The Sundarbans:
Climate Change and Adaptation Measures

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Section 1

Introduction

1.1 The Sundarbans

The Sundarbans is the largest continuous mangrove forest in the world, the majority of which (6,017 square kilometer) lies within the boundaries of Bangladesh; the rest of it is in West Bengal, India. The Bangladesh part of it consists of 4,143 km^2 of land area and 1874 km^2 of water area. The Sundarbans was declared a reserve forest in 1875.

The Sundarbans Reserve Forest (SRF) is a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests (Forest Department, 2010). The land area is covered with mangrove trees, shrubs, grass land or simply bare ground. The water bodies which crisscrosses the SRF consists of tidal river, canals, creeks, etc. The SRF is subject to semi-diurnal tides. Around 65% to 70% of the Sundarbans goes under water twice in a day. However, the percentage rises to 85% during the wet season.

The mean range of spring tide is about 2.9 meters at Heron Point and 4.0 meters at Mongla (source: IWM). The range varies across the Sundarbans depending on many factors including the depth of the water and the width of the area. On average, the tidal range is 3 to 3.5 meters during spring tide. On the other hand, during neap tide, the tidal range varies from 1.5 to 2.5 meters. The mean water level of the rivers rises during the rainy season and declines during the dry season. However, the tidal range is somewhat lower during the wet season and is higher in the dry season[1].

1.2 Impact of Climate Change

[1] Source: IWM

The impact of climate change on the SRF and the landscape region would be considerable. The landscape region would be primarily impacted upon through three separate avenues. They are: frequent cyclones and storm surges, rising salinity level and inundation of more land.

First, the probable impact of climate change would be more frequent and stronger cyclones hitting the SRF and the interface landscape region. Huge storm surges frequently accompany these cyclones. Measures have to be undertaken to minimize the exposure of the landscape population to more frequent and more intense cyclones and associated storm surges.

The most harmful impact of climate change would be felt due to rising salinity level in the region induced by sea level rise (SLR). In the expected scenario, the salinity frontier would continue to push inland, as well as into the Sundarbans. SLR, reinforced by local effects such as subsidence, would cause deep salinity intrusion into the landscape region and beyond. Rising salinity level would likely result in further reduction of land productivity in the region which has the potential to make the landscape population even poorer in the future.

The issue of inundation, however, seems to be quite controversial. Some researchers suggest that large areas of the SRF will go under water due to Mean Relative Sea Level Rise (MRSLR) by 2050. Some other experts, however, disagree. They argue that the sedimentation rate has been left out of the equation which should also be taken into account in the case of the Sundarbans. The rate of sedimentation will play a vital role in determining the extent of SLR impact on the Sundarbans. It seems almost all practitioners and experts agree that the sedimentation rate is around 1 cm per year. However, there are different opinions regarding the future rate of sedimentation. Some assume that even the current rate may not continue in the future due to unavailability of silt. Others disagree. They believe that with future RMSLR, the rate of sedimentation will increase, provided enough silt is available, as the depth and duration of water on inundated land will increase. As a result, they believe that there will be little

likelihood that the large portion of the Sundarbans will permanently go under water. However, it seems that if RMSLR is fast and not much silt is available, the Sundarbans may not have enough time to cope with the new sea level. Note that the inhabitants of the landscape region won't be directly affected, in the short run, by inundation as they mostly live inside the polders.

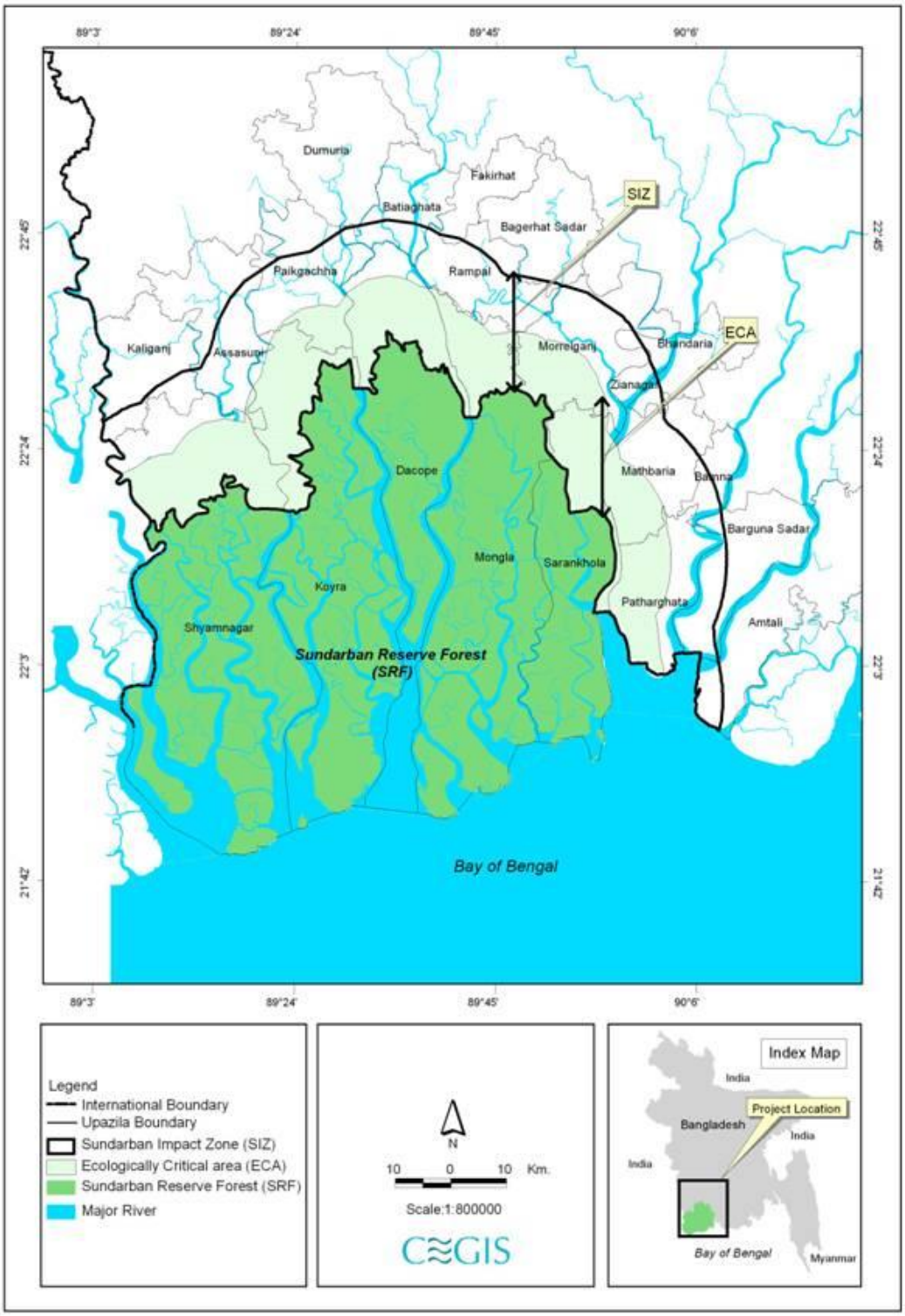
1.3 The objectives of the study

The Objective of the study is to identify the probable adaptation policy options for the policy makers especially targeting the poverty stricken segments of the population of the Sundarbans landscape of Bangladesh. The study has focused on those policy options which are particularly relevant to the Sundarbans landscape region. The policies which are generic and generally suggested for the poor of the rest of the country as well are not investigated in this report. In the case of each of the suggested policy options, a brief background of the current situation has been presented along with indications as to which agencies should be involved in the program implementation.

1.4 The Landscape: Definition

The Sundarbans region is defined as the SRF plus its interface landscape area. A narrower concept of the landscape region, known as the Economically Critical Area (ECA), consists of the areas which are within 10 kilometers from the perimeter of the SRF. The other, albeit broader, definition of the landscape region, known as the Sundarban Impact Zone (SIZ), consists of areas which are within 20 kilometers from the perimeter of the SRF. Clearly, the whole of ECA lies within the boundary of the SIZ. In this study, the SIZ is our area of interest. However, information on the ECA will be frequently used for analytical purposes as more information on the area seems to be available.

Figure 1: The Landscape Area: ECA and SIZ



1.5 Policy Formulation

The adaptation policies recommended in this report could be broadly categorized into three groups:

i) policies to reduce exposure of lives and properties of the landscape area to adverse climatic changes and events;

ii) measures which would lead to enhanced eco-friendly livelihood options for the poor people of the landscape area, reducing their vulnerability to climate change; and

iii) strategies relevant for the infrastructure sector, especially drinking water supply infrastructure, of the area

Probable future scenarios in the environment and economic arena of the region have been taken into consideration while formulating policy suggestions. For example, the current ban on tree felling has been assumed to continue. For illustration, the case of golpata and honey collection is presented below.

Activities associated with golpata, grass and honey collection are arduous and ill paying jobs. In addition, the bawals and mouals expose themselves to serious risks of suffering bodily harm even death. As one can easily imagine, such a job is only performed by persons suffering from crushing poverty. With expected steady GDP growth of the country, demand for some of these goods such as golpata is likely to decrease over time. In addition, with per capita income growth, less and less people would be interested in taking up such jobs. However, honey production will likely turn into a modern system of apiary instead of the current practice of hunting bee hives in the forest. However, in the short run, bee hive hunting in the forest will likely continue.

1.6 Structure of the Report

The remainder of the paper is organized as follows. Section 2 describes the location and demography of the landscape region, and examines economic condition and dependence of the residents of the landscape area on the SRF. Section 3 presents recommended measures to

reduce exposure of the local population to adverse climatic events and climate change. Section 4 specifies policy measures to enhance livelihood opportunities for the poverty stricken population of the area. Section 5 discusses policy issues related to infrastructure, while Section 6 concludes.

Section 2

Ecologically Critical Area (ECA) & Sundarban Impact Zone

2.1 Introduction

The Ecologically Critical Area (ECA) consists of areas which are within 10 kilometers from the perimeter of the SRF. The area covers 11 upazilas, partially or fully. As Rampal upazila has very little land within the ECA, we have ignored Rampal upazila in our analysis. The list of the rest of the ECA upazilas can be seen in Table 1. Note (Table 3) that more than 70% area of each of five upazilas namely Mongla, Sarankhola, Dacope, Koyra and Shyamnagar lie within the Sundarbans Reserve Forest (SRF). Nobody is allowed to live inside the SRF, however.

2.1.1 Population

Total population of the ECA in 2011 has been estimated at 1.12 million. Inter-census population growth between 2001 and 2011 was 14.75% (adjusted) for Bangladesh as a whole. Rural population has grown by 15.2% over the same period. However, It can be seen from Table 1, the population in the ECA areas has not increased at all rather it fell by 2.2%. The fall is most pronounced in Mongla and Morrelganj. Others have experienced either a fall or marginal increment in population. Considering the fact that the rural population growth was 15.2% for the country as a whole while the ECA area experienced negative population growth may be alluding to the reality that the socio-economic life in ECA/SIZ areas are harder compared to most other

rural areas of Bangladesh. As a result, locals are migrating out of our study areas on a large scale over time.

The population density of ECA upazilas (see Table 1) is much lower compared to the country average of 976 per square kilometer in 2011. The lowest density was in Patharghata (423 per square kilometer) in 2011 and experienced only 1.2% growth of population over the decade. Dacope with 530 per square kilometer had the second lowest population density and yet lost more than 3.3 percent of its population over the last inter-census decade. Perhaps poor quality of land - not land availability per head- scarcity of alternative job opportunities and exposure to frequent natural calamities are the factors which are causing migration on such a large scale. Recent research, however, indicates that storm surges or hurricanes in themselves do not

Table 1: ECA Population 2001 and 2011

Upazila	Population 2001	Population 2011	Upazila Area (in sq km, excluding reserve forest)	Upazila Land in ECA (in sq. km)	Upazila Population Density per sq.km in 2011	ECA Population 2011	ECA Population 2001	Change (in %)
Assasuni	249244	268754	402.4	12.1	668	8063	7477	7.8
Sarankhola	114083	119084	204.3	196.7	583	114673	109858	4.4
Mongla	149030	136588	190.0	175.3	719	126081	137566	-8.3
Morrelganj	349551	294576	460.9	165.9	639	106047	125838	-15.7
Shyamnagar	313781	318254	452.7	314.9	703	221394	218282	1.4
Koyra	192534	193931	319.6	301.8	607	183157	181838	0.7
Dacope	157489	152316	287.6	228.1	530	120802	124905	-3.3
Paikgachha	248112	247983	411.2	78.1	603	47117	47141	-0.1
Mathbaria	263527	262841	353.3	127.2	744	94623	94870	-0.3
Patharghata	162025	163927	387.4	224.7	423	95078	93975	1.2
Total			3,469.1	1,824.8		1,117,035	1,141,750	-2.2

appear to cause much migration. After all, big storm surges and powerful hurricanes take place only once in many years. However, if these extreme events[2] have lasting adverse impact on land productivity and degrade other sources of income, probability of migrating out sharply increases.

Table 2: Percentage of Population under Lower and Upper Poverty Line

Upazila		Extreme Poor as % of population (Lower poverty line)	Extreme Poor as % of population (Lower poverty line)	Poor as % of population (Upper poverty line)	Poor as % of population (Upper poverty line)	Literacy rate (%)
		2010	2005	2010	2005	2011
Assasuni		32.0	57.5	48.4	70.3	49.8
Sarankhola		28.2	48.7	48.0	62.8	58.9
Mongla		22.7	41.5	41.9	56.4	57.2
Morrelganj		27.0	50.0	46.5	64.0	60.7
Shyamnagar		33.8	65.2	50.2	75.7	48.6
Koyra		29.1	34.8	49.1	50.0	50.4
Dacope		24.9	60.4	44.5	73.3	56.0
Paikgachha		23.3	34.4	42.4	49.6	52.8
Mathbaria		25.6	17.9	38.0	38.1	61.7
Patharghata		6.1	36.1	12.9	56.3	60.5

2.1.2 Poverty

[2] For example, breaching of embankments may lead to salinization of cultivable land which constitutes a major income source for the villagers. If the land is damaged and is expected to remain so for more than a short period of time, the land owners and tenant farmers may be forced to actively consider migration as one of the coping strategies against reduced levels of income.

In Bangladesh, the percentage of population below lower poverty line was 17.6% in 2011. In the ECA area, except Patharghata, the percentage of population who lives below poverty line is higher, compared to the rest the country. Considering the fact that these are basically rural areas, the region still is in worse shape compared to the rural area of the country as whole, where 21.1% people live below lower poverty line. As can be seen in Table 2, two upazilas, Ptharghata and Shyamnagar, stand out. First, Patharghata is surprisingly better off. It would be interesting to identify the causes. If the drivers of lower level of poverty in Patharghata can be identified and could be replicated in other upazilas of our interest, that would be a huge step in alleviating poverty in the ECA/SIZ zones of the Sundarbans. Second, poverty situation in Shyamnagar of Satkhira district is the worst of all. Compared to country average of 21.1% (rural only), 33.8% people of Shyamnagar live below lower poverty line. Similar pattern emerges if one considers upper poverty line.

2.1.3 Literacy

In Bangladesh, 47.16% of rural population was literate in 2001. Shyamnagar and Assasuni of Satkhira district and Koyra of Khulna district scored slightly higher than 47.16% which is rural average for the whole country. However, their performance in terms of poverty is below country (rural) average. Again, Sarankhola (58.9%), Morrelganj (60.7%) and Dacope (56.0%) are in much better position in terms of literacy rate. In spite of their higher literacy rates compared to the rural Bangladesh as a whole, they seem to be doing poorly compared to the rest of the country in terms of poverty. Is it possible that poor quality of agricultural resources, especially affected by elevated level of water and soil salinity along with their exposure to extreme events, putting the populace of the area in a disadvantageous situation? However, their better than average literacy would be helpful in running crab fattening farms more efficiently as Sahu (2012) has found in West Bengal, India in a study.

2.2 Sundarban Impact Zone

The Sundarban Impact Zone (SIZ) consists of areas which are within 20 kilometers from the perimeter of the SRF. The area covers partially or fully 21 upazilas. By definition, ECA areas constitute part of the SIZ. As we have seen earlier, the SRF itself spans over parts of five upazilas of the area. The percentages of areas of 21 upazilas in the Sundarbans Reserve Forest (SRF), Ecologically Critical Area (ECA) and Sundarbans Impact Zone (SIZ) are shown separately in Table 3.

Table 3 : Area coverage in the SIZ by district and upazila name

District	Upazila	% of area coverage			
		SRF	In ECA	Outside ECA but in SIZ	SIZ in total
Barguna	Patharghata	-	58	42	100
Barguna	Bamna	-	-	39	39
Barguna	Barguna Sadar	-	-	34	34
Barguna	Amtali	-	-	9	9
Pirojpur	Mathbaria	-	36	49	85
Pirojpur	Bhandaria	-	-	14	14
Pirojpur	Zianagar	-	-	51	51
Bagerhat	Mongla	87	12	1	13
Bagerhat	Morrelganj	-	36	44	80
Bagerhat	Rampal	-	1	81	82
Bagerhat	Sarankhola	73	26	1	27
Bagerhat	Fakirhat	-	-	3	3
Bagerhat	Bagerhat Sadar	-	-	2	2
Khulna	Batiaghata	-	-	27	27
Khulna	Paikgachha	-	19	55	74
Khulna	Dacope	71	23	6	29
Khulna	Dumuria	-	-	-	-
Khulna	Koyra	82	17	1	18
Satkhira	Kaliganj	-	-	23	23
Satkhira	Shyamnagar	77	16	7	23

Satkhira	Assasuni	-	3	44	47

Source: CEGIS (2012)

A very small area of Dumuria upazila is also a part of the SIZ. However, in our calculations, that portion of SIZ has been ignored. Total population of the SIZ in 2011 has been estimated at 2.30 million.

2.2.1 Dependence on the Sundarbans

People living around the Sundarbans, especially people living in the landscape area are likely to be directly dependent on the Sundarbans. A substantial number of people from other parts of the country could also be involved in extracting and exploiting resources of the Sundarbans. However, their number seems to be not large. In a BIDS report, the proportion of people living in the ECA who are dependent on the Sundarbans was estimated at 28% (Forest Department, 2010). In a survey, Bangladesh Centre for Advanced Studies (BCAS) found that among their interviewees who live in the SIZ areas, 84.8% fishers and 89.3% who do forest related work live in the ECA part of the SIZ region (CEGIS 2012). One may reasonably conclude from BCAS study that less than 15% of people engaged in these professions live in the SIZ but outside the ECA. However, the sample seems to be biased towards ECA region i.e. over-sampling has occurred in the ECA.

Nonetheless, if 28% of ECA population assumed to be directly dependent on the Sundarbans, approximately little over 0.31 million people are in this category. If BCAS figures represent the actual situation, less than 80,000 from the rest of the SIZ are dependent on the Sundarbans. Altogether, it seems that at best 0.4 million people who live in the SIZ are directly dependent on the Sundarbans. Accuracy of the figure is contingent on the randomness of the BCAS sample. The figure 0.4 million, however, does not include the population who are indirectly dependent on

the Sundarbans. In order to better assess the situation, a rigorous well sampled survey needs to be undertaken

Section 3

Exposure Reduction

3.1 Introduction

The coastal zone of Bangladesh is prone to cyclones. Every year, cyclones hit the southern coastal region of the country. A severe cyclone will hit the country once in every three years on average. The problem is set to exacerbate with climate change. The cyclones are expected to be more frequent and more intense in nature. Accompanying storm surges are expected to be stronger, exacerbated by sea level rise.

In the context of long history of sufferance from storm surges associated with powerful cyclones, the government has built embankments, cyclone shelters and developed early warning system, effective evacuation system and worked diligently on raising awareness. The result of these efforts undertaken for more than five decades has resulted in dramatic drop in number of deaths. However, with climate change and existing deficiencies in the system, some improvements are needed over the current infrastructure. The following paragraphs present ongoing and planned infrastructural development and other undertakings that seek to minimize exposure of the SIZ population and suggest undertakings deemed necessary to enhance effectiveness of the warning and evacuation systems.

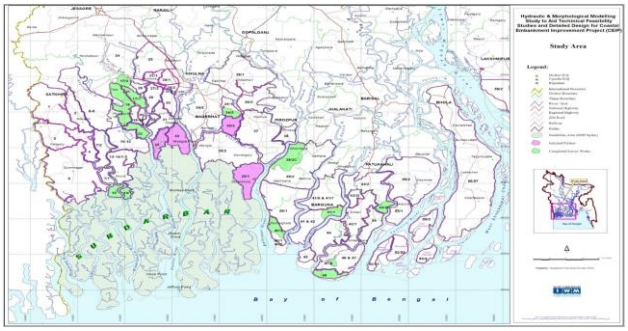
3.2 Embankments:

A World Bank document states that “The Government has always sought to buffer the socioeconomic activities and assets of the coastal population from natural hazard risks. Their commitment to develop a safe and inhabitable coastal zone dates back to the 1960s.

……..Overall, the Government invested about US$10 billion towards the development of structural (i.e. cyclone shelters, cyclone-resistant housing) and non-structural (i.e. early warning and awareness raising systems) disaster mitigation and preparedness systems” .

Figure 2 : Coastal Embankment Improvement Project (CEIP)

Objectives:
- Increase resilience of coastal population to natural disaster and climate change
- Reduce asset, crop and livestock loss
- Reduce recovery period required after natural disaster
- Improve agricultural production by reducing saline water intrusion



A number of polder embankments in the SIZ are going through reconstruction, rehabilitation, realignment and height enhancing programs under Coastal Embankment Improvement Project I (CEIP I), the first part of a multi-phased program financed by the World Bank (see Figure 2). The current phase of the program has particularly focused on the landscape districts plus Patuakhali as can be seen in Figure 2. The program is expected to reduce exposure of the ECA/SIZ population from natural disasters. There would be other phases of the program covering altogether 17 polder embankments for improvement, most of which are located in the SIZ districts.

3.3 Multipurpose Cyclone Shelters

A large number of cyclone shelters already exist in the area. More are being built with financing from various development agencies such as the World Bank.

Table 4: Cyclone Shelters; Requirement and Capacity

District	Upazila	Projected Population by 2025 as per BBS	Total Capacity of Cyclone Shelters after Completion of all Planned ones	Demand Projection	
				Population without Cyclone Shelters	Additional No. of Shelters Needed
Bagerhat	Sarankhola	126920	26612	100308	72
	Mongla	141173	42370	98803	71
	Morrelganj	304465	80908	223557	160
Satkhira	Shyamnagar	332348	44955	287393	205
Khulna	Koyra	193913	63110	130803	93
	Dacope	152316	35600	116716	83
	Paikgachha	247983	28380	219603	157
Pirojpur	Mathbaria	263216	86585	176631	126
Barguna	Patharghata	169782	119823	49959	36
	Total	1932116	528343	1403773	1003
Average capacity per shelter is assumed to be 1400					

As can be seen from Table 4, a large number of shelters have to be constructed soon. Even for the current level of population of ECA (around 1.12 million), the capacity of existing plus planned ones hardly satisfies 50% of the current requirement. However, one alleviating fact is that a substantial portion of the potentially affected people can also take shelter in other private or public brick-built buildings[3].

Apart from inadequate capacity of cyclone shelters in some areas, a number of cyclone shelters are difficult to access. In other cases, some NGO built cyclone shelters are in such locations that, after few years, those shelters no longer exist due to erosion. The upcoming ones should avoid such problems. Other problems such as lack of proper toilets, attending to special needs

[3] The issue is further discussed below

of women, accessibility for physically challenged, availability of drinking water, etc. are currently being addressed, at least in many newly constructed and under construction ones. These cyclone shelters could be used as schools and/or as office space when they are not in use in non-emergency times.

3.4 Foreshore Afforestation

Foreshore afforestation by dissipating wave energy reduces damage to embankments and help save the embankments from breaching. The major benefit of a well-planned foreshore afforestation program is that it helps protect life and property of the polder inhabitants. In addition, if appropriate combinations of species are chosen, the locals of the SIZ would be able to enjoy enhanced co-benefits of such programs. For example, presence of trees such as Goran Keora, and Khulshi would yield benefit in terms of enhanced potential for honey production along with other well-known cobenefits of a properly designed coastal afforestation program. In exchange of the co-benefits, the nearby inhabitants could be involved into co-managing the maintenance of the plants and the embankments.

At present, much more needs to be done regarding foreshore afforestation. Previous less than successful afforestation programs need to be carefully studied and pitfalls plaguing those endeavors have to be identified and avoided in future afforestation programs.

3.5 Brick-built Houses

Over time, with economic growth, more and more houses will be brick-built with concrete roof. These houses can play the role of mini-cyclone shelters during emergencies for a single or multiple neighboring families. These houses could be built on stilts if needed. The advantage of these brick-built houses is that the potential users can go to the “shelters” almost at the last minute. With experience of many evacuations and not many actually devastating storm surge,

people are frequently reluctant to move to cyclone shelters. With the availability of neighboring "cyclone shelters", it would be easier for them to evacuate when actual need arises.

In order to expedite the process of having more brick-built buildings with concrete roof, subsidies and tax breaks could be provided on building material such as bricks. Subsidized house building loans could be extended to the locals for the same purpose. As more and more such houses are built, usage of cyclone shelters will correspondingly decline.

3.6 Early Warning and Evacuation System

Early warning and evacuation system, especially the evacuation system, have become more and more effective over the years. However, the current system of early warning is not small area specific and doesn't give area specific inundation depth warnings. As a result, people of the coastal area as a whole are getting tired of evacuations and, in many instances, are reluctant to evacuate[4]. More precise forecasts regarding the land fall location plus area specific inundation would help improve the situation.

For precise forecasting, capacity of Bangladesh Meteorological Department (BMD) needs to be enhanced. Their technical capacity needs to be improved. Donor agencies are interested in such endeavor. However, quality staff for the purpose seems to be in short supply in the BMD. With current levels of status and remuneration available at BMD, not many people with requisite qualifications would be interested in joining the team. The issue is complicated as BMD is a government department and as such the specific problem of quality manpower needs to be resolved in an innovative manner.

3.7 Exposure Reduction through Migration

3.7.1 Introduction

[4] There are other well-known reasons such as risks of theft for non –evacuation or delay in evacuation.

As can be seen in Table 1, the population of the ECA has actually fallen during the inter census period of 2001 to 2011 in contrast to the rest of the rural Bangladesh which experienced 15.2% growth over the same period. This, in some sense, is good news for the sustainability of the Sundarbans as large number of poor people living in proximity of the forests inevitably leads to enhanced biotic pressure on the nearby vulnerable forests. The phenomenon seems to be the reality across the world. In view of this, policies may have to be adopted which ultimately lead to further thinning out of population in the ECA/SIZ areas.

One of the policy aspects regarding the SIZ area should then be to reinforce push/pull factors which would induce migration from the landscape region, reducing demographic pressure in the ECA/SIZ areas. It is expected to result in reduced biotic pressure on the SRF. Policies should be such that the migrants from the area would be better off, compared to the situation they would have been in had they stayed back. In addition, researchers have found (Ravallion 2007; Glaeser 2011) that the later generations of rural migrants are almost always better off compared to its counterparts who stayed back. It works as an added incentive for migration to urban areas. If such win-win policies could be devised, it would be better for both the local people and the ecology of the area, especially for the sustainability of the SRF.

One problem is if migration policy becomes highly successful and the area becomes less populated, land availability per person would rise in the area. This may draw immigrants into the area from other land poor areas. Under the constitution of Bangladesh, a Bangladeshi citizen can’t be prevented from migrating to the SIZ.

3.7.2 Training and Skill Development

One way to lure the local population, at least the young, away from SIZ area is to train them to be skilled ones so that they could get better income opportunities outside the region. The

prospective opportunities could be, for example, in the garments sector, other sectors in the urban areas, and abroad.

3.7.2a Export oriented readymade garments sector:

The export oriented readymade garments sector is the largest manufacturing sector and the largest manufacturing employer in the country. It has exported around $24.49 billion (Finance Division, 2015) worth of apparels in 2013-14 employing, directly and indirectly, millions. The aim is to reach $50.0 billion by 2021-22. Future for enhancing readymade garment export seems to be good in view of prospective gradual exit of China from this sector. Currently, China is the largest exporter with 40% of total world export, and Bangladesh is in second position with 6.4% market share (source: World Bank). With China moving to higher value added exportable products, prospect for the Bangladesh garments sector seems to be bright. With rise in export, increasing number of garment workers would be needed in the country as a whole. The inhabitants of the SIZ should be trained and prepared to seize the upcoming employment opportunities in the readymade garments sector.

Local women and men could be trained in training institutes for jobs in the garments sector. Recent trend indicates that it is getting increasingly harder for the illiterates to get a job in the sector. With relatively higher literacy rate of the area, it should be easier for them to get a job with acquired training in the sector. Recently, Bangladeshi garment workers are also being hired in other countries. This should work as an added incentive.

As the readymade garment sector employs large number of women, the opportunity for employment is correspondingly large for them. When women along with men migrate to the urban areas and are employed there, it is likely that their migration is permanent.

The World Bank is already financing such projects which extend training for employment in the modern sector. For example, the IDA financed Northern Areas Reduction-of-Poverty Initiative

(NARI) project extends training for poor women to make them eligible for jobs in the export-oriented garment sector. The program has training centers, dormitories for the trainees and job placement facilities. The trainees also receive a small stipend during their training period. This well thought out program has the Ministry of Labor and Employment (MoLE) as the coordinating agency and the Bangladesh Export Processing Zones Authority (BEPZA) as the implementing agency. Our suggestions are allong the same line. Programs such as this could be financed in order to undertake training programs for men and women for the garments, transport and construction sectors. In addiion, the programs can also train up poor people of the Sundarbans region for overseas jobs.

3.7.2b Overseas Employment

Millions of Bangladeshis are currently employed in different countries across the globe. The primary market for Bangladeshi labor is the Middle East and Malaysia along with few developed countries. Remittance from them to Bangladesh was $14.23 billion in FY 2013-14 (Finance Division, 2015). Local youths could be trained in skills which are in demand in the host countries. For example, construction and agricultural workers, cleaning and maintenance staff, shop and restaurant help are in much demand. If job aspirants are locally trained in terms of job skill and some rudimentary language proficiency, they should be better prepared for recruitment.

The training institutes could also help them in accessing information[5] on job opportunities and help them in navigating the employment procedure. If required, small amount of loan could be extended against confirmed job offer. Precaution should be undertaken so that the overseas job applicants do not get cheated out of their meager savings.

3.7.2c Other Domestic Job Opportunities

[5] BBS (2013), Survey of Utilization of Remittance

Some of the skills, mentioned above, which would be imparted could also be useful for getting a local job. With economic growth, more and more skilled workers would be needed in different sectors of the economy. For example, in the transport sector, increasing number of drivers and mechanics would be in demand. Training for such domestic market oriented jobs will be of help for the new job aspirants in the modern sector.

3.7.2d Implementing Agencies:

Training programs could be arranged by government agencies, NGOs, and private profit-oriented entities. Among government entities, Department of Youths and Sports, Bureau of Manpower, Employment and Training (BMET), Ministry of Labor and Employment (MoLE) and Bangladesh Export Processing Zones Authority (BEPZA) could be involved. NGOs and profit oriented private entities could also play a vital role in actually extending the training. PKSF, BGMEA and BKMEA could provide valuable guidance to the training programs.

Finally, if facilities and subsidies are provided for the training program meant for local people, almost inevitably people from neighboring areas would be attracted. Overcrowding may eventually crowd out, to some extent, the local residents. In order to prevent such an outcome, only local people should be made eligible for such training programs. For example, one of the eligibility criteria could be proof of residency in the locality for the last ten years at least.

Section 4

Enhancing Livelihood Opportunities

4.1 Mud Crab Aquaculture

4.1.1 Introduction

Demand for live crab and crab meat is increasing worldwide. Rising international demand has induced sharp rise in production and export of mud crab from Bangladesh in recent years[6]. In particular, mud crab (Scylla serrata) culture has been assuming greater importance in the coastal regions of Bangladesh including the Sundarbans impact zone. Scylla serrata is also known as green mud crab or mangrove crab. Its meat is considered tastier compared to other crabs by many. Perhaps this is the reason why mud crab (Scylla serrata) commands higher price in the international market compared to other comparable crabs. Its higher price could be partly attributed to its popularity with the consumers and relatively larger size.

A mud crab spends almost 90% of its life cycle in mangroves. As mud crab lives in mangroves, it is naturally available in the Sundarbans, the largest mangrove in the world. They can be found in large numbers in the districts surrounding the Sundarbans such as Khulna, Bagerhat, and Satkhira. In the coastal southwest region of Bangladesh, crablets are collected from the SRF, tidal rivers, and creeks as well as shrimp farms or ghers. For crab farms in the landscape region, Sundarbans' mangrove region is the primary source of crab fry.

The landscape region is also suitable for crab farming. More than one hundred ninety thousands of hectares of land which are located close to the tidal zone in the southwestern region of Bangladesh are suitable for crab aquaculture (Salam et al., 2003). Much of it overlaps the Sundarbans landscape region.

The suitability of mud crab aquaculture in brackish water and estuarine areas and easy availability of crablets from the wild make crab farming for the people, rich or poor, of the Sundarbans landscape region an attractive option.

4.1.2 Crab Aquaculture

[6] However, in-country demand for live crab or crab meat remains limited as the Muslims prefer not to have crab meat.

Basically, there are two types of mud crab aquaculture: grow-out and crab fattening. Under the grow-out system, juvenile mud crabs are stocked in some form of enclosure such as a tank or pond. Crablets are fed and reared until they reach marketable size. Juvenile crabs grow quite fast reaching marketable size in 4 to 10 months depending on species and the definition of marketable size. The grow-out system is less popular with the farmers as it takes longer period of time to realize return on investment.

Crab fattening, on the other hand, is a process which basically involves keeping immature female crabs (less than 80 grams) and/or recently molted water crabs (usually less than 120 grams) in some form of enclosures for a period of 2 to 4 weeks until they mature. Enclosures such as cages, floating cages, ponds or tanks are used to hold mud crabs for fattening purposes. The matured crabs are then harvested and sold in the market.

Matured female crabs mean female crabs with developed gonads and filled mantle cavity. Market demand for gravid female mud crabs with full orange-red egg masses is strong in the East and Southeast Asian countries. Empty or recently molted crabs are kept in the enclosure until they completely fleshed out. In other words, their shells become hard.

Crab fattening as opposed to grow-out system has some advantages. First, turnover is fast; the whole process lasts 3 to 4 weeks. Second, risk of cannibalism is greatly reduced as no molting takes place. In the cage system where crabs are put in separate cages, the possibility of cannibalism taking place is remote. Third, due to short production time, risk of disease is lowered. Survival rate is more than 90% in fattening system, while the rate is only 40% in grow-out system (Source: NIOT). As a consequence, financial risk of crab fattening seems to be minimum.

Note that the crab fattening system depends on yhe relatively bigger size of crabs which they have to source either from the wild or from grow-out farms. In Bangladesh, many shrimp ghers play the role of grow-out farms. In a situation where wild-caught crablets are in short supply, the crab fattening farms have to source seedstocks from the grow-out farms.

Crab fattening is done mainly following two systems: fattening in cages and the other is fattening in encircled earthen brackishwater pond. Relevant operators in the sector understand that both systems are profitable. The enclosures can also be constructed in the tidal rivers of the SRF and its creeks. Jahan and Islam (2016) in analyzing profitability of crab fattening under pond system found that return on crab fattening is at 18% in one season which lasts from November to February. The data were collected in 2013 and a rigorous cost accounting method was followed. Cost of crab fattening per acre per season was estimated at Tk. 729,169 at 2013 price level and profit was Tk.134,695 per acre. The estimated return seems to be quite high given such a short period of investment.

Begum et al. (2009) found that the cage system is more profitable compared to the encircled pond system. One reason for the poor performance of the pond system is cannibalistic behavior of the mud crabs. When a crab molts, it becomes soft-shelled and risks becoming food item of others, usually larger crabs. The rates of return estimated by the authors in both cases are even higher compared to the estimate of Jahan and Islam (2016). However, estimated capital requirement of the cage system, according to Begum et al. (2009), is much higher compared to the pond system. However, the return rate is also higher in the case of the cage system.

4.1.3 Crab Hatchery

Current production of mud crabs in Bangladesh is almost entirely dependent on seedstocks collected from the nature. Juvenile mud crabs are collected from the wild especially in Khulna, Satkhira and Bagerhat among other districts. While collecting juvenile crablet is a profitable

occupation for many living around the Sundarbans which provide an alternative source of income to thousands, including a large number of women, dependence on the wild, however, may lead to unsustainable level of collection and result in adverse environmental impact.

Large expansion of mud crab aquaculture would lead to enhanced pressure on the natural source of supply of crablets. For example, in many East and Southeast Asian region, crab culture was dependent on collection of crablets from the wild. Countries such as Indonesia and Phillipines experienced price rise in the past for crablets as enhanced demand had put pressure on its natural sources of supply. As a result, these countries have moved on to hatchery produced crablets. If Bangladesh decides to encourage crab aquaculture in a major way in order to earn foreign exchange and to provide alternative income opportunities for the coastal population, especially for the poverty stricken people of the Sundarbans landscape region, the only sustainable way would be to go for hatchery produced crab seedstock.

The primary problem of hatchery production of seedstock is high mortality rate. The attempt is going on for hatchery-sourced crablets in Bangladesh albeit with limited success. The Department of Fisheries is in the process of establishing a full-fledged mud crab hatchery in Bangladesh in order to supply hatchery produced seedstock. PKSF and Bangladesh Fisheries Research Institute (BFRI) are also in the process of development of crab hatcheries.

Bangladesh should develop relationships with countries such as China, Japan, and Vietnam where commercial production of crablets for farming are already taking place. In neighboring India, Rajiv Gandhi Centre for Aquaculture in Tamil Nadu has established a mud crab hatchery. Their mortality rate seems to be quite low. With increased demand for hatchery produced crablets, private entrepreneurs are also expected to come forward. The process of establishing public and private hatcheries could be accelerated with assistance from agencies such as the World Bank, GIZ and USAID.

Location of a crab hatchery should be carefully selected. While proximity to grow-out and fattening area frequently predominates the choice of the location, it is important for the site to have unpolluted source of marine seawater and freshwater as it better reflects offshore water conditions under which mud crab eggs hatch naturally (Shelley and Lovatelli 2011).

4.1.4 Female Participation

Both men and women participate in the juvenile crab collection process. However, women primarily collect from river banks and ghers. Their presence in the collection from the SRF is quite limited. On the other hand, men collect crablets from all available sources.

The women of the crab grow-out and fattening families participate in the production process at different levels. They are most active in feeding and harvesting parts of the process. However, their participation rate in marketing part of the process is comparatively low (Joarder, 2014). This could be attributed to unfriendly social customs or work load due to household chores or both.

Similarly, in the neighboring West Bengal, Sahu et al. (2012) found evidence indicating active participation of women in the mud crab culture. The rate of women participation, as in Bangladesh, is higher in feeding activity and lower in marketing activities. Experience in both Bangladesh and West Bengal indicate that with growth of crab culture (both grow-out and fattening), there will be more participation of women in the labor force. In addition, their participation increases their role in the household decision making processes as has been found in Sahu et al. (2012) study. The authors also found that more educated farmers run crab fattening enterprises more efficiently. Relatively higher literacy rate in the ECA/SIZ areas is expected to be conducive to a relatively efficient crab fattening aquaculture in the area.

4.1.5 Export

Total earning from mud crab export from Bangladesh has reached $22.91 million dollars in 2013-14 compared to $15.83 million in the previous year (Source: Dept. of Fisheries). China is the main destination of crab export from Bangladesh. Crab is also exported to many other Southeast and East Asian countries such as Taiwan, Malaysia and Singapore among others. The USA and some European countries import limited amount of crab from Bangladesh.

Usually soft shell crabs, female crab with undeveloped gonad and undersized crabs are rejected by exporters. However, in recent years, soft shell crabs are also being exported at a smaller scale. Physically damaged crabs, for example with broken legs, are also rejected for export purposes. The rejected crabs are either consumed or go to the crab fattening farms. After fattening, the crabs with hard shell and female crabs with developed gonads are exported.

4.1.6 Shrimp PL Collection

It is well known that shrimp PL is collected from the wild of the SRF and its adjacent areas. In the process of collection, the collector causes death of seventy to eighty other types of PL. Many women and children are employed in the shrimp PL collection process. In consideration of the adverse impact of the collection process on the environment, the authority has correctly decided to ban the activity altogether. However, in reality, the ban has had limited impact – collection of shrimp PL from the wild continued unabated.

With the growth of crab farming and fattening activities and growth of export market, more direct and indirect employment associated with mud crab aquaculture would be generated in input supply, processing and packaging, marketing, and transportation sub-sectors. If crab farming and fattening become major activities in the impact zone, the men and women involved in shrimp PL collection should be able to find alternative employment opportunities which may alleviate economic pressure on them to engage in activities which are deemed harmful to the environment and at the same time illegal.

4.1.7 Recommendations

- Mud crab culture in mangrove pens should be encouraged. Simple enclosures for crab farming should be constructed in the existing water bodies within the mangrove system. Suitable areas should be identified by the Forest Department with technical assistance from the Department of Fisheries, and specialized organization such as BFRI, BAU, and the World Fish. Technical assistance could be sought from other countries and experts with experience in the field. The mangrove pens should be comparatively accessible to the communities living next to the forest. Crab farming in this manner is eco-friendly and, with sufficient publicity, these crabs could command higher price in the international market due to their natural way of farming.

- It is important to develop a formulated feed for mud crabs as trash fish which are usually fed to crablets are not easily available in Bangladesh. The crab farmers and fatteners, as a result, have resorted to using tilapia as the main source of crab feed[7].

- BFRI at Paikgacha is in the business of undertaking research, extending training to interested crab farmers, and disseminating technical information to the crab farmers. Their capacity in these areas should be substantially enhanced. More funds and human resources should be allocated to enhance its capacity in advisory role and mud crab research. NGOs such as Shushilan, Oxfam and Caritas which are already involved in promoting crab farming should be involved in the process of information dissemination and training. Currently, there is a great need for extension services in this sector and with rising crab farming and fattening activity, the demand for extension services are expected to rise even further. A comprehensive training and extension program should be in place under the Department of Fisheries for mud crab farmers and fatteners.

[7] Shelley, C., 2013

- Credit, as in other cases of business activities, will play a vital role in the promotion of crab farming and fattening activities. For crab grow-out farms, loans from SME windows of the commercial banks and NGOs could be arranged. As the cage system of crab fattening is associated with fast return, NGOs with micro-finance program should be brought into the endeavor. The government run PKSF, in particular, can play a significant role in promoting credit to crab farmers and fatteners. The government and development partners could play a vital role in enhancing the role of the NGOs in this sector, especially for the poor and marginal population of the area.

- Easily accessible training courses should be offered to the dealers and exporters so that their handling, processing and packaging capability improves. Their improved performance would increase the value of their export products and command higher FOB value. This would indirectly benefit the stakeholders of the mud crab aquaculture.

- Shyamnagar upazila currently is a major crab producer among the SIZ upazilas. It's contribution to crab export is correspondingly high. Note that (see`Table 2) Shyamnagar is the worst sufferer due to poverty among the ECA upazilas. In terms of literacy rate, Shyamnagar is again the worst performer among the group. Upazila's familiarity with crab grow-out and fattening practices should be fully exploited in any poverty alleviation programs for Shyamnagar.

- The Forest Department, which is in charge of the Sundarbans as a part of their mandate, is primarily focused on trees and related issues. They are not particularly staffed to manage the fishery or crab related issues. As a result, both crab and fishery sectors are not as well managed as tey should be. However, the FD may opt to involve other relevant departments and institutions who have relevant experience.

- Sometimes It is being recommended that natural waterways should be restocked with hatchery produced seedstock or crablets in Bangladesh. The idea has been tried in other countries such as Japan with limited success. Substituting wild-caught crablets with hatchery produced ones and consequent lower collection rate from the natural sources should lead to natural balance over time; no intervention is necessary - only human encroachment needs to be curtailed. In author's assesment, Bangladesh has not reached the stage when restocking should be considered. However, delay in the establishment of hatcheries producing seedstock may one day lead to such an unfortunate situation.

4.2 Fisheries in the Sundarbans and the SIZ

4.2.1 Introduction

Consumption of fish contributes 60% of daily animal protein supply for the people of Bangladesh. Fish production clearly plays a vital role in the economy by supplying a crucial source of micro-nutrient. The food habit of the Bengalis, the dominant ethnic group of Bangladesh, is historically characterized as "machhe bhate bangali" i.e. the Bengali sustains on fish and rice. Little wonder that fish aquaculture has been an integral part of Bangladesh and that a major occupation of the Bengalis is fishing.

The Sundarbans is crisscrossed with rivers, canals and a variety of water bodies. Fishing in the wetlands of the Sundarbans is allowed with permits from the Forest Department. Annual fish output of the Sundarbans region is given in Table 5. Yearly fish output has recently dropped from 22,451 tons in 2010-11 to a low 15,945 tons in 2012-13. However, fish production has somewhat recovered in 2013-14. However, the fall could be due to drop in the number of permits given by the FD.

Table 5: Annual Fish Output of the Sundarbans (in ton)

Year	2009-10	2010-11	2011-12	2012-13	2013-14
Output	20,437	22,451	21,610	15,945	18,366

Source: Department of Fisheries

If average market price is Tk. 150/kg, the market value of total catch in 2013-14 was Tk. 2.75 billion. If fish catch increases by just 50% in the future under a better management regime, the value of total catch could be around Tk 4.13 billion.

In order to improve sustainability of fish production and preservation of biodiversity in the Sundarbans, fishing has been completely banned in 18 khals throughout the year.

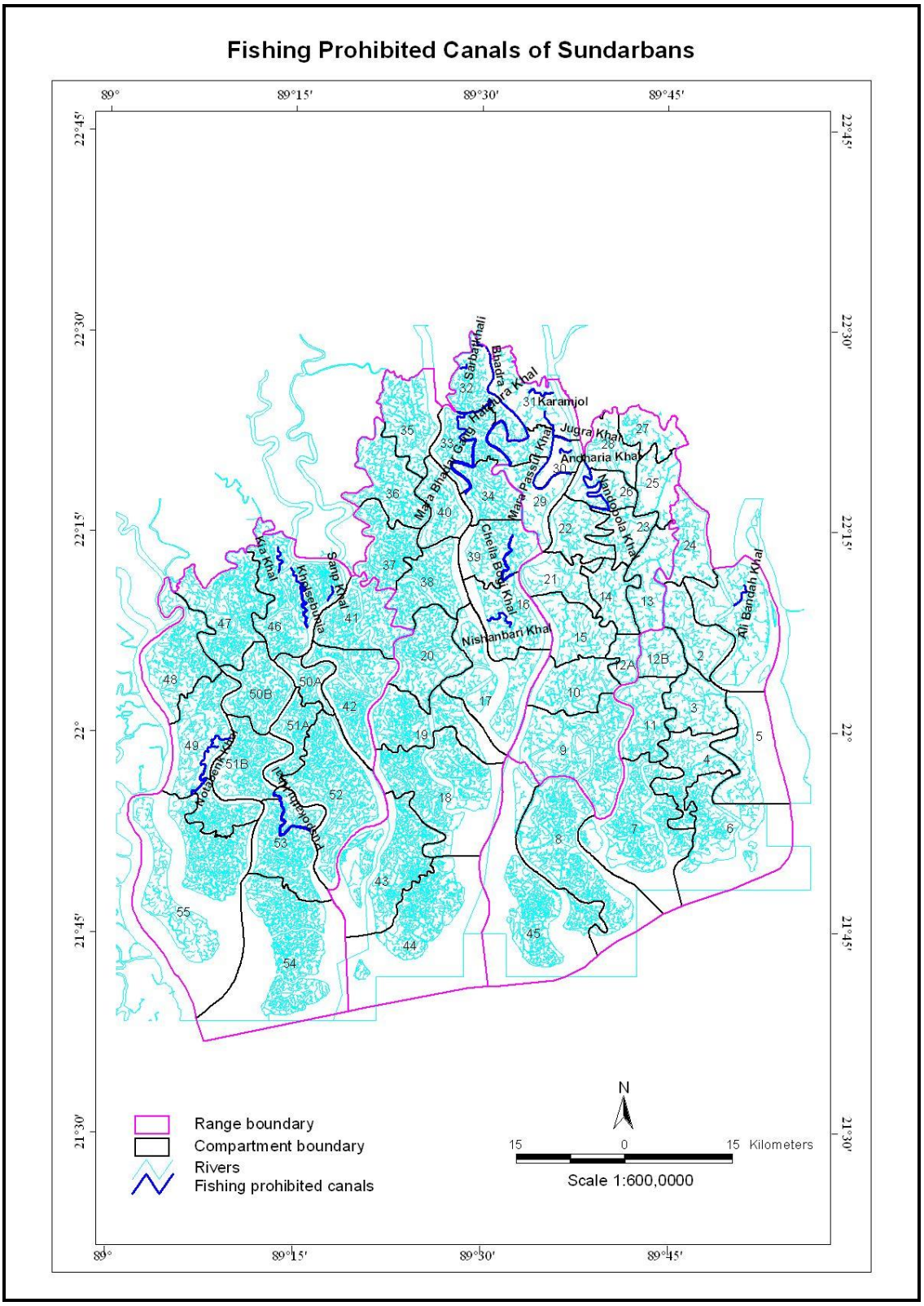

Fishing Prohibited Canals of Sundarbans
89°
89°15'
89°30'
89°45'
22°45'
22°30'
22°15'
22°
21°45'
21°30'
Sarbat Khal
Bhadra Khal
Gabu Khal
Karamjol
Jugra Khal
Andharia Khal
Maya Bhadra
Maya Passur Khal
Nanigopola Khal
Chela Bhadra Khal
Nishanbari Khal
Ali Bandah Khal
Kra Khal
Khasbuna
Samp Khal
Kotbenu Khal
Pandokhali Khal
Range boundary
Compartment boundary
Rivers
Fishing prohibited canals
N
15
0
15 Kilometers
Scale 1:600,0000

Figure 3

However, there seems to be little scientific background studies as to why fishing ban in these particular khals is the optimal choice compared to some other sets of khals or rivers for that matter. Nonetheless, it shows the willingness of the Forest Department to impose ban on fishing if need arises. Fishing is also banned in all three wildlife sanctuaries of the Sundarbans namely Sundarbans West Wildlife Sanctuary, Sundarbans South Wildlife Sanctuary and Sundarbans East Wildlife Sanctuary. What is required at this point is to undertake a series of scientific studies in order to identify the water bodies where fishing should be banned. Bangladesh Fisheries Research Institute (BFRI) located at Paikgacha in Khulna, Khulna University, IUCN and World Fish could be consulted for the purpose.

There exists no comprehensive baseline assessment of fish stock in the Sundarbans. Assessment needs to be undertaken on an urgent basis with technical assistance from BFRI, Khulna University, BAU, World Fish and the Department of Fisheries. If needed, fish stock assessment experts from other countries could be hired. The program should be coordinated by the Khulna Circle of FD. The stock assessment should be undertaken periodically, preferably once in every five years. However, more frequent assessments, say once in every six months, should be undertaken using sampling system and studying the relationship between catch and effort.

The landscape upzilas boast a large number of fishers[8] as can be seen in the following table. In the ECA upazilas, around 70,000 people identify fishing as their primary profession. There are many others whose secondary profession is fishing. A substantial number of people, who are identified as landless labor, also occasionally work as part time fishers.

[8] People who identify fishing as their primary occupation

Table 6: Number of Fishers in ECA Upazilas

Upazila	Sarankhola	Mongla	Morrelganj	Shyam-nagar	Koyra	Dacope	Paikgacha	Mathbaria	Patharghata
No. of Fishers	4540	2196	12450	2930	17175	2492	1677	4474	21900

Source: District Statistics 2011 Series, 2013. Bangladesh Bureau of Statistics, Dhaka.

Total ECA population was around 1.12 million in 2011. Out of about 70,000 fishers in the ECA upazilas, around 45,750[9] live in the ECA. Assuming a typical household has 4.65 members, more than 212,000 people in the ECA are basically members of fisher households[10]. BCAS findings in a household survey indicate that fishers live in far higher number within the ECA zone compared to those who live beyond the ECA. If that is the case, the number of fishers living in the ECA has been underestimated here. In our estimate, 19% of the ECA working population is primarily fishers. Such large dependence of the ECA (and SIZ) population on fishing strongly suggests that any policy to improve socio-economic condition of the landscape population has to focus on the fisheries sector along with the agricultural sector..

With rising salinity, brackish water aquaculture is set to expand. Commercial aquaculture especially involving brackish water tolerant species such as crab, shrimp, Tilapia, etc. should be encouraged to expand. As huge international market exist for crab, shrimp and Tilapia, export market for crabs and tilapia should be explored as well in view of expected rise in their production. With the development of aquaculture, there would be job opportunities in the production, processing and packaging processes for the locals of the SIZ. As the commercial aquaculture is primarily a domain of the richer section of the society and, in most cases, owned by the absentee entrepreneurs, the local poor are only indirectly benefitted. That topic is not explored in depth in this study.

[9] Author's estimate

[10] Those who are not primarily fishers have been ignored

4.2.2 Community Based Fisheries Management in the SRF

The Sundarbans is crisscrossed with rivers, canals and a variety of water bodies. Fishing in the wetlands of the Sundarbans is allowed with permits from the Forest Department. However, there is substantial scope for improvement on the current management practices of the Sundarbans' wetlands. Primary reason behind less than optimal performance is lack of required expertise within the FD and the fact that focus of the FD management is essentially trees. The resulting outcome, in general, is in line with less than optimal management that usually characterizes performance of the government agencies with regards to public water bodies.

In recent years, a new system of Community Based Fisheries Management (CBFM) is successfully operating for a number of inland public water bodies in Bangladesh. A number of studies have found that after the implementation of such a system to the publicly-owned water bodies, income and expenditure of the poor fisher, and their per capita fish consumption have increased substantially within a short period of few years; fish production per hectare, in overwhelming number of cases, has substantially increased; and has resulted in greater bio-diversity (Mustafa (2015); Thompson; Khan (2012)). Under MACH project, a USAID funded, community based co-management fisheries project, fish yield in the project areas increased from 58-171 kg/ha to 316-389 kg/ha and led to re-establishment of 8-10 threatened fish species within a period of six years (Thompson).

Under the CBFM system, community based organizations (CBO) are formed and exclusive fishing rights in concerned public water bodies are transferred to these CBOs. In exchange of exclusive fishing right, the CBO pays a predetermined amount or a portion of sales proceeds to the concerned authority. In our case, the concerned water bodies are wetlands inside the

Sundarbans. The CBOs would consist of stakeholders, especially poor fishers of the area and the concerned authority is the Forest Department.

As can be seen in Table 7, while Sundarbans East Forest Division produced more than 90% of total fish output, Sundarbans West Forest Division is responsible for less than 10% of total fish production. Introduction of community based co-management system in West Sundarbans may not be worthwhile considering substantial initial investment of resources and support needed, at least, during the initial years. An optimum policy seem be to bring only wetlands of the Sundarbans East Forest Division under the community management program in the beginning.

Table 7: Annual fisheries production (mt) from the Sundarbans in 2010–11

Species	**East Sundarbans**	**West Sundarbans**		**Total**	**%**
	Bagerhat	Khulna	Satkhira		
Hilsha/Illish	400	0	0	400	1.78
Big Prawn	66	0	0	66	0.29
Small Shrimp/Prawn	588	0	0	588	2.62
Koral/Bhetki	18	0	0	18	0.08
Other Fish	19856	914	609	21379	95.23
Total	20928	914	609	22451	100

Source: Bangladesh Sundarban Delta Vision 2050

Importance of thinking through the question of eligibility for membership in the CBOs can't be over emphasized given the complexity of the issue in the case. Unlike most inland water bodies, fishers of the Sundarbans do not necessarily come from the local neighboring communities. As a matter of fact, some of the stakeholders may actually live in far off places from the Sundarbans, even in other parts of the country. A large number of wetlands may not have any people living near them. In such circumstances, our suggestion would be to exclude everybody who does not live in the SIZ. Then the stakeholders living in the SIZ such as professional fishers, landless part time fishers, etc. could be eligible for membership in the CBOs. A CBO

would have a democratically elected body of Management/Executive Committee which would make management and other decisions on behalf of the members of the CBOs.

Officials from the Forest Department, the Department of Fisheries, Chairmen of the relevant Union Parishads, locally influential people, experts from agencies such as the World Fish and representatives (Presidents) CBOs would be the members of the Co-management Committee(s). Wetland Management decisions would be undertaken by the CBOs but endorsement, coordination, and oversight is the job of Co-management Committee(s). Considering the area of the wet lands of the East Sundarbans, a number of such co-management committees have to be formed. As the co-management committees are for the Sundarbans wetlands, the committees should be chaired by the officials of the Forest Department.

Previous experience suggests that without the participation of local elites, community based co-management may not work at a satisfactory level. Hence, inclusion of locally influential people is essential. However, the elites have the tendency to take control of the resources and marginalize the economically weaker section of the committee. Precautionary measures have to be adopted so that they are in the co-management organization, but enough mechanisms should be in place so that they cannot take control of the organization.

In view of the above, the poor should be made aware of their rights and provided leadership training so that they can participate in the capacities of members and office bearers of different committees and sub-committees. Voting rights, eligibility for different posts, term limits, etc. should be such so that the poor fishers are overwhelmingly represented in the decision making processes within the CBOs.

Development of an effective CBO, representing poor fishers, would take a long period of incremental improvement. During the initial period of operation by the CBOs, some external agencies such as NGOs or professional organizations such as the World Fish could help them in organizing CBOs and advising and helping them in the process of establishing CBOs, developing the management system, rules and regulations in running the CBOs. It is imperative that in setting rules and regulations, the CBO members have to set the rules themselves and external agencies role would be there to facilitate the process, and share experience and knowledge with the CBOs. Knowledge sharing among CBOs by meetings, exchange visits and newsletters should be encouraged. This would help in promoting a sense of belonging to a bigger community of CBOs, improve management and technical practices, improve problem solving skills, and enhance fish production among others. Information sharing and dissemination should also be done by government agencies such the Forest Department and the Department of Fisheries.

The process of managing and decision making has to be open and transparent. Accountability, especially financial accountability, has to be strictly maintained and accounts have to be updated as soon as possible. Some members, especially the ones representing poor fishers, of the CBOs must have training to at least understand the basics of the accounts. Without financial probity, confidence in the CBOs and CMCs will wither away fast and may eventually lead to failure.

The proceeds from fishing should be divided into three portions. First, the fishers would get lion's share; second, the Forest Department would get an amount which is equivalent of what the Department has earned per year on average from permitting fishing within the Sundarbans; and third, a portion should be kept aside as savings. The proportions should be set as percentages of sale proceeds. The proportionate share of the Forest Department should ensure

that with expected increment of fish output, Department's revenue from the wetlands would also proportionately rise. The savings from sale proceeds would help in financing the organization when initially available external resources (for running the CBOs) would run dry. Clearly, the role of the external agents has to fade out after certain period of time and the CBOs have to learn how to run the system on their own.

There must be a few strict guidelines to the CMCs which need to be adhered to. Some guidelines (but should not be limited to) are given below:

1) No threatened fish or other aquatic species would be captured. If inadvertently caught, they should be released back immediately to the water body whether dead or alive;
2) There should be restrictions on fishing gear with too fine a mesh. The mesh size could be decided on the basis of specific biodiversity needs of the Sundarbans;
3) No destructive methods of fishing such as using explosives, poisoning water bodies, etc. would be employed;
4) Extent of fishing would not exceed the sustainable fishing limit of the water bodies; and
5) Extra care would be undertaken to preserve and enhance biodiversity of the water bodies.

There are credible reports that fishing boats with permits to fish in the Sundarbans frequently sell their catch to the trawlers which illegally enter the forest. These trawlers are fast. Lacking speedboats or fast boats, the officials of the Department of Forests are at clear disadvantage to deter intrusion of these trawlers. As a result, royalty which is collected by the authority is lower compared to what it would have received in the absence of those illegal trawlers. Obviously, monitoring of fishing boats leaves much to desire. If the system of co-management of water bodies is instituted in the Sundarbans, the fishing boats of the CBOs, in their own interest,

would monitor such lapses carefully. The system of co-management is expected to cut down illegal fishing practices in the Sundarbans.

Fishing should be banned for the spawning season say for two months (closed season) and, simultaneously, some areas i.e. designated small fish sanctuaries would be off-limit for fishing throughout the year. Closed season would protect brood stocks and help reproduction processes. Decisions regarding locations of sanctuaries and timing of closed season have to be decided by the CBOs with technical assistance from the Department of Fisheries and entities such as the World Fish. Again, the CBOs should decide what is good for regeneration of aquatic species including fish. There should be clear demarcation as to which areas are sanctuaries and the information has to be communicated to the fishers who would fish in the wetlands. The areas of the sanctuaries should be easily recognizable, too.

Long term leasing say for at least ten years is an essential requirement without which there would be little incentive to sustainably manage, let alone investment deepening in, the leased areas. With satisfactory performance, the agreement between the Forest Department and the community should be renewed. Criteria for satisfactory performance should be agreed upon by the community and the FD beforehand.

4.2.3 Homestead Pond Aquaculture

Homestead ponds primarily originated from borrow pits from which soil was excavated in order to raise the platforms of the houses to be built. The primary reason was to avoid flooding, not aquaculture. Belton and Azad (2012) estimated that 4.27 million households of the country have a pond. Jahan et. al. (2010) found that pond owning households constitute 20% of the rural households. However, the proportion of homestead pond owning households is even higher (59%) in polder areas of the south (Bloomer 2012). The median size of the ponds of the polder

areas is estimated at 0.039 hectare (CAARP-World Fish, 2009), which is smaller compared to the rest of the country. The total number of homestead pond is expected to rise in the future with rising population requiring more houses.

Note that 59% of households in the landscape zone have a pond and let's assume that each non-poor household has a pond for argument's sake. Clearly, a pond owning household in that case is not necessarily non-poor. For example, in Syamnagar, the worst poverty stricken upazila in the landscape region, only 49.8% of the households are above upper poverty line.

Homestead pond aquaculture is dominated by carp production – basically Indian major carps such as rohu (Labeo rohita) , catla (Catla catla) and mrigal (Cirrhinus cirrhosus) and a variety of Chinese carps. Nile tilapia (Oreochromis niloticus) and Pangasius (Pangasianodon hypophthalmus) are two other species frequently cultured in homestead ponds. The system is characterized by low intensity, extensive production method which requires very little management, labor or capital. Frequently, no stocking is undertaken by the pond owners themselves, leaving the business of recruitment to the nature.

If households can be encouraged to move from extensive style management of the homestead ponds to semi-intensive culture, the production can easily get doubled. For example, International Food Policy Research Institute has found the average productivity of homestead pond was at 1.52 tons/hectare in 20 districts of Bangladesh (IFPRI, 2012). Apparently, regular application of fertilizer and feed while following recommended measures for fingerling stocking can easily raise the productivity to 3 tons/hectare (ADB, 2004). Pond aquaculture has become quite popular in areas such as Mymensingh and Jessore. Proximity of the landscape zone to Jessore should be of help in dissemination of information and gaining first hand information from the actual practitioners.

Given the size of the ponds in the Sundarbans landscape region, boost in pond productivity is not going to financially contribute in a big way. However, the concomitant rise in fish consumption within the household would nutritionally help the family members. However, rise in total output and the fact that most of the saleable portion of the output is sold at the local market should lead to lower fish price in the market benefitting non-pond owning families - mostly poor and landless households- as well.

Polyculture is usually favorably compared to monoculture, as under polyculture different species thrive without harming other species and utilize nutrients which would not otherwise be utilized in the pond. It even leads to better pond water quality. For example, presence of Nile tilapia, Indian major carps and Chinese carps utilize algal bloom in a pond in which the primary crop is pangasius (Belton & Azad, 2012). The result is greater nutritional diversity for the family and additional revenue for which, apart from stocking cost, there are no additional costs to incur.

Homestead pond aquaculture, preferably semi-intensive version of it, should be encouraged as it ensures steady supply of protein and source of micronutrients for the pond owning family. There exists enough evidence that fish from homestead pond is used for both home consumption and as a source of cash. If the pond could be converted into a perennial one, that is sufficient water remains in the pond throughout the year, year round supply of protein and micronutrients are ensured. Fish from perennial ponds could be timed and harvested when fish price is high. On the other hand, households owning seasonal ones are forced to sell their products at a time when supply is high and price is low as all seasonal ponds in an area start to lose water during the same time period of the year.

Another advantage of homestead pond aquaculture is that fish can be sold when family necessity arises. Specifically, in times of distress, sales proceeds of fish from homestead pond can help survive the distress period. It has been observed that a catastrophic illness or

disastrous climactic event could push even a relatively better off family under poverty line. Sales receipt from fish sales could help alleviate such a disaster and help avoid costly loans.

The Department of Fisheries should take an extensive program in disseminating relevant information. However, previous efforts have had limited success. The causes of reluctance regarding adoption of better fish culture practices need to be identified and addressed. Easily accessible extension services should be in place for technical assistance. The households may need credit for the expenses which could be made available through micro-credit agencies present in the landscape area.

4.2.4 Cage Aquaculture

One limitation, for example, of pond-based aquaculture is that, in pond culture, the poor, especially the landless ones, can't participate as they likely don't own any pond - the number one requirement for the pond based system. As a result, participation in aquaculture for the landless remains limited. However, a recently introduced system of cage aquaculture could be a prospective solution, at least to a certain extent.

Cage aquaculture is gaining popularity in recent years in Bangladesh. However, in some other countries, the system is widely in use for many years. Cage aquaculture for a number of species is widely practiced in a number of Southeast Asian countries such as Indonesia, Thailand and Vietnam. In Bangladesh, the method has started to establish itself in different parts of the country.

Cage aquaculture is a suitable way of fish culture in which poorer section of the society as well as women can participate. Initial financial requirement is quite low and the turnaround period is short thereby the risk involved in the process is minimized. The cages can be built using locally available materials such as bamboo poles and nets. In absence of an owned pond, open access water bodies such as rivers, khals, and beels could be utilized for the purpose. Fish output

under cage aquaculture system is substantially higher compared to the pond system. On average, current output in Bangladesh under cage aquaculture is 22 kg/m^3 of cage. In contrast, fish output in a pond is only around 1.5 ton/hectare on average.

Fishers can harvest their fish at least twice a year. The fish from the cage can be consumed by the poor fishers and sold for cash income. It seems, resource-poor fishers frequently form groups and start cage aquaculture as groups. Group formation has several advantages: first, blocking their access to public water bodies would be difficult to implement; second, small amount of capital per person is required in order to start a venture; and third, the number of hours they have to spend per participant would be lower compared to the case if they would have done it separately.

Commercial feed pellets are used for the cages. However, for resource-poor fishers, complete commercial feed may not be affordable. In such cases, low cost feed such as rice and wheat bran, mustard oil cake, fresh natural foods such as duck weed, or snails and simple kitchen vegetable wastes could be fed. The diet could be supplemented with commercially available feed pellet.

The most cultured fish under the cage aquaculture system is monosex tilapia (Nile Tilapia) i.e. male tilapia only as they outgrow female ones. The specie enjoys fast growth and is a saline tolerant variety. In view of salinity level of the SIZ areas which is expected to get worse over time as a result of sea level rise, monosex tilapia is perfect for Bangladesh. Some other species such as pangasius, grass carp even fresh water prawn could be cultured using the same method.

Any initiative which considers using open access water such as rivers, khals and beels must take socio-economic and cultural aspects of the concerned community into account. For example, one major problem is the access to public water bodies. With possible rise in the

number of such cages say in the local river - an indication of profitability- attention of the powerful and wealthy locals would be drawn. They may start to engage in the business considering its commercial success and may push the landless out of business. As access to open access water body and security of tenure are fundamental requirement for the success of such poor-friendly system, it is imperative that potential threat to access and security of tenure have to be adequately addressed.

There exists some limited adverse impact of cage aquaculture on environment. Environmental concern is associated with COD and BOD loads of excess fish feed and fish excreta. Too many cages in a small area can result in BOD and COD loads exceeding the carrying capacity of the water body in which the cages are placed. Care should be taken so that a large number of cages are not placed in small water bodies. The best water body for the purpose is where the water is flowing. Fortunately, there are numerous water bodies with flowing water such as khals and rivers in the Sundarbans landscape area.

The fishers, being resource poor and deficient in technical knowledge, need assistance from the authority. The Department of Fisheries can help them with technical assistance and relevant information. Their financial need could be addressed by microcredit lending agencies. As a matter of fact, the situation is ideal for a microcredit program as credit requirement is only in terms of thousands of taka, and the prospective borrowers themselves are interested in forming groups.

In order to provide guaranteed access of the landless and fishers to the rivers and other public water, a list of eligible people could be prepared with assistance from local Upazila Nirbahi Office (UNO), Union Parishad, and Upazila Fishery Office. The listed would have the right to participate in cage aquaculture in the local public water bodies.

4.3 Agricultural Sector

4.3.1 Introduction

The mainstay of the landscape region is agriculture. A large proportion of people living in the ECA/SIZ area identify agriculture as their primary profession. Within the agricultural sector, cereal production is the dominant economic activity of the region. Apart from own labor, the sector also employs landless labor in the process of cultivation. Naturally, any program which directly leads to enhancement of productivity of agricultural land bound to have positive impact on the vast majority of people living in the area. Considering the fact that large segment of the local population suffers from grinding poverty, the poorer section of the people living in the area stand to gain from such initiatives.

From Table 8, it is clear that cropping intensity figures of the ECA upazilas are quite low. The primary reason for lower cropping intensity, especially upazilas of Khulna Division is salinity. Saline land and scarcity of fresh water during the dry season hinders cultivation of rabi crop in the region. Consequently, large areas of cultivable land are of one crop per year variety. Cropping intensity ranges from a low 108 in Paikgacha to 135 in Sarankhola for Khulna Division upazilas[11]. Patharghata (146) and Mathbaria (147) of Barisal Division enjoy higher cropping intensity, perhaps due to better availability of fresh water for irrigation. In comparison to overall intensity in Bangladesh (182), the cropping intensities of landscape upazilas are much lower. As can be seen in Table 8, total boro output is quite low in these upazilas.

[11] The case of Mongla has been ignored.

Table 8: Cropping Intensity by Upazila

Upazila		River Water Salinity in March 2012	HYV Boro Area	HYV Boro Productio in ton	Cropping Intensity	
Assasuni						
Sarankhola		9.1	272	114	135	
Mongla		13.8	7	9	93	
Morrelganj		2.0	6447	12922	119	
Shyamnagar		25.2	4817	7524	115	
Koyra		18.2	4215	7021	122	
Dacope		14.6	74	157	111	
Paikgachha		14.3	2030	8061	108	
Mathbaria		1.6	3930	9546	147	
Patharghata		6.3	125	270	146	

4.3.2 Saline-resistant and Less Water Using Agricultural Crops

Extension services should be provided so that saline resistant crops such as Bina dhan 10, a rabi crop, get adopted. For example, Bina dhan 10 can tolerate up to 10 ds/m, beyond which yield would suffer and cultivation would become unprofitable for the farmer. If the soil is salinity free and irrigation water is fresh, average output per hectare would be around 7 ton/hectare. However, under saline circumstance, average output/ha would be around 5 ton.

Large tracts of land, which are perhaps within SIZ but are not currently being cultivated during the dry season, may qualify for Bina dhan 10 cultivation. Apparently, some areas in Barisal Division and Khulan District, part of which lies within the SIZ, could also be utilized for Bina dhan 10 crop (Mondal et al. 2015; IWM[12]). The areas within SIZ which could be used for cultivating saline tolerant varieties need to be identified.

Promote crops such as wheat and maize which use less water compared to boro crop. While boro requires frequent irrigation, wheat, on the other hand, requires only two to three irrigations during the crop cycle. Evidence suggests that wheat yield of 4 ton/ha could be achieved with

[12] Personal communication

only two to three irrigations (Akanda et al. 2015). The idea is that with limited amount of available fresh water during the dry season, adoption of such crops would lead to higher level of rabi output within the polders.

The polders should let fresh water in during high tide as late as possible in the dry season, and store fresh water in the khals and water bodies within the polder. Excavation of khals and relevant water bodies could be undertaken in order to enhance storage capacity.

Again, submergence tolerant paddy crop needs to be introduced to save crops grown inside the polders. Crops (mostly transplanted aman), the ones cultivated during the rainy season, get submerged due to excessive rain, siltation around the sluice gates of the polders, or higher water table outside the polder compared to inside. Submergence tolerant rice varieties such as BRRI Dhan 51 and 52 could be promoted. More submergence tolerant rice varieties should be developed. The problems associated with siltation around the sluice gates of the polders need to be addressed as soon as possible. BWDB, the organization responsible for managing the polder embankments, should pay attention to this recurring problem.

Short to mid-duration aman crop need to be introduced instead of current practice of cultivating late maturity aman crop. Short duration aman crop would allow early establishment of rabi crop such as boro, wheat, maize, etc. Evidence suggests that early establishment of these crops lead to higher level output. Early establishment of rabi crops can take advantage of moisture still left in the field. The field can be used by dibbling without tilling the soil. The system of late maturity aman and then waiting for the dry field for tillage results in late sowing of rabi crops. Rabi crops then are exposed to strong wind and rain in April and cyclonic storm in May causing damage to or destruction of the crop. Early establishment of rabi crop such as boro, wheat, maize, and sunflower reduces exposure to risks.

A Cautionary Note

Note that in the process of searching alternative crops, sometimes fruits, vegetables and some pulses which are in little demand are suggested. Once output of these minor crops start to rise, due to their little actual demand, price collapses leading to huge losses suffered by the producers. Alternative crops should be in great demand so that rise in its production in the SIZ and/or coastal belt won't lead to prices crashing. For example, wheat, maize, edible oil are always in huge demand in Bangladesh and abroad. There are plenty of scopes to raise their production without abnormally lowering their farm gate price.

Implementing Agencies

BRRI, BINA & BAU may be given the responsibility for the development of more short duration aman and rabi crops such as early maturity boro and wheat variety and submergence tolerant rice cultivars in the interest of facilitating higher level of crop production in the southern coastal region, including the SIZ region. DAE would remain responsible for promotion and extension services in order to facilitate adoption of above mentioned varieties.

4.4 Homestead Production System

Most rural households in Bangladesh have a small patch of land next to or surrounding their homesteads. Vegetable and fruit plants/beds, cattle-shed, chicken coop, yard and a pond[13] usually occupy the space. The area itself may be small, around 700^2 meter (Karim et al. 2015). Even villagers who are classified as functionally landless may possess such a piece of land. The small plot is used for producing food products essential for nutritional wellbeing of the family. Food products such as fruits, vegetables, fish, milk, egg, meat, etc. are produced on this

[13] Only 20% rural households have a homestead pond. However, the percentage of homestead pond owning families is 59% in southern Bangladesh polder zone (Bloomer 2012)

plot and consumed within the household. A portion of output is also sold in the market - almost always in the local market. The sale proceeds are used for buying other necessities of life.

The pond occupies around 33% of the land and plays a pivotal part in the whole homestead food production system (HFS). The pond itself is used for fish culture, bathing, washing, watering gardens, and for livestock rearing. In terms of share of income in HFS, the pond is responsible for a major portion of monetary value of HFS produce (Sundaray et al. 2015). Considering the economic importance of homestead pond and its potential for contributing to HFS income through aquaculture, a detailed analysis is presented in Section 4.2.3.

Produces supplied by the homestead food production system (HFS) plays an important nutritional role and is a good source of supplementary income for the rural poor, especially the functionally landless. Kabir et al. (2015), based on a survey covering a number of polders, found that the contribution of HFS towards total household income is 23% on average. The survey covered families with less than one hectare of land. Not of all of them are considered poor in Bangladesh. HFS's contribution to the food security status of the functionally landless is substantial (Karim et. al. 2015). The authors found that the dependence on HFS supplied food staples is almost 70% for functionally landless poor. Other researchers (Wiersum 2006; Galhena et al. 2013; Mandal et al. 2015)) observed that dependence of resource-poor farmers on HFS supplied staples much larger compared to their relatively better off counterparts. Another group of studies have found that when HFS is assisted, they are more productive, and households' intake of a variety of micronutrient rich food increases (Talukder et al. 2000; Galhena et al. 2013). In terms of resource use, HFS is mostly based on family labor thus employing hitherto unutilized labor especially female labor.

Recognizing the importance of HFS, the United Nations declared 2014 as the International Year of Family Farming. In Bangladesh, this sector is not getting enough attention from the authority.

However, a number of studies have shown their importance to the rural poor especially the functionally landless ones. If HFS sector is properly addressed in the Sundarbans landscape zone, it would help the poverty stricken segment of the population of the area in a big way.

The HFS is an internally integrated system and the pond plays, as stated above, the central role in it. For example, pond water is used for livestock rearing and poultry production. On the other hand, livestock manure and poultry litter are used for fertilization of the aquacultural pond in order to have higher fish yield (Kabir et al. 2015). Similarly, livestock manure is used in the vegetable beds and fruit gardens in order to have higher level of production from them. Sometimes, pond water is used for small-scale irrigation, too. Homestead land is usually at higher level of elevation and as such less vulnerable to flood and salinity problem. As a result, HFS system is less vulnerable to adverse climatic event.

HFS is not geared to produce a single crop. Rather, it is characterized by a range of vegetable and fruit plants, a variety of fish species, four types of livestock, and three species of poultry. Its diversity makes it even less vulnerable to adverse climatic event. If one or more products do poorly, the other products would be there unlike a monocrop system whereby if the crop performs poorly, the farmer pays dearly for it.

On the other hand, it was observed (Mandal 2015) that the farmers which focus and specialize on few vegetables earn better compared to other HFS farmers who do not specialize. Their objective is to maximize profit to a certain extent. The dilemma is whether to sacrifice food and nutritional security in order to pursue higher income.

Fish culture, fruit and vegetable gardening are the safer options. The risks associated with poultry farming and livestock rearing seems to be higher in the HFS. Disease and episodes of epidemics seem to be the primary reasons for elevated risks (Karim et al. 2015). The

Department of Livestock Services (DLS) could play a vital role here by extending its services vigorously to the poor people of the SIZ area.

In order to enhance productivity, supply of quality inputs and dissemination of information are vital. In the Sundarbans impact zone of Bangladesh, households are in need of credit and technology extension support (Kabir et al. 2015). The Department of Agricultural Extensions (DAE) has much experience in disseminating technical information. They could pay attention to the HFS sector. If credit is needed, micro-credit agencies are well suited for the purpose.

Along with poorer section of the rural area, if other non-poor families are encouraged to utilize their homestead, production and sale of locally produced food staples would increase. Enhanced supply would indirectly benefit the poor by depressing prices of those produces in the local market.

The families need to be made aware about nutritional value of different fruits and vegetables. It is especially important in the case of aquaculture. Overwhelming number of families in Bangladesh consider, due to cultural reasons, major Indian carps as good food. In reality, they have little nutritional value apart from being a source of protein supply. On the other hand, the Small Indigenous Species (SIS) such Mola, Chanda, Darkina, etc. are good sources of vitamin A and other micronutrients. With proper knowledge backed by supply of quality inputs, they can choose the right combination of fruits and vegetables, and species of fish required for their nutritional wellbeing.

4.5 Commercial Apiculture

The SRF is one of the primary honey producing areas of Bangladesh. The plants of the Sundarbans which are considered as important nectar and pollen sources are: Baen, Sada

Baen, Goran, Gewa, Garjan, Hargoza, Kankra, Keora, Khulshi, Passur, Saila,and Shingra. However, the most important nectar producing species are Goran, Khulshi and Keora[14]. Khulshi is found along the creeks, and Keora grows in newly accreted land. Goran tree predominates the more saline western part of the Sundarbans forest. Honey which originated from these trees is considered as the better quality ones.

In the Sundarbans, honey flows heavily from the beginning of March and lasts almost four months as can be seen in Table 9. There are other plants which bloom earlier, but as a source of nectar, they are less important.

Table 9: Nectar Source and Flowering Period: Important Plants of the Sundarbans

Common name	Botanical name	Flowering time
Khulshi	*Aegiceras corniculatum*	March-April
Goran	*Ceriops decandra*	April-May
Keora	*Sonneratia apetala*	End April-Mid May
Passur	*Xylocarpus mekongensis*	End March-Mid April
Gewa	*Excoecaria agallocha*	May-June
Kankra	*Bruguiera gymnorrhiza*	April
Baen	*Avicennia officinalis*	May-June

Source: Zmarlicki (1994)

With climate change, salinity level is expected to rise in the coastal zone of the country. The average salinity level will rise in the Sundarbans, too. It is expected that over time, the proportion of Goran (*Ceriops decandra*) trees will rise at the expense of Sundri *(Heritera fomes)* trees and other fresh water dependent plants. The whole process is not going to take place over a few short years rather the process could take several decades to complete.

Once the number of Goran trees in the Sundarbans increases, potential of the Sundarbans as a source of honey production will also correspondingly enhance. The fact that honey currently

[14] Zmarlicki, Cyprian B., March 1994. Draft Final Report on the Development of Apiculture, Integrated Resource Development of the Sundarbans Reserved Forest, UNDP and FAO, Bangladesh.

collected from the Sundarbans mostly originate from the western part of the forest tends to support the notion that saline areas of the Sundarbans are better for honey production.

Honey collectors, locally known as the mouals, enter the Sundarbans on 1st April for honey collection; they are not allowed in before that. Harvest time lasts up to the end of June. They mostly collect honey from the nests of Apis dorsata in the wild. The problem is that the mouals collect honey from any hive they encounter whether honey in the hives are ripe or not. In the process, they collect inferior quality honey.

According to the experts, the Sundarbans can produce anywhere between three to five thousand tons of honey in a season if appropriate measures are undertaken. The mouals of the Sundarbans usually get a price of Tk. 125 to Tk. 135 per kg for collected honey, perhaps with rudimentary sieving. Total value of honey output in the Sundarbans could be anywhere between Tk. 375 million to Tk. 675 million per season if the full potential is exploited.

Total world export of honey was US$2.3 billion in 2014, up 10.8% from 2013. Over the last five years, the trade has gone up by more than 50%. In 2014, China was the largest exporter (US$260.3 million), while Vietnam's (6th largest exporter) export was US$127.8 million. Export volume from Bangladesh is currently negligible. Proper usage of the potential of the Sundarbans and the rest of the country can help improve the situation. Overall, the world export market is not that big, however. Nonetheless, Bangladesh should strive to claim a share in the export market as much as possible. In recent times, honey price ranged from US$2.5 (Vietnam) to US$4.5 per kilogram. Assuming price at US$ 3/kg, if Bangladesh could export 10,000 tons of honey per annum, it should fetch US$30.0 million per year.

Commercial beekeeping can be a good source of supplementary income and employment for the poor people of the ECA and SIZ areas..Mouals and other residents of the ECA/SIZ area could be encouraged to adopt modern system of apiculture in the area. The business of

producing honey in the boxes i.e. modern system of apiary is profitable and involves little manual labor. The capital requirement is, while not negligible, less than one hundred thousand taka for a 5-box honey farm. Easier access to credit could be arranged through the locally active NGOs and commercial bank branches, and in cooperation with BSCIC.

The most important assistance would be to inform, train and extend support to prospective beekeepers regarding the modern method of apiculture. The beekeepers should have easy access to information on queen rearing, bee disease management, bee biology, etc. among others. Also, the beekeepers should be trained to collect pollens from the box as it would add to the income stream from beekeeping. In addition, the apiarists should be made keenly aware of the importance of maintaining hygiene in the whole process. Otherwise, diseases would spread from one bee farm to another, causing serious damages to the whole industry including the beekeepers themselves.

Apis dorsata is the main honeybee in the Sundarbans. They are the largest in size among the honey bees. They are ferocious, possess high stinging reflex and of frequent migratory habit. Each colony has only one comb which produces 30 to 40 kilograms of honey per productive colony. This type of honey bees could not be domesticated to date; hence cannot be utilized for commercial apiculture. There are two other types of honey bees which are found in the country: Apis cerana and Apis florae. Their honey production capacity is quite limited.

Apis mellifera, on the other hand, has less stinging and swarming habit and is of almost no absconding habit. Each colony may consist of several combs. A productive colony produces more than 50 kg of honey per year. They are domesticated and are the main specie which is being used for modern apiculture throughout the world. The specie is currently being used by the commercial apiarists across Bangladesh including the Sundarbans landscape area.

The beekeepers are, however, prohibited from placing their boxes/beehives inside the Sundarbans. The ban is originated from the fear that introduction of an alien specie may harm the indigenous variety of the honey bees. If something goes wrong, it may actually hurt the regenerative processes of the Sundarbans resulting in major damages to the forest. As stated earlier, the private entrepreneurs are currently placing their beehives just outside the Sundarbans. As Apis mellifera usually forage within 3 to 5 kilometers radius around the hive, two things happened: first, Apis mellifera has already been introduced in the Sundarbans; and second, commercial apiarists are only able to exploit a small section of the SRF for honey production. If boxes could be placed at different locations across the Sundarbans, better exploitation of the potential of the Sundarbans as a source of honey production would have been possible. The boxes could be placed in and around the forest posts of the Sundarbans and at any other places the honey producers choose to.

The beekeepers who adopt the modern method of apiary usually face a common problem which involves feeding the bees when there is no honey flow. In Bangladesh, the bees have to be fed at least during the rainy season. Usually, some sort of sugary syrup is fed during the period just to keep them alive. However, right before the time when nectar starts to flow again, they are usually well fed so that they are ready to exploit the nectar season fully. Apart from March to June period of honey flow in the Sundarbans, the beekeepers may have to move their boxes to other nearby areas where honey flows. For example, if they move their boxes to nearby Khulna-Jessore region during the lean months (not rainy season), they can not only avoid the feeding costs, but can produce more honey enhancing their income in the process. The beekeepers have to be made aware of the honey flow seasons in neighboring regions so that they can take advantage of it. For example, honey flow seasons of the mustard (*Brassica juncea*), rape (*Brassica napus*), litchi (*Nephelium litchi*), coconut palm tree (*Cocos nucifera)* and kul (*zizyphus jujube*) could be exploited.

Nonetheless, it seems that bees probably have to be fed for at least four months (rainy season) in a year. One bright spot is that in an experiment in the nineties, an experimental bee colony was deliberately left behind in Burigoalini[15] during the monsoon season. The bees survived (not absconded). As most of our honey collection areas are in the western division of the Sundarbans, this experiment should be repeated. If successful, there would be little need for feeding the bees during the monsoon! Clearly, the profit levels of the apiarists of the ECA/SIZ would further increase.

Honey collected from the Sundarbans is a mixture of ripe and unripe honey and is considered inferior in quality with high moisture content of around 25%. Honey with high moisture content tends to start fermenting soon after harvesting. When permits are issued, in order to improve on quantity and quality of honey and for better management of honey collection areas, the same group of mouals should be given permission to the same collection area year after year. That way, mouals will pay more attention to the management of “their” honey collection areas.

Bangladesh seems to lack a modern honey processing plant to date. However, a small number of private sector firms claim to have established such processing plants. A modern processing plant is essential in Khulna to support the honey production activities of the Sundarbans. In order to improve the quality of raw honey, an apiary expert could be employed by the Department of Forests to assist them in assessing the ripeness of honey in the wild hives of the Sundarbans. Bangladesh Small and Cottage Industries Corporation (BSCIC) is promoting apiculture across Bangladesh. Their expertise should also be tapped.

Future foreshore afforestation programs along the sea/river side of the embankments of the SIZ polders would likely be undertaken in order to provide better protection to the inhabitants of the polders, minimize damage to the embankments, and lower the probability of breaching. If Keora,

[15] Burigoalini is located in the Sundarbans West Forest Division

Khulshi and Goran trees are extensively used for the foreshore afforestation programs depending on site conditions, it would provide a boost to honey production in the SIZ.

4.6 Tourism

The World Conservation Union (IUCN) defines ecotourism as "Environmentally responsible travel to natural areas, in order to enjoy and appreciate nature (and accompanying cultural features, both past and present) that promote conservation, have a low visitor impact and provide for beneficially active socio-economic involvement of local peoples." The Sundarbans, world's largest continuous mangrove forest and home of famous "Royal Bengal Tiger", is a tourist attraction for the eco-tourists. The Sundarbans was declared a UNESCO World Heritage Site in 1987. This attraction for the tourists, foreign as well as local, could be harnessed in order to develop ecotourism centering on the Sundarbans.

The objective of this section is to provide context for ecotourism in relation to the Sundarbans and indicate ways to secure benefits from the business of ecotourism for the people who live in the ECA and SIZ areas of the Sundarbans. The focus here is primarily on activities which would directly benefit local population and the ecosystem. The part of the ecotourism program which is not directly related to the local economy is not discussed.

It should be recognized early on that only a small fraction of the total tourist budget is going to be spent locally. The lion's share of the overall expenditure of a typical eco-tourist would be spent on transportation to and from the area, hotels in big cities and towns and only a small portion would be spent on local transport, guides, souvenirs and food that would be bought in and around the Sundarbans. As stated above, the objective of this section is to suggest ways as to how to enhance the share of the local economy in the budget of the prospective tourists.

A properly designed and managed ecotourism can provide options of alternative livelihoods for the local people. It would also enhance knowledge base of the tourists about the Sundarbans and may result in increased support for conservation of the fragile ecosystems of the forests such as the Sundarbans.

A variety of ways to promote ecotourism along with numerous practical suggestions on how to improve tourist infrastructure have been made in the Integrated Resources Management Plan for the Sundarbans for 2010-2020 (Forest Department 2010). Those recommendations and analyses are not repeated in this section. The discussion here has been kept short on purpose.

Promotion of eco-tourism in the Sundarbans could focus on several attractive features of the Sundarbans. Some of the current centers of attraction for the tourists are Karamjal, Harbaria, Katka, Dubla Char, Nilkamal, Sheikertek Temple, Mandarbaria, etc. A variety of package programs could be developed consisting of various interesting spots to suit the tastes of the incoming tourists. Some areas of interest, but by no means an exhaustive list, are discussed below.

a. Karmajal: Karamjal is the biggest tourist attraction measured by the number of tourist visits. It attracts more than 100,000 tourists per year. Its wooden trail in the forest, crocodile breeding center, presence of monkeys and deer are popular with the tourists. At Karamjal, the tourists would be able to enjoy the natural beauty of the forest and get acquainted with various species of plants. In addition, if they are lucky enough they could watch occasional tiger drinking water or resting. In order to enter Karamjal, prior permission from FD is not required. The infrastructural facilities at Karamjal should be improved in order to give the tourists better service and more satisfaction.

b. Dublar Char: A Fishing Island

Dubla Char could be another interesting and major tourist destination in the Sundarbans area. Tens of thousands of fishers, their helpers and fish traders gather in the char during winter months of October to February each year. Their purpose is to catch fish from the marine zone, process and trade their catch. Although their area of operation is at the periphery of the SRF, mere presence of so many fishers, the way they build thousands of temporary huts with locally available building materials, fish processing by sun drying and their activities is a spectacle to watch. In the month of November, rash mela, a locally important Hindu festival draws large number of religious pilgrims from faraway places to the char. The pilgrims take sacred bath in the river Kunga as a part of the ritual. A number of tourists are usually present to watch the spectacle. A carefully packaged program, intended for prospective tourists, should include Dubla char.

c. Fishing with Otter

A number of fishermen in areas close to the Sundarbans use trained otter to enhance their fish catch. This could be an interesting sight to the tourists. The tourist guides could fill in with interesting details on how the whole thing works. The fishermen could also take tourists onboard who are interested to participate in the fishing activity assisted by otters. This way, both tour guides and fishermen would be able to enhance their income and tourists would find the itinerary more interesting.

d. Boat Race for Honey Collection

Mouals, honey collectors of the Sundarbans, collect honey from the wild beehives of the Sundarbans. Every year, mouals (honey collectors) on April 1 get their boats ready to move into the forest at Burigoalini range. The moment forest officials signal green light, the boats start the race in order to get to the best bee hives ahead of others. The scene of a colorful boat racing

against the forest background has already started to attract attention of the tourists. A number of them attend the boat racing occasion each year. In recent years, a number of adventure tourists have started to accompany the mouals in the forest and to some extent participate in the honey collection process. The racing ceremony along with the scope of getting into the forest with the mouals, if well publicized with necessary background information, would surely attract more adventurous type of ecotourists.

Recommendations

- Promotion of ecotourism in Bangladesh should only focus on low impact tourism. Mass tourism that has started to develop focusing on the Sundarbans should be discouraged. Any large scale increase in mass tourism would inevitably lead to degradation of the forests. Utmost care should be undertaken not to damage the beauty of the forest and harm flora and fauna of the ecosystem. The problem is that there is hardly any system of managing tourists visiting the Sundarbans apart from collection of fees for entering the forest.
- In order to raise awareness about the fragility and the ecological importance of the Sundarbans, tourists, particularly domestic tourists, should go through a sensitization process. This could be made compulsory on the companies which intend to be in the business. As for eco-tourists from abroad, they are usually appreciative of the nature; otherwise they would not be interested in investing so much money and time to visit a forest in another country.
- The tourism program should be geared towards respect to local culture and importance of biodiversity. The name and fame of the Sundarbans is primarily based on the fact that this is the home of the famous Royal Bengal Tiger. However, in order to preserve the habitat of this famous specie and to avoid habitat fragmentation, tiger sighting aspect of the tour program has to be under-emphasized, especially “the tiger sighting part”.

Instead, natural beauty of the forests, its rich biodiversity, flora and fauna, and bird sighting should be promoted. A well trained and knowledgeable army of tour guides from the locality could be used for the purpose. The guides should be well versed and knowledgeable about the surroundings.

- Regarding sustainable benefits to the local community, a well managed eco-tourism program would provide economic benefits and alternative livelihoods for the local people. In order to increase income of the locals, youths from the area could be trained as guides and souvenirs could be sold to the visiting guests. Cultural programs which would reflect local myths and customs should be arranged in order to provide context to the tour program. As these cultural programs would be locally arranged, the sale proceeds would directly benefit the local economy.
- In order to have larger share of the tourist budget and give the tourists genuine local experience, a system could be developed whereby tourists, in exchange of certain amount of payment, could choose to spend a night with a local family, if possible with a Munda[16] family.. The system would directly benefit the local populace and the tourists would experience a genuine flavor of the lifestyle of the locals.
- Such a system is currently in place in a number of ecotourism destinations in India. Basically, a number of interested villagers are registered with the authority. The villagers' backgrounds are checked. Tourists while visiting the place could choose to spend a night with the family of one of the registered villagers. The villager provides them with an independent room with toilet facility for overnight stay. The family shares dinner and breakfast with the guests. In exchange, the villager gets predetermined amount of money. A similar system could be developed here. If needed more information could be sought from India. In addition, to gain practical experience, a small team of officials,

[16] Mundas are an ethnic group who depend on the forest for livelihood.

expert and ecotourism practitioners could be sent to India in order to gain a clearer understanding of the system.

- However, it should be noted that large scale ecotourism bound to degrade fragile ecosystem of the Sundarbans. In addition, an apparently successful ecotourism could degrade and destroy the local culture and make the local economy too dependent on tourism which is considered as a risky business considering the local context.
- Already, a growing number of local and some foreign tourists[17] have started to visit the Sundarbans and are causing solid waste management problems in some areas of the forest. Tour companies should be made responsible for cleaning up the litter. Harmful habits of the tourists to damage floras of the Sundarbans must also be contained. Tourists sometimes also play music using loud speakers, creating serious noise pollution. Again, tour companies could play a vital role in raising ecological awareness and promoting ecologically sensitive behavior on the part their clients.
- The entry fees that are currently being charged add up to a small portion of the overall expenditure a typical tourist has to incur. For the foreign tourists, the portion is even smaller. The current entry fees for the domestic tourists are quite low. Note that even if entry fees are increased by several folds, it would only lead to a small percentage increment in the overall expenditure a tourist has to bear. Consequently, one time sharp rise of entry fees seems unlikely to have significant impact on the number of visiting tourists. Enhanced receipt from entry fees then could be used for the preservation of biodiversity of the Sundarbans.

4.7 Information Dissemination

Information Dissemination has been frequently suggested as a part of solution for many problems discussed above. Note that millions of Bangladeshis currently own smart phones and

[17] The number of tourists was 208,000 in 2010-11

a huge number of them live in rural areas. It would be wise to take advantage of such development. The system of information dissemination should extensively use the advantage of IT and improvement of telecommunication sectors. One obvious way is to produce information rich, good quality videos and upload them on youtube. The videos should contain information and show how to actually do things. In addition, success stories of other farmers, fishers and honey producers, for example, could be shown in the videos. Again, information rich and regularly updated websites in Bangla should be developed.

Net addresses of those videos and websites could be sent to the telephones of relevant people through text messages or shared whenever any interaction between the extension officials and beneficiaries takes place. Union Information Centers could be intensively and extensively used for dissemination purposes.

Section 5

Infrastructure

5.1.1 Infrastructure for non-saline drinking water

The southern coastal belt of Bangladesh, inhabited by millions of people, face scarcity of fresh water even for drinking purposes during the dry season . As such, top priority should be accorded to this problem as millions are suffering from it even now. The inhabitants of the SIZ face a similar dire situation during the dry season of the year. The problem of salinity and associated scarcity of potable water starts to worsen from December and reaches its peak in March and April. The severe scarcity starts to improve from the month of May. The problem virtually disappears during the rainy season and comes back again in the following December completing the cycle.

During the dry season, pond water which has no connection with shallow aquifer remains non-saline. However, these ponds tend to dry up during dry the season when the non-saline water is needed most. However, there are fresh water ponds which contain water throughout the dry season or at least for a part of it. The shallow aquifers can get salinized during the dry season, too. Since tubewell draws water from shallow aquifer, tube-well water also gets saline. However, there are fresh water shallow aquifers distributed across the coastal belt. Deep aquifers, on the other hand, usually contain fresh water which could be used for drinking and other purposes.

The villagers frequently identify scarcity of drinking water as the most important problem induced by worsening salinity situation. As a result, the people inhabiting the area spend time (usually women's time) and resources in order to get access to potable water. They collect water from places where they can either get Pond Sand Filter (PSF) water, or from a source of non-saline water such as salinity-free pond. In some cases, they have to walk up to 3 kilometers for the purpose, wasting valuable productive hours of work. Some have opted for rain water harvesting, but it entails costs which the poor and ultra poor can ill afford. Fresh water for drinking purposes is also sold by private entrepreneurs at Tk. 0.50/liter at least, which again is a financial burden on a typical poor family. As a result, some are forced to restrict the amount of water they drink or drink unsafe potable water to the detriment of their health.

Salinity of drinking water is associated with hypertension, diarrhea, dysentery, preeclampsia and post-partum morbidity and mortality (Aneire Khan et al (2011); Dasgupta et al. 2015). Dasgupta et al. (2015) found the relationship between infant mortality and salinity exposure during the last month of pregnancy to be highly significant. Rabbani et al (2013) studying rural Shyamnagar Upzila of Satkhira district with high level of salinity of drinking water found that at least one member of each of the study households has experienced diarrhea or dysentery at least once in each month.

5.1.2 Probable Solutions

There are many systems of salinity free water supply to the villagers residing in the SIZ. Some of the systems are described below:

5.1.2.a Pond Sand Filter (PSF)

PSF system is based on slow sand filtering principle to remove (although not entirely) turbidity and fecal coli form from surface water. The system is usually donated by the GOB or various NGOs.

One major problem of PSF system is that if the pond water dries up during the dry season, the system will be of little help when it is needed most. The ponds which don't dry up are mostly connected to shallow aquifers. Unfortunately, the water of shallow aquifer frequently gets saline during the dry season and the PSF system is not meant to desalinize water either. Over the next few decades, as surface and shallow aquifer water is supposed to get more and more saline induced by climate change, PSF system may not be of much help.

The strong point of the system is it is cheap to install and user fee is low. For example, in some villages, a family pays only Tk. 10 once in every three months. Unfortunately, due to management related problems, the system is being increasingly considered as unworkable.

5.1.2.b Rain Water Harvesting

The system essentially entails collection of rain water from the roof of the households, especially if the roof is of corrugated iron which is quite common in rural Bangladesh. PVC pipes are attached to the edge of the roof to collect rain water. Next, the collected rain water is directed into a tank, made of plastic or brick and mortar. When rain starts, no water is collected for the first half an hour so that relatively clean water gets collected. The collected water is then used during the dry season or throughout the year as needed.

The system is costlier compared to the PSF system. However, with rising salinity problem, the system looks very promising.

5.1.2.c Small Desalinization Plant

With increasing salinization of surface water, there will be little but to opt for desalinization of surface/shallow aquifer water in order to produce drinking water at least for the dry season. Such system is already being tried and found to be quite promising.

One problem is that the system produces highly saline water as a byproduct. Disposable of the highly saline water could create some problem. Also, initial investment is quite high considering the current income level of rural entrepreneurs. Nonetheless, with higher per capita income of the country in future, this should not pose much of a problem. The main obstacle in using cheaper version of reverse osmosis system which is currently in use is that it cannot handle water with higher than 5 ppt salinity level. By 2050, the areas, which will experience much higher salinity level, have to opt for the costlier versions of desalinization plants.

5.1.2.d Shallow Aquifer Water Pump with Overhead Tank

The water is pumped and filtered in the treatment chamber. Next, filter water is pumped up into an overhead tank. The source of the water is shallow aquifer. The distribution network of pipes has water dispensers after certain intervals so that villagers can collect water within a reasonable distance from their houses.

The problem is, as stated above, shallow aquifers tend to experience elevated level of salinity during the dry season as well. For areas with bacteria free, fresh water containing shallow aquifers, the system should be an excellent choice.

Required initial investment is little high. Total cost of installing such a system would depend on the capacity of the system plus length of the distribution of networks. In order to meet the

running costs, the user families could be charged Tk. 30 to Tk. 60 per month depending on their economic status.

5.1.2.e Deep Tube-well

Deep aquifers in the area are expected to mostly contain fresh water. Deep tube-wells could be installed for exploiting those aquifers. The distribution network of pipes would have water dispensers after certain intervals so that villagers can collect water within a reasonable distance from their houses. As the capacity would be substantial, the pipe network may be extended to other neighboring villages if they are not too far. Over time, however, serious consideration should be given to the possibility of converting the system into piped water supply system for the villages. One possibility is to initiate the process of piped water supply system for those villages or cluster of villages where population density is high.

The benefit of the system is that water quality would be good needing no desalinization processes and could cover large areas with piped network. However, required initial investment is high.

5.1.3 Conclusions

The systems described above can coexist and can be promoted simultaneously. Apart from rain water harvesting and full-fledged piped water system, villagers need to spend time to collect water from the designated areas which is time consuming and the burden of doing so usually falls on women folk of the family. This adds an additional burden on them. Nonetheless, the systems are superior to the alternative of collecting water from faraway places.

Both PSF and shallow aquifer water pump with overhead tank systems are not designed to get rid of salinity from water – they need non-saline water source, be it pond or shallow aquifer. With elevated level of salinity in future, it is conceivable that in some areas, non-saline surface

or shallow aquifer water source will be hard to find. Under such circumstances, the systems of rain water harvesting, deep tube-wells drawing deep aquifer fresh water, small desalination plant, etc. could be employed for solving the problem. .

DPHE is already investing resources and setting up systems for addressing the fresh water scarcity problem in the area. More resources need to be invested through the agency and NGOs to assist the villagers in effectively addressing the problem.

5.2 Saline Resistant Infrastructure

5.2.1 Introduction

Buildings and roads are meant to be used for a long period of time. As salinity is destined to rise, rising salinity needs to be taken into consideration when roads and buildings are built. Once they are built, especially the buildings, it is very costly to retrofix the problem, whereas the cost of addressing the problem while under-construction is relatively easy and cheap.

5.2.2 Buildings

Over the next few decades, with rising family income, the number of brick built buildings with concrete roof is set to rise sharply. With elevated level of salinity, maintenance cost of a building would be substantially higher in the form of more frequent maintenance need. In addition, overall usable lifetime of buildings would be substantially shortened. In order to avert such problems in the future, precautionary measures need to be undertaken when the buildings are being constructed.

PWD should be sensitized to the prospective problem regarding elevated level of salinity and required to undertake remedial measures during the construction of new public buildings. National Housing Authority (NHA) and other relevant agencies need to undertake mass awareness campaign to make the population of the landscape area aware of the issue and to

disseminate information on the remedial and precautionary measures against the salinity problem. Rigorous studies need to be undertaken in order to get monetary estimates of such salinity induced potential damages to the buildings.

5.2.3 Roads

Building infrastructure, especially roads linking local area to markets, growth centers and urban areas, is usually the safest way to initiate development process in an essentially rural area like the landscape region. However, the problem is a well developed infrastructure may eventually draw migrants from other areas increasing the population of the area. A balance needs to be struck between development need and sustainability of the SRF.

Keeping the dilemma in mind, the following policies should be pursued at minimum:

i) Use of non-motorized traffic should be encouraged as much as possible in the area;

ii) No paved road should b built next and parallel to the perimeter of the forest. Doing so would likely degrade the forest faster. A bad example which should be avoided is Chandpai to Sarankhola road which runs parallel to the perimeter of the forest; and

iii) LGED, Union Parishads and other agencies should undertake precautions against rising salinity when building roads so that the maintenance cost and cost of remedial measures remain reasonable.

Section 6

6.1 Conclusions

The overall objective of the report is to identify policies and actions need to be undertaken in order to alleviate poverty situation in the Sundarbans interface landscape region in the context of climate change. The current study approached the problem from three different angels:

exposure reduction, promotion of eco-friendly livelihood options and protecting the current and future stock of physical assets from salinity induced damages.

Only those recommendations have been reported which are not generic and applicable to any typical rural area of Bangladesh, rather they are specifically suited for the Sundarbans landscape region. Due to eco-sensitivity of the region and abundance of the bounties of nature, it seems aquaculture, both mud crab and fish variety, and agricultural sector should play the lead roles in the generation of livelihood opportunities for the people living in the landscape.

The World Bank is already experienced in such income generating programs in saline areas. One such program, Community Climate Change Project (CCCP), is an attempt to help enhance community resilience against adverse impacts (including salinity) of climate change in the country. It is being funded from Bangladesh Climate Change Resilience Fund (BCCRF). The area covered includes southern saline zones and other climate change vulnerable areas of Bangladesh. The program is extending goat/sheep and poultry rearing support; promoting crab culture, and homestead gardening among many other activities. The program, in order to alleviate potable water problems, has also installed a small number of desalination plants. Our recommendation would be to undertake similar programs on a larger scale across the Sundarbans landscape region.

The other sectors which could play crucial supplementary role are ecotourism and apiculture. In addition, measures that need to be undertaken to protect lives and properties have been identified and discussed in the report.

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