where the strategies, synergies and priorities at the ground assume paramount importance – and something which is both unclear as well as unattended by the polity.

Climate change and Sundarbans: reeling under a cumulative impact

But before we attempt to explain how clarity could be sought in this rather difficult and abstruse domain, we must outline climate change impacts and development deficits separately.

Observed changes

- Sea surface temperature (SST) in Sunderbans is increasing at 0.5 degree centigrade (oC) per decade; globally observed SST warming rate is 0.06 oC per decade.
- Sea level is rising in Sunderbans at a higher rate than the global average. In the last 25 years sea level has risen in Sundarbans at a rate of 8 mm/year – more than double the global average. This is due to a combination of factors including land subsidence and faulty embankment design.
- Though the exact nature of change in rainfall pattern is still not clear, it has been observed that rainfall has become erratic and its intensity has increased.
- Intensity of cyclones have also increased. It is estimated that the severe cyclonic storms over Bay of Bengal have increased by 26 per cent over the last 120 years.

The development deficit

- One of the most underdeveloped regions of the country.
- About 44 per cent of the people live below the poverty line.
- The per capita electricity consumption is one-fourteenth of the national average. Majority of households don't have access to electricity.
- About 60 per cent of the households don't have access to clean drinking water.
- 87 per cent people live with some sort of food shortage – food insecurity is high.
- There is a huge deficit in health care infrastructure. The Sundarbans will need three times more infrastructure (doctors, PHCs, specialised hospitals etc.) to meet the guidelines specified by the government. About one-third of the population doesn't have access to primary health care.
- The education system does not provide the options to people to expand livelihood opportunities. There is just one degree/technical college in a 250 sq km area. The drop-out rates are very high.
- The coverage of institutional banking and insurance facilities in Sundarbans is very low. Only about 10 per cent of the population avail institutional banking and there is no agricultural insurance.
- There are no major industries. Marketing infrastructure for agricultural, fishery and non-timber forest produce sectors is negligible.
- Sunderbans still lacks disaster warning and disaster shelters. In fact, it lacks a comprehensive disaster management system.

Social and economic pressures

- Sunderbans is probably the most densely populated part of India. The population density in 2001 was about 900 persons/sq km. In 2011, it is expected to be more than 1,000 persons/sq km. This will be four times the national average.
- The population in the Sundarbans has been increasing at about 18 per cent per decade.
- About 78 per cent of the economy and 65 per cent of workers are dependent on agriculture – directly or indirectly.
- The cultivable land per agricultural worker is less than 0.5 ha and about 85 per cent of the farmers are small and marginal.
- Fishery and collection of non-timber forest produce supplement the agricultural income, but both are under tremendous pressure due to over exploitation.

Impacts: cumulative effects of climatic and non-climatic factors

- Sundarbans is losing land due to submergence and erosion at a fast pace. In the last 80 years it has lost about 250 sq km. Four islands have been completely wiped out. The pace of land loss is increasing.
- Sundarbans is also loosing agricultural land to settlement to accommodate rising population as well as due to land mismanagement and change in land use.
- Soil salinity has increased because of sea water ingress and retention (largely due to the cyclonic activities), thereby reducing the productivity of the agricultural land.
- Land loss, soil salinity and land fragmentation have all resulted in reduced agricultural output.
- Fishing resources are dwindling because of a combination of over-exploitation and climatic changes. Fish density in shallow waters has reduced and the catches of commercially important fish have declined.
- There is a clear decrease in the yield of NTFP like honey and wax.
- Today, the resource base of Sunderbans is not able to sustain the lives and livelihood of people. The population of Sunderbans is therefore migrating to survive.

Culmination of climate change and development deficits: the adaptation challenges

- **Land management:** How to ensure distribution and productivity of land where land resources are not only diminishing in size because of erosion, but the quality is also deteriorating fast because of high salinity.
- **Embankments:** How can embankments be effective in saving the land and people of Sundarbans.
- **Controlling population:** An immediate task is to redistribute the people who live here. Both for effective land management and constructing embankments, people need to shift. Relocation and rehabilitation policies will assume paramount importance in determining whether the ecosystem can be saved and whether some people can continue living here sustainably.
- **Cultivation:** How should agricultural patterns be changed in the wake of increasing salinity and decreasing land holdings?
- **Fishing:** How can fishing be made more productive and less risky?
- **Infrastructure:** How can the daily hardships of commuting, lack of electricity or health facilities be alleviated?
- **Disaster management:** How can information be disseminated faster, predictions be made more accurately and sufficient infrastructure developed for communication, evacuation, rehabilitation and restoration?
- **Impacts of climate change:** There is an urgent need to launch scientific inquiries into how various kinds of climatic changes will affect lives and livelihoods. We need to know more to effectively design policies for tomorrow.
- **Information and communication:** Knowledge thus generated needs to be circulated among people widely so that they can make informed choices. This is a cross-sectoral challenge that is letting people, who are mostly clueless about physical changes taking place in their environment, down today. They desperately need to learn about how climate change will affect SST, rainfall, sea level rise and how these in turn will affect agriculture, fishing, disasters and health.
- **Choices:** Finally, how can it be ensured that people have much better choices? Addressing the above mentioned aspects will help, but a lot of creative thinking is still required in terms of policy and strategies. This includes measures from making technical education available in the region to setting up mobile banking facilities.

Focusing attention on adaptation

Strategy and policy responses

What is needed in Sunderbans in short-term was very clearly spelt out by the people in the household survey conducted by CSE. Their concerns and priorities reflect the dire need to increase the adaptive capacity – assets, health, education, and governance (see Box: *People's priorities … and concerns*). But for

PEOPLE'S PRIORITIES: WHAT THEY WANT

Better, all season roads – for faster and easier access to institutions, facilities, utilities; to help escape faster

Health – to improve incomes by saving in health expenditure and keeping healthy that improves productivity for earning members

Education – exclusively to find alternative livelihoods

Power – to improve family productivity, for entertainment, comfort and often for minimizing threats such as snake bites and tiger attacks

Better disaster management (perhaps an Aila-effect) – Shelters, early warning system and aid

Alternative livelihoods – To reduce dependence on natural resources for livelihood

PEOPLE'S CONCERNS

Loss of livelihood: Erosion, land loss, salinity, reducing yield, competition absence of option

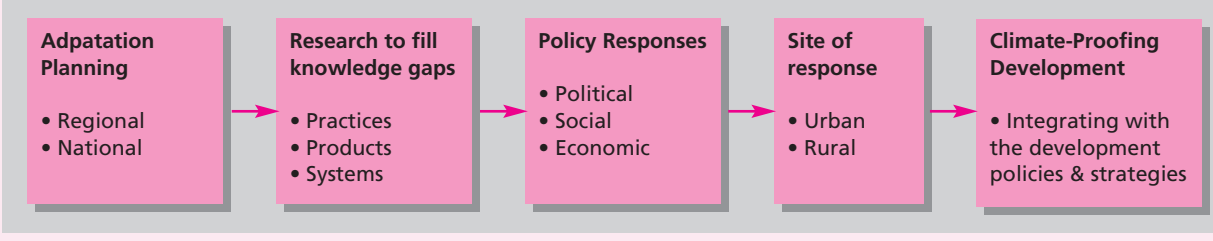
Physical threat/loss of home, land etc

Changing climatic patterns affecting natural systems

Social insecurity

(As sampled from household survey carried out between July 2011 and August 2011)

Diagram: Process of integrating adaptive practices and processes in development planning locally



long-term sustainability, Sundarbans needs more than roads, hospitals and technical institutes. It needs a new development plan to mainstream climate change. The new plan for the Sundarbans must revolve around following major components: land management, sustainability of the natural resource base, livelihood management, disaster management and most importantly, coherent governance. The priority areas for action include:

- **Zoning Sundarbans according to vulnerability:** Experts feel that strategically moving people to safety must be a priority, particularly those who live in the critically vulnerable areas of islands which are losing land at a faster rate. To institutionalise the process zonal land maps need to be created, classified against a vulnerability scale across Sunderbans. Land for rehabilitation must also

be identified within or in the adjacent districts, and economic activities should also be planned.

- **Regional planning, and rehabilitation and relocation:** A new policy is desperately needed to address how vulnerable people and those who would be displaced are resettled. This will necessitate a comprehensive regional planning. Proximity of Sundarbans to Kolkata and peri-urban settlements between Kolkata and Sundarbans seem to hold the key, along with providing people with other options.
- **Embankments:** Sunderbans needs a new embankment policy and design that reduces land loss as well as is able to withstand sea water ingress. There are many proposals on the table, but the costs are prohibitive and have to be paid through an international arrangement.
- **Bolstering existing livelihood patterns:** This will need both research and infrastructural support. Intensifying agriculture, crop diversification and introduction of saline resistant crops are must. So is the creation of a robust storage and marketing infrastructure. More options need to be made available to people in the longer projections.
- **Creating opportunities that don't depend on nature:** Conventional natural resource-based livelihoods will not be able to sustain the population in Sundarbans. While modifications and diversification in crop and cropping patterns based on research and administrative support will help, it will certainly not solve the problem. Thus *education* that offers employability must be the focus here. According to many respondents in the household survey, need for industrial technology institutes (ITI) and polytechnic institutes were keenly felt which would enable people to acquire skills. These skills, people feel, would offer them the much needed choice and bargaining power as well as better opportunities when they migrate within or outside the state.
- **Awareness and information:** As climatic conditions become more severe, people will need information to adapt. At a social level, people are at a peculiar crossroads where they have lost the traditional knowledge but have not been able to replace it with new or mainstream knowledge. Information generation, management and dissemination strategy must be priorities at the local level.

Adaptation governance: Institutions hold the key

The case of Sundarbans highlights the importance of concerted adaptation governance since in Sundarbans, authority orders and jurisdictions are already overlapping today and often work at cross-purposes (or perceived to be so). Whether climate induced changes in the natural systems and its impacts on the lives of people in the Sundarbans are integrated individually in the every sector (such as agriculture, fisheries, disaster management, education, health) that form the socio-economic structure of the region or adaptation becomes a concerted and holistic element in the development plans of the region, or mainstreamed – matters little. Successful adaptation governance seems to depend on how aware the population is about the changes in the natural systems and interpret their implications, something that is a subject of communication systems. Even efficacy of a participatory policy process depends on awareness that enables people to ask for better adaptation governance. Presently, climate agenda has no representation in the local or regional management practices.

Interestingly, there is little need for additional institutional arrangements in Sundarbans for effective climate change adaptation. Despite the fact that Sundarban Development Board is no longer the nodal planning agency that it was conceived as and has been relegated to a mere implementation agency, there seems to be enough room to accommodate adaptation planning and strategising within its mandate. One only needs to sort out conflicting authorities that various regions of Sundarbans are subjected under. Sundarbans' misery seems to hinge on this very aspect – while a large section of the land is administered by the Central government directly such as the 2,500 sq km of Project Tiger, protected forests and coastal zone while the other – the human habitation part – is managed by the state government.

Climate change is already a prerogative for the federal government in terms of its mitigation geopolitics. Adaptation, however, needs much greater local participation both in planning and implementation. So a clear policy encompassing the changes that are already evident, autonomous adaptation – the way

people are responding to these changes – and possible technical, social and economic interventions – or planned adaptation – must be the prerogative of the state government. The Centre, on its part, needs to extend expertise, tools and support to these efforts without duplicating them. A clearly demarcated institutional arrangement in matters of climate change adaptation – planning and execution respectively – needs to be ascertained that will facilitate effective climate change governance in Sundarbans.

ADAPTATION LESSONS FROM SUNDARBANS

Develop and adapt

The adaptation challenge on the ground in an under-developed region such as Sundarbans offers a clear perspective on its linkages with development policies, which is an emerging research issue globally.[2] Majority of the studies, however, have either been from primarily a climate change perspective or from the side of development; they have seldom been from a perspective of mutual influences and an interactive relationship. Accordingly, in absence of a clear understanding in the dubious domain of adaptation and development deficits, international climate change policies and research efforts have focused more on global questions of mitigation and adaptive management, with comparatively little concern for local development potentials and problems[3,4]. The case study of Sundarbans makes a very strong statement how crucial it is to find solutions that are local (highlighting need of region specific analysis), timely and serve both adaptation and development goals – independently or through their mutual co-benefits.

ADITYA GHOSH / CSE

People as well as the ecosystem are equally important in this region. It is crucial to find solutions that are local, timely and serve both adaptation and development goals

Ecosystem-specific analysis and action needed

"Mainstreaming' adaptation or 'climate-proofing' development appears possible only at a local level, and not at national levels as proposed by many, this analysis points out. Despite the rhetoric on mainstreaming, there is little clarity on moving on to the next level where action is more important than mere exposition. While in theory it is important to strategise development in a manner that can integrate and respond to additional climate burdens, it is time we study how interventions and strategies can be targeted to achieve specific aims. The 'development toolbox'[5] that are considered common for adaptation differ according to the ecosystem. This is why adaptation research and studies must be ecosystem specific in a country such as India and compiled to yield a national level vulnerability index. This report highlights the need of such an index for rethinking and designing policies.

The micro-elements within the adaptation governance in the broader policy realm can be seen in the diagram. This schematic layout of adaptation could be one possible way of structuring responses and integrate them with the existing systems of governance.

A social science approach

This study supports the view that fragmented research on synergies of natural and social science in adaptation will be by far, inadequate.[6] While climatology, hydrology or ecology provide impact projections, (though they are far from foolproof because of paucity of data and historical records), they have little significance in designing interventions. Even with the most accurate projections, natural science can merely serve as policy tools, indicating to effects of climate change on the ecosystem.

Sundarbans case strongly supports a few emerging voices that urge to involve social sciences much more intensively in the adaptation research.[7] Local narrations of hardships and experiences are much more poignant than the official data and natural science can ever represent. It takes an hour to walk a kilometer in the monsoon season in most places. Local commute on the boats, despite being inexpensive (Re 1 in most cases), is unnerving as 40 people cram extremely precariously in the space of 10. These boats neither have any safety standards nor protection to rain, storm for their passengers. There is a constant conflict between man and the tigers, snakes and crocodiles. But as the population keeps increasing, productivity of the nature dwindles and desperation of people increases. These people cannot be put on an endless wait till enough time-series data (needed for accurate scientific projections) emerge and are interpreted. People need solutions that must address a range of social and economic issues and offer them choices.

Provide choices, let people decide

It is also important to recognise what the people want, and respect their ambitions, aspirations and preferences. Majority of the farmers in the country, for example, do not want their next generations to be farmers.[8] Because this choice is a subject of opportunities, quality of life and conditions that shape the response of the farmers, counter-choices from an adaptation perspective would be critical that will allow him to feel comfortable in his existing socio-economic climate. Today, majority of them want to migrate to urban areas in search of better livelihood and prospects, often for offering better education to their children. The past decade (between 2001 and 2010), about 22 million people have migrated from rural areas to the cities,[9] the percentage of rural population to the total population has declined from 71 per cent to 68 per cent and for the first time, increase in population in the urban areas surpassed that in the rural.

Various policy failures have driven this phenomenon but that the response of people is clear: They want to shift to urban areas, for a better life until rural India is able to provide urban amenities. Finding of this report also evinces that people want choices and not incongruous, disparate policies.

This is only possible if, much like the concept of development, adaptation also involves notions of justice, equality and human rights. The concept of "just sustainabilities"[10] focuses on environmental and inter-generational justice, but this is not identical with concepts of social justice in a development

context. Adaptation is often viewed as small doles or assistance or at best an accounting process where setting up a 'disaster shelter' is all that the global donors are interested in.

Sundarbans' story tells us that adaptation must be an open-ended process and not an outcome that has highly dynamic population groups without pre-defined entry and exit points. The vulnerable must be empowered to come in and go out of the system as they feel, or settle within. The empowerment demands much higher level of social capital and economic options, after all the feeling of 'being able to adapt effectively' is a people's perception.

Adaptation policy and governance: Links mustn't break

None of these interventions can exist in isolation. Success of one depends on that of the other. This highlights the nature of adaptation as a complex socio-economic, political and technical process that needs integration with the daily governance. The structure detailed in the diagram highlights these linkages and synergies. Within this broad structure, there are multifarious sectors (let's say, for instance, veterinary medicines, early warning protocols) and institutions which will govern them. Sundarbans, fortunately enouhg, already has a special agency for carrying out coordination between various other agencies (such as forest department and irrigation) that form the overall governance of Sundarbans. This agency must take up the challenge of weaving adaptation components in each of the sectors and institutions that work in the region.

Sectors

While a separate adaptation policy would not work, additionalities must be clearly identified and carried out in conjunction of existing structure of policy and governance in every sector. Whether it is about livelihood opportunities such as agriculture and fisheries, or infrastructure such as disaster management, power, roads and health systems, adaptation issues must be addressed in each. This needs integration of 'climate' elements in both strategy designs and implementation.

Institutions

A high level of institutional synergy is imperative. The nodal agency for Sundarban affairs has not been able to handle the developmental challenges in the region. Forest department is the custodian of large parts of Sundarbans and within the forest department, there is division of mandate. While Sundarbans National Park reports directly to Ministry of Environment of Forests, the state forest department and other state departments often work at cross purposes. High degree of institutional clarity is needed – while creating an additional climate change adaptation wing might add confusion in an already complicated management process, a state-level or an ecosystem-level authority seems important.

Who pays for adaptation?

One of the major economic paradoxes of the Sunderbans economy is the fact that conservation is costly in terms of foregone benefits (if not in terms of conservation expenditure). The effect of a rise in output prices (e.g., shrimp, prawn, timber, etc.) further increases the value of foregone benefits resulting from conservation. However, benefits are dispersed globally and locals are on one hand denied access and on the other not even compensated for the benefits they forgo.[11]

Absence of 'global markets' for Sundarban Biosphere Reserve does not allow the host country to capture these benefits fully, which can be formally institutionalized through resource transfers under conventional aid, transfers under the Global Environmental Facility (GEF), debt-for-nature swaps, etc. It is imperative that such mechanisms be strengthened.[12] Adaptation should also be undeniably entwined with the redistribution of financial resources from North to South and issues of fair compensation for past industrial emissions[13].

Poorest in Sundarbans have little capacity to adapt to a changing climate, lacking the assets, social networks, mobility, and political power, commonly cited as being critical for adaptation.[14] This is why it is also important for adaptation to be delivered through poverty reduction and development programmes. However, an increasingly hostile climate in Sundarbans is making development increasingly expensive, necessitating new investments in agriculture, greater provision of social and private insurance, new buildings and infrastructure. In a hostile climate, every rupee achieves less and not being proactive would end up spiraling expenditures towards disaster relief, as is experienced across the world. The World Bank estimates that it has provided grants and loans for disaster relief and recovery of more than $38bn over the last two decades.

Unless the specific context of the poor is taken into account in Sundarbans, adaptation could increase the vulnerability of the poor.[15] This is why we need additional funds for climate 'safety margins' (whether infrastructure or health systems).[16] Politics of adaptation has largely focused on the provision of 'development assistance' to compensate least developed countries. Adaptation funds for least developed counties and proceeds from the 2 percent levy on the CDM remain woefully low and the criteria by which to measure and evaluate adaptations yet to be designed.[17]

A key issue in the negotiations for a renewal of the UN Framework Convention on Climate Change in Copenhagen is the notion of ''adaptation debt'' that should be paid as a kind of compensation by developed countries for harm done to developing countries.We must work towards creating a just adaptation framework where historic responsibilities will be recognized and addressed much like emission.

Annexure

CASE STUDY

Location: Mousuni *Gram Panchayat,* Namkhana block, South 24 Parganas

Mousuni island, a *gram panchayat* of Namkhana block in the western part of Sundarbans, is only 30.28 sq km[1]. The island is encircled by the Muriganga and Bartala rivers in the west and north-west, Pitt's Creek and Chenayer River in the east and Bay of Bengal in the south.

ADITYA GHOSH / CSE

Grounded! Fisherfolk in Mousuni have been pushed back by advancing sea, forcing them to settle on the embankment. Many had to quit fishing, these boats are now mortgaged to pay off for the new homes. In monsoons it is also too risky to venture the seas for fishing

SAIKH RUSTAM, Age: 52 years, Family members: 5
He has lost his home thrice in little more than 12 years and now lives virtually on the embankment. As he lost land to the advancing sea, he had to change his profession to a fisherman from a farmer. His family does not have young men or women who could migrate out in search of work, which, he feels has resulted in considerable hardship and impoverishment for him.

ADITYA GHOSH / CSE

His income is not stable as fishing is possible only in summers and he has no means of livelihood during four monsoon months when the river is dangerous. He engages himself in daily labour in farming and other kinds of unskilled work, only when they are available. He claims that there is no more land left for him to shift if he loses his home one more time, as all that is left is private land. He has not even been able to construct a proper mud house and lives in a shanty as he is still paying his loans for repairing his boat.

Knowledge about government schemes on alternative livelihood: Yes. Knows about the Magatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) but prefers not to get engaged as the payment is made in a bank account, which he never had initially and even now going to withdraw money means losing a day's wage for him as the only bank in the area is two hours jounrney depending on the weather conditions.
Knowledge about climate change and its impact: No, except stronger wind speeds and sharper erosions.

SAHARA BIBI, Age: 45-48 years, Family member: 4

After losing her home twice in seven years to erosion, Sahara Bibi's family had little choice, but to let her sons discontinue education and start working. Her younger son, Md. Sahzahan is now working as a mason in Kerala while the elder one is working as a shop assistant in a ration shop. Sahzahan has been in Kerala for two years and earns about Rs 300 a day, which is much more than what he would have earned as an agricultural labourer or under government's employment generation scheme, NREGS. His uncle took him to Kerala for the first time and now Sahzahan is influencing his fellow villagers to come along with him. He spends a couple of months, particularly in the monsoons every year, in the village.

ADITYA GHOSH / CSE

Knowledge about government schemes on alternative livelihood: None.

Knowledge about climate change and its impact: No, apart from increasing number of pre-seasonal cyclones.

Mousuni is classified as one among 10 most vulnerable sea-facing clusters of islands along with Sagar, Ghoramara, Jambudwip, Namkhana, Dakhsin Surendranagar, Dhanchi, Dalhousi, Bulchery, and Bhangaduani in South 24 Parganas[2]. The case study covers Baliara *mouza*.

Despite being in close proximity to Sagar Island, one of the better developed blocks in the Sundarbans, Mousuni is a classic example of an underdeveloped area. The island consists of 4 revenue *mouzas*, Mousuni, Bagdanga, Kusumtala and Baliara.

Since 1969, Mousuni Island has lost about 15 per cent of its total area while the population has risen by about 265 per cent in the same period. This has driven more and more people to draw sustenance from the forests, rivers and the sea. Under such circumstances, modern education can equip individuals for employment outside the eco-region but there are few opportunities for demand driven training on offer.

ARUP MONDOL, age 45

The island was always vulnerable to natural disaster but basic infrastructure such as flood relief centres, cyclone shelters and warning systems have not been developed. The school buildings currently double up as shelters but the capacity is small and it lacks basic amenities needed for such a purpose. Mondol feels that impacts of Aila are a precursor to what might be in store for the island. He feels that climate change has already altered the rainfall pattern which is now more prominent pre and post monsoon periods. In his experience flash floods and inundation have also increased with lesser amount of rainfall, indicating to a higher level of rivers flowing around the island.

ADITYA GHOSH / CSE

The unpredictability of extreme weather events is something that was bothering the villagers he said. It seems that all the experience and expertise with the village-folk in forecasting natural disasters are failing them now. A robust disaster warning system was absolutely vital now amidst unpredictable weather conditions, he said.

Anwara Bibi (F), Age: 34 years, Family member: 04
Wife of a fisherman, she says she would love to migrate out but neither her husband nor she herself has the skills or the requisite network necessary to move out. Monsoon is the time when the family has very little income because increment weather does not allow them to venture the high seas.

ADITYA GHOSH / CSE

Population and economy

The population of the island according to 2001 census is 20,013, with 3,340 families.

According to data with the *gram panchyat*, a large percentage of a family's income in Baliara is seasonal/marginal in nature (56.80 per cent families) of which 43.20 per cent families are under poverty line and 13 per cent are APL category. There are 35 per cent families who work on their own agricultural land in the village Baliara. Only 5.67 per cent families work in unorganised sectors and 2.45 per cent families work in organised sectors. About 64 per cent of the population is highly economically vulnerable here[3].

Agriculture is dominated by paddy, but with time, farm sizes as well as the yield have diminished, particularly after Aila and because of land loss from erosion. Agricultural land across the island has reduced from 19.250 sq.km in 1986 to 10.63 sq km in 2006 (Namkhana Block office data) in the Baliara *mouza*.

Since Cyclone Aila in 2009 which inundated paddy fields with saline water and made cultivation impossible for next two years, many have started fishing to generate additional income. But because of meagre capital that does not allow mechanised boats or good nets, lack of skill and the competition involved, it has failed to be a viable livelihood alternative for people. These fishermen do not venture into deep seas, their catch mostly serves local demand.

The family owns a non-mechanised fishing boat and nets that allow then to operate independently but irregular income because of competition from industrialised and mechanised fishing as well as declining stocks. But she is mortally afraid about the erosion which is advancing at an alarming pace. Currently the family lives on the embankment itself and has no land to shift if the embankment collapses one more time.

Knowledge about government schemes on alternative livelihood: No
Knowledge about climate change and its impact: No

Muslema Bibi (F), Age: 20 years, Family member: 03
Anwara's neighbour Muslema however has experienced much greater hardship which makes Anwara scared about the consequences of losing a home. After she got married and moved to Mousuni from Namkhana, the block headquarters, the family was pushed back by the advancing sea that engulfed their homes twice over the past five years. Muslema and her family do not own a fishing boat or nets anymore, which the family was forced to sell off to rebuild their house after the forced relocation. The family never owned any agricultural land.

Now her husband either has to rent a boat, work as a daily labourer in the larger fishing trawlers or in the paddy fields. The household income has dropped sharply and the family is under heavy debt as the fishing trips often remain unproductive while rent of the boat keeps accumulating with interest. According to Muslema, number of days with meaningful catch has been going down consistently for past one year or so as many more people have now started fishing in the rivers, creeks and the shallow sea.

The despondency of Muslema stems from lack of choice, she feels. For survival, the family either must migrate or find a way to engage in an alternative livelihood. The former has not been exercised because of lack of skills and inability to penetrate the right network while the choice of the latter could not be exercised because of lack of knowledge about options.

Knowledge about government schemes on alternative livelihood: No
Knowledge about climate change and its impact: No

According to the household survey, majority of the families earn between Rs 700 and Rs 1200. Most of the dwelling units are made of mud made and only about 13 per cent families are electrified through Baliara Solar Station established by the West Bengal Renewable Energy Development Agency (WBREDA). A few families have installed solar energy on their own initiative. The *mouza* is one of 18 across Sundarbans where grid electricity will not be provided and is a part of Rural Village Electrification (RVE) project under Union ministry of new and renewable energy (MNRE).

Erosion

One of the main reasons for the economic and social vulnerability is because of land loss in the island, which may not have been conclusively attributed to climate change or anthropogenic causes or an interaction of the two, but it remains the most critical challenge to a holistic adaptation policy.

The size of Mousuni island is gradually reducing – from 33.52 sq km in 1969 to 28.28 sq km in 2009 with continuing coastal erosion. The southern-most part of the island, the Baliara *mouza*, is worst affected by the coastal erosion which has lost 36 per cent of its land between 1969 and 2009. The *mouza* is still eroding at the rate of 0.041 sq km/year.

Already 157 plots (2.40 sq km area) which were recorded in the Bengal Settlement Survey Map of 1942 has been eroded by coastal erosion and more than 600 revenue plots (2.40 sq km area) presently situated on

inter tidal zone, are slowly eroding away[31].

According to different zones of elevations it is to be observed that 51 per cent families are highly vulnerable, 37 per cent are moderately vulnerable and 12 per cent are less vulnerable. About 33 per cent of people Below Poverty Line (BPL) live in a low lying zone, highly vulnerable to flooding.

Climate change

This island has a coast line of 40.19 km and the rise in mean sea level itself threatens the population who live near the shore. Already many households have lost their homes to erosion, caused by advancing seas and in some cases faulty embankment engineering. Many families in the *mouza* are still living on the embankment itself and have no place to shift backwards, as we will see in the following section.

Any change in monsoon pattern, particularly pre- and post-monsoon rains, would jeopardise paddy cultivation and can lead to higher tidal surges that will escalate the danger of saline water intrusion into the agricultural fields and overtopping of embankments.

Increase in the cyclonic events and tidal surges along with sea level rise have already started affecting fisherfolk in the village, many of whom depend on subsistence fishing.

Existing stresses: People's perspectives

The analysis of the semi-structured interviews clearly establish an absence of planning, both in the short and long range to mainstream climate change adaptation into local development strategies.

- Poverty
- Overdependence on natural resources
- Lack of penetration of education
- Poor health infrastructure
- Lack of efficient disaster management system
- Lack of infrastructure: power & roads

Aila has left an indelible mark on the lives of people here. As the island keeps losing land, Arup Mondol, a medium farmer, with a little more land than the average landholding, says "Hardship in everyday life is agonising but thank god people don't have much idea about climate change or the kind of disaster it can bring about. Agriculture does not provide any meaningful return which led many to start fishing. But that hasn't helped as it is hazardous, needs much higher investments and involves skills that farmers take time to acquire. Also competition in fisheries has increased and people with less capital are losing out."

According to him, the lack of infrastructure and erosion were the main causes behind the misery of people. He claims to know about climate change and feels that if another cyclone such as Aila hits the island in the next 10 years, people in the entire island will have no options but to migrate out in search of lives and livelihood. "Education levels are really low here so people cannot migrate for skilled work, they have to migrate as unskilled labourers and never earn enough to take their families along," he added.

Mousuni: observations

The larger development planning for the region, the interviews revealed, has failed to envisage how people will continue living in the island with a sense of security and dignity. There is a piecemeal approach that can, at best, serve a short term agenda. Population pressure and diminishing returns from natural resources are at loggerheads, the sustainability of the island itself is threatened. An indicator to this is a

very high out-migration rate in Baliara village. Migration, for people of Mousuni, is a social response to the lack of livelihood opportunities in and around Mousuni, including that in the Namkhana block.

Many families are now entirely dependent on remittances for all the important expenses. In Mousuni, the migration flow is towards Kerala as socially, migration destinations depend on agent network and on the number of people migrating to a particular destination through acquaintances. These are mostly seasonal migration as people revealed that they do not earn enough yet to relocate with their families, neither do they have the skills to demand higher pay. However, remittances often help families to start small businesses for the families and also provide necessary capital for education and local migration for other members.

Notes and References

Chapter 1: Introduction

1. S Rayner and E L Malone (eds.) 1998, Human Choice and Climate Change,. Battelle Press, Columbus, OH, 1564 pp
2. L Schipper and M Pelling 2006, Disaster risk, climate change and international development: scope for, and challenges to, integration. Disasters, 30: 19–38. doi: 10.1111/j.1467-9523.2006.00304.x
3. D Simon 2007, Urbanization and global environmental change: 21st Century challenges. Cities and global environmental change: exploring the links. *The Geographical Journal,* Vol. 173:1, pp. 75–92
4. M Doria, E Boyd, E Tompkins and W Adger 2009, Using expert elicitation to define successful adaptation to climate change, Environmental Science & Policy, 12, pp.810-819. doi:10.1016/j.envsci.2009.04.001
5. N Nakicenovic et al 2000, Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K., 599 pp
6. J Leggett, W J Pepper and R J Swart 1992: *Emissions Scenarios for IPCC: An Update*. In: Climate Change. The Supplementary Report to the IPCC Scientific Assessment [Houghton, J.T., B.A. Callander and S.K. Varney (eds.)], Cambridge University Press, Cambridge, UK, pp. 69-95.
7. Emily Boyd and Maxwell Boykoff 2010, Permissible vulnerabilities? Examining cultural interpretations of climate risk and resilient adaptation strategies among urban elite in Mumbai, http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1256566800920/6505269-1268260567624/Boyd.pdf
8. H H Dang, A Michaelowa, and D D Tuan 2003, Synergy of adaptation and mitigation strategies in the context of sustainable development: the case of Vietnam. Climate Policy 3: S81–S96
9. Anon 2011, Big economies of the future - Bangladesh, India, Philippines, Vietnam and Pakistan - most at risk from climate change http://maplecroft.com/about/news/ccvi.html
10. Anon 2011, 'India ranks 134 in human development index', *Hindustan Times*, November 2, http://www.hindustantimes.com/News-Feed/India/India-ranks-134-in-human-development-index/Article1-764014.aspx
11. Anon 2010, http://adaptation-fund.org/system/files/AFB.PPRC_.3.10%20Proposal%20for%20India.pdf
12. Anon 2008, UNFCCC, Ecosystem-based adaptation: An approach for building resilience and reducing risk for local communities and ecosystems http://unfccc.int/resource/docs/2008/smsn/igo/029.pdf
13. Anon 2007 Climate Change Working Group II: Impacts, Adaptation and Vulnerability, Chapter 6.4.2.1: Freshwater resources, http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch6s6-4-2-1.html
14. A Challinor, J Slingo, A Turner, & T Wheeler 2006, 'Indian Monsoon, Contribution to the Stern Review', University of Reading, available from http://www.sternreview.org.uk.

Box: DEFINING ADAPTATION

1. Anon 2007, Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Cambridge University Press, Cambridge, United Kingdom, 1000 pp.
2. Levina Ellina and Dennis Tirpak 2006, Adaptation To Climate Change: Key Terms, Organisation For Economic Co-Operation And Development (OECD), Page 6

3. Ibid
4. Martha Mwandingi 2006, UNDP-GEF Climate Change Adaptation, www.undp.org/gef/adaptation
5. Anon 2004, United Kingdom Climate Impact Programme: Costing the impacts of climate change in the UK,

Box: METHODOLOGY OF RESEARCH

1. Elizabeth Malone, and Emilio La Rovere 2004, 'Assessing Current and Changing Socio-Economic Conditions', Technical Paper 6 in United Nations Development Programme 2004, *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures,* http://content.undp.org/go/cms-service/stream/asset/?asset_id=2200853
2. M C Lemos & Emily Boyd 2009, 'The politics of adaptation'. Chapter in Boykoff, M. forthcoming. 'Politics of Climate Change: A Survey', Cambridge University Press.

Chapter 2: The Indian Sundarbans

1. A B Chaudhuri and A Choudhury 1994, *Mangroves of the Sundarbans*, *Volume I: India*, IUCN, The World Conservation Union.
2. B Gopal and M Chauhan 2006, 'Biodiversity and its conservation in the Sundarbanmangrove ecosystem', *Aquatic Sciences* Vol 68 No 3**,** Springer, pp. 338-354.
3. M A Hoque, M S K A Sarkar, S A K U Khan, M A H Moral and A K M Khurram 2006, 'Present Status of Salinity Rise in Sundarbans Area and its Effect on Sundari (*Heritiera fomes*) Species', *Research Journal of Agriculture and Biological Sciences*, Vol 2 No 3, pg 115-121.
4. Ibid.
5. Syed Azizul Haq 2010, 'Impact of climate change on "Sundarbans", the largest mangrove forest: ways forward', paper presented in 18th Commonwealth Forest Conference, www.cfc2010.org/papers/session7/Haq-s7.pdf
6. Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal, Page 295
7. R Chakrabarti 2009, 'Local People and the Global Tiger: An Environmental History of the Sundarbans', Global Environment Society, *A Journal of History and Natural and Social Sciences*, www.globalenvironment.it/CHAKRABARTI.pdf
8. Ibid.
9. Ibid.
10. Census of India 2011, 'Provisional Population Data of South and North 24 Parganas'.
11. • Population of Sundarban blocks in North 24 Parganas in 2001 was 962202. Increase in population between 2001 and 2011 was 12.86 per cent, so provisional population of Sundarban blocks in North 24 Parganas district in 2011 was 12.86% of 962202+962202= 1077666
    • Population of Sundarban blocks in South 24 Parganas in 2001 was 2795154. Increase in population between 2001 and 2011 was 18.05%, so provisional population of Sundarban blocks in South 24 Parganas district in 2011 was 18.05% of 2795154+2795154=3299579
    • So total population of 19 blocks of Sundarbans is 1077666+3299579=4377245 or 4.37 million
12. Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal, pg 31
13. Ibid., pg 30
14. District Statistical Handbooks 2005-06 (combined), Bureau of Applied Economics & Statistics, Government of West Bengal, wbplan.gov.in/htm/ReportPub/WB_HandBook.pdf
15. Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal, pg 51
16. Ibid.
17. District Statistical Handbooks 2005-06 (combined), Bureau of Applied Economics & Statistics, Government of West Bengal, wbplan.gov.in/htm/ReportPub/WB_HandBook.pdf

Box: CONFLICT WITH THE ECOSYSTEM

1. V Santhakumar, Enamul Haque, Rabindranath Bhattacharya 2005, 'An Economic Analysis Of Mangroves In South

Asia', The Canadian Center for South Asian Studies (CCSAS), University of Ontario, Institute of Technology, Canada

Box: A KEY CARBON SINK

1. R Ray, D Ganguly, C Chowdhury, M Dey, S Das, M K Dutta, S K Mandal, N Majumder, T K De, S K Mukhopadhyay, and T K Jana 2011, 'Carbon sequestration and annual increase of carbon stock in a mangrove forest', *Atmospheric Environment* Vol 45 Issue 28, Pages 5016-5024, http://www.sciencedirect.com/science/article/pii/S1352231011004638
2. Ibid.
3. Ibid.
4. Value of forest carbon globally is €5 per tonne. The value of Sundarban in terms of carbon storage will thus be 21.13 million tonnes x 5 x 69.8 (exchange rate of Euro to Indian rupees) = Rs 737.4 crore. Similarly, the annual uptake can be valued at 2.79 million tonnes x 5 x 69.8 = Rs 97.3 crore

Chapter 3: Impact: Aila and the others

1. Alok Gupta, J Basu and Archita Bhatta 2009, '@110/hr', *Down To Earth*, Vol 18, No 3, June 30, Society for Environmental Communications, New Delhi.
2. Anon 2007, 'Synthesis of Projected Global Temperature at Year 2100', Climate Change 2007: Working Group I: The Physical Science Basis, Intergovernmental Panel on Climate Change, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-5-4-6.html
3. J Church, J Hunter, K McInnes, and N White 2004, 'Sea-level rise and the frequency of extreme events around the Australian coastline', in *Coast to Coast '04 – Conference Proceedings*, Australia's National Coastal Conference, Hobart, 19-23 April; A Cazenave and R Nerem 2004, 'Present-day sea level change: observations and causes'. *Reviews of Geophysics*, Vol 42, pp. 20, http://www.agu.org/pubs/crossref/2004/2003RG000139.shtml; S J Holgate and P L Woodworth 2004, 'Evidence for enhanced coastal sea level rise during the 1990s', *Geophysical Research Letters*, Vol 31, http://www.agu.org/pubs/crossref/2004/2004GL019626.shtml; R Thomas, E Rignot, G Casassa, P Acuna, C Kanagaratnam, T Akins, H Brecher, E Frederick, P Gogineni, W Krabill, S Manizade, H Ramamoorthy, A Rivera, R Russell, J Sonntag, R Swift, J Yungel and J Zwally 2004, 'Accelerated sea-level rise from West Antarctica', *Science*, Vol. 306 no. 5694 pp. 255-258, http://www.sciencemag.org/content/306/5694/255.abstract
4. Anon 2007, 'Synthesis of Projected Global Temperature at Year 2100', Climate Change 2007: Working Group I: The Physical Science Basis, Intergovernmental Panel on Climate Change, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-5-4-6.html
5. O P Singh 2001, 'Long term trends in the frequency of monsoonal cyclonic disturbances over the north Indian Ocean', *Mausam* Vol 52, No 4, pg 655-658; OP Singh 2002, 'Inter-annual variability and predictability of sea level along the Indian coast' *Theoretical and Applied Climatology*, Vol 72, No 1-2, pp 11-28
6. A Mitra, A Gangopadhyay, A Dube, ACK Schmidt and Kakoli Banerjee 2009, 'Observed changes in water mass properties in the Indian Sunderbans (northwestern Bay of Bengal) during 1980-2007', *Current Science*, Vol 97, No 10, pp. 1445-1452
7. S K Jadhav and A A Munot 2007, **'**Increase in SST of Bay of Bengal and its consequences on the formation of low pressure systems over the Indian region during summer monsoon season', *Mausam*, Vol 58, pp 391-396
8. Ibid.
9. S Hazra and B Samanta 2009, 'Studies in selected sectors of Mousuni *gram panchayat* of Namkhana Development Block for climate change adaptation and awareness', School of Oceanographic Studies, Jadavpur University, Kolkata
10. Here sea level rise implies the change in the relative sea level, measured from observed tide data. Relative sea level is the height of the sea measured with respect to the level of the land. Mean sea level, another commonly used term, is a measure of the average height of the ocean's surface (such as the halfway point between the mean high tide and the mean low tide). Relative sea level is determined though tidal measurement from land. However, this cannot be free from the data of land level change (subsidence, uplift, compaction of sediments, near shore siltation), but measured over a longer period, it gives a fairly correct estimate of the sea level persisting over the study area. For any coastal vulnerability analysis, scientists prefer calculating changes in

the relative sea level which is more useful to understand contributions of erosion, inundation and invasion of sea on the land area of the region rather than some abstract mathematical or global value

11. S Hazra, K Samanta, A Mukhopadhyay and A Akhand 2010, 'Temporal Change Detection (2001-2008) Study of Sundarban', School of Oceanographic Studies, Jadavpur University, Kolkata
12. A S Unnikrishnan, K R Kumar, S E Fernandes, G S Michael and S K Patwardhan 2006, 'Sea level changes along the Indian coast: observations and projections', *Current Science*, Vol 90 No 3, pp. 362-368
13. Anamitra Anurag Danda, Gayathri Sriskanthan, Asish Ghosh, Jayanta Bandyopadhyay and Sugata Hazra 2011, *Indian Sundarbans Delta: A Vision,* New Delhi, World Wide Fund for Nature-India, p 27
14. http://climate.nasa.gov/keyIndicators/index.cfm#seaLevel
15. S L Dowell and L J Rickards 1993, 'Recent developments in sea level networks and data centres', pp. 39-50. Sea level changes and their consequences for hydrology and water management. In: Proceedings of an International UNESCO Workshop held at Noordwijkerhout, Netherlands, 19-23 April 1993. Koblenz: Bundesanstalt fur Gewasserkunde.
16. S Hazra, K Samanta, A Mukhopadhyay and A Akhand 2010, 'Temporal Change Detection (2001-2008) Study of Sundarban', School of Oceanographic Studies, Jadavpur University, Kolkata
17. Ibid.
18. S Nandy and S Bandyopadhyay 2008, 'Trend of sea level change in the Hugli Estuary, West Bengal', S*ouvenir and Abstracts Volume*, 21st Conference of Indian Institute of Geomorphology, Tripura University, pp. 83-84.
19. Personal communication, Dr A S Unnikrishnan, Senior Scientist, National Institute of Oceanography, Goa
20. Ibid.
21. M A Allison 1998, 'Historical changes in the Ganges-Brahmaputra delta', *Journal of Coastal Research*, Vol 14, No 4, pp. 1269-1275
22. E Gilman 2002, 'Guidelines for coastal and marine site planning and examples of planning and management intervention tools', *Ocean and Coastal Management*, Vol 45, No 6-7, pp 377-404.
23. Hazra, S, Ghosh, T, Dasgupta, R and S Gautam 2002, 'Sea level and associated changes in the Sundarbans', *Sciens and Culture*, Vol 68, No 9-12, pg 309-321.
24. C Loucks and others 2010, 'Sea level rise and tigers: predicted impacts to Bangladesh's Sundarbans mangroves', *Climatic Change*, Vol 98, No 1-2, Pg 291-298.
25. http://www.portal.gsi.gov.in/portal/page?_pageid=127,723790&_dad=portal&_schema=PORTAL&linkId=1216
26. P Guhathakurta, O P Sreejith and P Menon 2011, 'Impact of climate change on extreme rainfall events and flood risk in India', India Meteorological Department, Shivajinagar, Pune
27. S Hazra, K Samanta, A Mukhopadhyay and A Akhand 2010, 'Temporal Change Detection (2001-2008) Study of Sundarban', School of Oceanographic Studies, Jadavpur University, Kolkata
28. S K Jadhav and A A Munot 2007, **'**Increase in SST of Bay of Bengal and its consequences on the formation of low pressure systems over the Indian region during summer monsoon season', *Mausam*, Vol 58, pp 391-396
29. Ibid.
30. P Guhathakurta, O P Sreejith and P Menon 2011, 'Impact of climate change on extreme rainfall events and flood risk in India', India Meteorological Department, Shivajinagar, Pune
31. Anon 2011, 'Forget the chill, 2010 was India's hottest year on record', *The Times of India*, January 14, http://articles.timesofindia.indiatimes.com/2011-01-14/india/28369135_1_temperature-degrees-warmest-year
32. O P Singh 2007, 'Spatial variation of sea level trend along the Bangladesh coast', *Mar Geol*, Vol 25, pg 205-212.
33. G Gopinath and P Seralathan 2005, 'Rapid coastal erosion of the Sagar Island, West Bengal', *Environmental Geology*, Springer Berlin Heidelberg. Vol 48 No 8, pg 1058-1067
34. S Hazra, T Ghosh, R Dasgupta and S Gautam 2002, 'Sea level and associated changes in the Sundarbans', *Science and Culture*, Vol 68, No 9-12, pg 309-321.
35. O P Singh 2007, 'Long-term trends in the frequency of severe cyclones of Bay of Bengal: Observations and simulations', *Mausam*, Vol 58, No 1, pp. 59-66.
36. S K Jadhav and A A Munot 2009, 'Warming SST of Bay of Bengal and decrease in formation of cyclonic disturbances over the Indian region during southwest monsoon season', *Theoretical and Applied Climatology*, Vol 96, No 3-4, pgs 327-336

37. O P Singh 2001, 'Long term trends in the frequency of monsoonal cyclonic disturbances over the north Indian Ocean', *Mausam* Vol 52, pp 655-658
38. S R Shetye, A D Gouveia and M C Pathak 1990, 'Vulnerability of the Indian coastal region to damage from sea level rise', *Current Science*, Vol 59 No 3, pp. 152-156.

Chapter 4: Land: the bone of contention

1. A Mitra, A Gangopadhyay, A Dube, A C K Schmidt and K Banerjee 2009, 'Observed changes in water mass properties in the Indian Sunderbans (northwestern Bay of Bengal) during 1980-2007', *Current Science*, November 25, Vol 97, No10, pp. 1445-1452
2. K Rudra 2011, 'The proposal of strengthening embankment in Sundarban: myth and reality', http://www.counterviews.org/sunderban_aila.html
3. Kanailal Sarkar, Tagore Society of Rural Development, personal communication
4. K Rudra 2011, 'The proposal of strengthening embankment in Sundarban: myth and reality', http://www.counterviews.org/sunderban_aila.html
5. S Hazra, K Samanta, A Mukhopadhyay & A Akhand 2010, 'Temporal Change Detection (2001-2008) Study of Sundarban', School of Oceanographic Studies, Jadavpur University, Kolkata
6. D Ganguly, A Mukhopadhyay, R K Pandey and D Mitra 2006, 'Geomorphological study of Sundarban deltaic estuary', *Journal of Indian Society of Remote Sensing*, Vol 34, No 4, pp 431-435.
7. S Hazra, K Samanta, A Mukhopadhyay & A Akhand 2010, 'Temporal Change Detection (2001-2008) Study of Sundarban', School of Oceanographic Studies, Jadavpur University, Kolkata
8. Data supplied by West Bengal Irrigation Department
9. K Rudra 2011, 'The proposal of strengthening embankment in Sundarban: myth and reality', http://www.counterviews.org/sunderban_aila.html
10. Dr Kalyan Rudra, personal communication
11. K Rudra 2011, 'The proposal of strengthening embankment in Sundarban: myth and reality', http://www.counterviews.org/sunderban_aila.html
12. Ibid.
13. Anon 2011, 'Post-Aila salinity defeats Sunderbans farmers', *The Hindu*, June 8, http://www.thehindu.com/sci-tech/agriculture/article2087079.ece
14. M Habibullah, U A Ahmed and Z Karim 1998, 'Assessment of foodgrain production loss due to climate induced enhanced soil salinity', in *Vulnerability and adaptation to climate change for Bangladesh*, S Huq, Z Karim, M Asaduzzaman and F Mahatab (eds.), Kluwer Academic Publisher, Dordrecht, The Netherlands, pp. 39-54.
15. A M S Ali 2005, 'Rice to shrimp: Land use/ land cover changes and soil degradation in southwestern Bangladesh', *Land Use Policy* Vol 23, No 4, October 2006, pp. 421-435
16. S Hazra, K Samanta, A Mukhopadhyay & A Akhand 2010, 'Temporal Change Detection (2001-2008) Study of Sundarban', School of Oceanographic Studies, Jadavpur University, Kolkata
17. Ibid.
18. Ibid.
19. Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal, Kolkata
20. Population density in Sundarbans is well over 900. Thus, 70 sq km would mean approximately 906 x 70 comes to approximately 65,000 people

Box: WILL THE DUTCH DESIGN WORK HERE?

1. A Kazmierczak and J Carter 2010, 'Adaptation to climate change using green and blue infrastructure', The Netherlands Live with Water: public awareness raising campaign, University of Manchester
2. J Aerts 2010, 'Adaptation cost in the Netherlands: climate change and flood risk management, financial arrangements for disaster losses under climate change'; www.climateresearchnetherlands.nl
3. http://www.nature.com/climate/2010/1004/full/climate.2010.28.html
4. J Aerts 2010, 'Adaptation cost in the Netherlands: climate change and flood risk management, financial arrangements for disaster losses under climate change'; www.climateresearchnetherlands.nl

5 http://www.rediff.com/business/report/nhai-to-raise-rs-10000-cr-via-public-issue/20111010.htm
6. K Rudra 2011, 'The proposal of strengthening embankment in Sundarban: myth and reality', http://www.counterviews.org/sunderban_aila.html

Box: AQUACULTURE TO BRICK KILNS

1. K Rudra 2011, 'The proposal of strengthening embankment in Sundarban: myth and reality', http://www.counterviews.org/sunderban_aila.html

Chapter 5: Survival archipelago

1. Rural Household Survey 2005, Office of the District Magistrate, South 24 Parganas
2. Central Marine Fisheries Research Institute 2005, 'Marine fisheries Census 2005, Part-III (1) - West Bengal', Government of India, Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries, Krishi Bhavan, New Delhi
3. Sundarban Development Board, 2010-11
4. Anon 2009, 'Agricultural Research Data Book 2008', Indian Council for Agricultural Research, quoted in the report 'Looking Back to Change Track', The Energy Research Institute (TERI)
5. S Hazra, K Samanta, A Mukhopadhyay and A Akhand 2010, 'Temporal Change Detection (2001-2008) Study of Sundarban, School of Oceanographic Studies, Jadavpur University, Kolkata
6. A B Chaudhuri and A Choudhury 1994, 'Mangroves of the Sundarbans Volume I: India', IUCN - The World Conservation Union
7. http://www.thehindubusinessline.com/industry-and-economy/agri-biz/article2021516.ece
8. A Danda 2007, 'Surviving in Sundarbans, Threats and Responses', University of Twente, Netherlands, PhD Dissertation, *mimeo*
9. A B Chaudhuri and A Choudhury 1994, 'Mangroves of the Sundarbans Volume I: India', IUCN - The World Conservation Union
10. Anon 2005, 'Analysis of trends in operational holdings (Consolidated Report)', Agro-Economic Research Centre, Visvabharati, Ministry of Agriculture, Government of India
11. Rural Household Survey 2005, Office of the District Magistrate, South 24 Parganas
12. S K Jadhav and A A Munot 2009, 'Warming SST of Bay of Bengal and decrease in formation of cyclonic disturbances over the Indian region during southwest monsoon season', *Earth and Environmental Science*, Theoretical and Applied Climatology, Vol 96, No 3-4, 327-336.
13. A A Danda, G Sriskanthan, A Ghosh, J Bandyopadhyay and S Hazra 2011, 'Indian Sundarbans Delta: A Vision' World Wide Fund for Nature-India, New Delhi
14. A Sen 2000, 'The ends and means of sustainability', keynote address at the international conference on 'Transition to Sustainability', May, http://iisd.org/pdf/sen_paper.pdf
15. S Bhattacharya 2007, 'Lessons learnt for vulnerability and adaptation assessment from India's first national communication', Paper 7 of BASIC Project, Winrock International, pp. 11
16. Based on information collected by the DoF/World Bank funded GEF component of the Fourth Fisheries Project
17. D Alexander 1993, 'Natural disasters', UCI press, London, pp. 631
18. A Singh, P Bhattacharya, P Vyas, S Roy 2010, 'Contribution of NTFPs in the Livelihood of Mangrove Forest Dwellers of Sundarban', *Journal of Human Ecology*, Vol 29, No 3, pg 191-200.

Box: CONTAMINATION IN FISH

1. A Kumari, R K Sinha and K Gopal 2001, 'Organochlorine contamination in fishes of the river Ganges', *Aquatic Ecosystem Health and Management*, Vol 4, No pp 505–510.

Box: INCOME FROM NTFP

1. A Singh, P Bhattacharya, P Vyas, S Roy 2010, 'Contribution of NTFPs in the Livelihood of Mangrove Forest Dwellers of Sundarban', *Journal of Human Ecology*, Vol 29, No 3, pg 191-200.

Box: HONEY AND WAX

1. S Sen 1995, 'Impact of Mangrove Eco-system on the Rural Scenario with Reference to Moules: A case study of 24 Parganas (South), West Bengal', (Unpublished), Anthropological Survey of India, Calcutta

Chapter 6: Development deficit

1. Anon 2011, 'Improving energy infrastructure in Indian Sundarbans', West Bengal Green Energy Development Corporation Limited, Govt. of West Bengal
2. Census of India (2001), Government of India.
3. As per internal communication from Sundarban Development Authority to RGGVY in May 2010
4. Anon 2011, 'Improving energy infrastructure in Indian Sundarbans', West Bengal Green Energy Development Corporation Limited, Govt. of West Bengal
5. Ibid.
6. Ibid.
7. West Bengal Renewable Energy Development Agency, http://www.wbreda.org/
8. Anon 2011, 'Improving energy infrastructure in Indian Sundarbans', West Bengal Green Energy Development Corporation Limited, Govt. of West Bengal
9. The proposal has been approved by Rural Electrification Corporation (REC) for an amount of 110 Crores.
10. Decentralised distributed generation is defined as installation and operation of small modular power generating technologies that can be combined with energy management and storage systems. DDG operated at the local level taking advantage of renewable energy technologies. The DDG projects, if widely replicated, can reduce the burden on both electricity supply shortfalls and reducing the urgency of costly grid extension. DDG offers the potential for affordable, clean and reliable electricity with minimal losses and effective maintenance and local cost recovery.
11. Current definition of village electrification (in effect from the year 2004-05) means:

- The number of households electrified should be at least 10 per cent of the total number of households in the village.
- Basic infrastructure such as distribution transformer and distribution lines are provided in the inhabited locality as well as the Dalit Basti hamlet where it exists.
- Electricity is provided to public places like schools, panchayat office, health, centres, dispensaries, community centres etc.

12. Anon 2011, 'Improving energy infrastructure in Indian Sundarbans', West Bengal Green Energy Development Corporation Limited, Govt. of West Bengal
13. Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal, Chapter 6.
14. Data presented by the minister-in-charge during debate in the Indian Parliament, April 27, 2005 [minister?]
15. World Health Organisation 2003, Climate change and human health: Risks And Responses, [incomplete]
16. A Rahman 2008, 'Climate change and its impact on health in Bangladesh', *Regional Health Forum*, Vol 12, No 1
17. S Bhattacharya, C Sharma, R C Dhiman and A P Mitra 2006, 'Climate change and malaria in India', Malaria Research Centre, National Physical Laboratory and NATCOM Project Management Cell, *Current Science*, Vol 90, No 3, February 10
18. Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal, Chapter 05
19. Ibid.
20. Ibid.
21. Ibid.
22. Ibid.
23. A Oliver-Smith 1996, 'Anthropological research on hazards and disasters', *Annual Review of Anthropology*, Vol 25, pp. 303-28
24. J Whitehead 2005, 'The neo-liberal state in disaster management', *Anthropology News*, December 2005 http://www.aaanet.org/press/an/1205/AN2005Dec_whitehead.pdf
25. A Mukhopadhyay 2009, 'Cyclone Aila and the Sundarbans: An enquiry into the disaster and politics of aid and relief', Mahanirban Calcutta Research Group, http://www.mcrg.ac.in

26. Anon 2009, 'District Human Development Report, South 24 Parganas', Development and Planning Department, Government of West Bengal
27. Anon 2010, *Social impacts in post-Aila Sundarbans,* Jayaprakash Institute of Social Change, Kolkata
28 Ibid.
29. http://nrega.nic.in/netnrega/home.aspx

Box: COMMUNITY RADIO IN BANGLADESH SUNDARBANS

1. Platform on Disater Risk Reduction, http://www.sdc-drr.net/node/442

Box: MICROCREDIT UNDER SCRUTINY

1. S Zohir, 'Number of Microcredit Clients Crossing the US $1.25 a day threshold during 1990-2008', Economic Research Group 2010, estimates from a nationwide survey in Bangladesh, Microcredit Summit Campaign
2. D Roodman and J Morduch 2009, 'The Impact of Microcredit on the poor in Bangladesh: Revisiting the evidence', Working Paper Number 174, June, Centre for Global Development
3. Abhijit V Banerjee, Duflo Esther, Rachel Glennerster and Cynthia Kinnan 2009, "The Miracle of Microfinance? Evidence from a Randomised Evaluation', Working Paper, Cambridge, MA: MIT Department of Economics and Abdul Latif Jameel Poverty Action Lab.
4. Anon 2011, 'Microcredit in Bangladesh helped 10 million', Janaury 27, http://www.bbc.co.uk/news/business-12292108; James Melik 2010, 'Microcredit death trap' for Bangladesh's poor', November 3, http://www.bbc.co.uk/news/business-11664632

Chapter 7: Migrating to survive

1. Anon 2010, *Social impacts in post-Aila Sundarbans,* Jayaprakash Institute of Social Change, Kolkata
2. Personal communication, July 2011
3. R Basu 2010, 'Storm buffets, job drought uproots', *The Telegraph*, May 26.
4. Personal communication, Debal Roy, Chief Environment Officer, Government of West Bengal, July 2011
5. Anon 2009, *Cyclone Aila in West Bengal*, a report by Jamsedji Tata Centre for Disaster Management, Tata Institute of Social Sciences, Mumbai.
6. Anon 2010, *Social impacts in post-Aila Sundarbans,* Jayaprakash Institute of Social Change, Kolkata
7. C Tacoli 2009, 'Crisis or adaptation? Migration and climate change in a context of high mobility', prepared for *Expert Group Meeting: Population Dynamics and Climate Change, UNFPA* and the International Institute for Environment and Development, UNFPA and IIED, London, pp 24-25 June; F Laczko and C Aghazarm 2009, 'Migration, Environment & Climate Change: Assessing the Evidence', *International Organisation for Migration* (IOM), Geneva.
8. Personal communication, Anurag Danda, Worldwide Fund For Nature (WWF) - India
9. R Black, D Kniveton, R Skeldon, D Coppard, A Murata and K Schmidt-Verkerk 2008, 'Demographics and Climate Change: Future Trends And their Policy Implications for Migration', University of Sussex, Development Initiatives, Wells, UK, issued by the Development Research Centre on Migration, Globalisation and Poverty.
10. Richard Black, Stephen R. G. Bennett, Sandy M. Thomas and John R. Beddington 2011, 'Migration as adaptation', 27 Oct , *Nature,* Vol 478, pg 447
11. Anon 2006, *A report on corporate abuse in Sundarban*, Society for Direct Initiative for Social & Health Action, Kolkata
12. C Tacoli 2009, 'Crisis or adaptation? Migration and climate change in a context of high mobility', prepared for *Expert Group Meeting: Population Dynamics and Climate Change, UNFPA* and the International Institute for Environment and Development, UNFPA and IIED, London, pp. 24-25

Chapter 8: An agenda for action

1. Anil Agarwal and Sunita Narain Redressing Ecological Poverty Through Participatory Democracy: Case Studies from India, Political Economy Research Institute, University of Massachusetts Amherst
2. Bert Metz and Marcel Kok 2008, Development policy as a way to manage climate change risks of Climate Policy 8 (2), IDS Bulletin 39 (4), ''Poverty in a Changing Climate'', edited by Thomas Tanner and Tom Mitchell

3. Saleemul Huq, H Reid 2004, Mainstreaming adaptation in development. IDS bull 35(3):15–21
4. M V Aalst, I Burton, T Cannon (2008) Community level adaptation to climate change: the potential role of participatory community risk assessment. Global Environ Change 18(1):165–179
5. Heather McGray, Anne Hammill, Rob Bradley 2007, Weathering the Storm Options for Framing Adaptation and Development, World Resources Institute (WRI)
6. Janssen et al 2006 showed in a bibliometric study of more than two thousand publications
7. Terry Cannon, Detlef Mu¨ller-Mahn 2010, Vulnerability, resilience and development discourses in context of climate change, Natural Hazards, 55:621–635, DOI 10.1007/s11069-010-9499-4
8. 40 p.c. want to quit farming: survey http://www.hindu.com/2005/08/01/stories/2005080114651800.htm
   40% Farmers want to quit Farming-NCAP Study
   http://www.indianfarmers.org/news_singlepage/40_Farmers_news.html
9. Stop blaming rural migration for urban ills: Study http://articles.economictimes.indiatimes.com/2011-11-30/news/30458780_1_urban-areas-rural-areas-urban-population
10. J Agyeman, R D Bullard, B Evans (eds) (2003) Just sustainabilities. Development in an unequal world. Earthscan, London
11. V Santhakumar, A K Haque, R Bhattacharya 2007, An Economic Analysis of Mangroves In South Asia, Tata McGraw Hill
12. D Pearce, and D Moran 1994, The Economic Value of Biodiversity, Earth Scan Publication Ltd, London
13. M C Lemos,and Emily Boyd 2009, The politics of adaptation, Chapter in Boykoff, M. forthcoming. Politics of Climate Change: A Survey. Cambridge University Press
14. T Tanner & T Mitchell 2009, Entrenchment or Enhancement: Could Climate Change Adaptation Help to Reduce Chronic Poverty?
15. J Farrington & J Clarke 2006, Growth, Poverty Reduction and Development Assistance in Asia: Options and Prospects
16. E Boyd and E Tompkins 2010, An Introduction to Climate Change. Oxford, OneWorld
17. E Tompkins, M C Lemos, E Boyd 2008, A less disastrous disaster: Managing response to climate-driven hazards in the Cayman Islands and NE Brazil. Global Environmental Change, Vol.18: 4. Page 736-745

Annexure: Case study: Mousuni *Gram Panchayat*

1. S Hazra and B Samanta 2009, 'Studies in selected sectors of Mousuni *gram panchayat* of Namkhana Development Block for climate change adaptation and awareness', School of Oceanographic Studies, Jadavpur University, Kolkata
2. Ibid.
3. Ibid.

Centre for Science and Environment
41 Tughlakabad Institutional Area, New Delhi – 110 062, India
Ph: 91-11-2995 6110, 2995 5124, 2995 6394, 2995 6499
Fax: 91-11-2995 5879, 2995 0870
Email: chandra@cseindia.org **Website:** www.cseindia.org