নিসর্গ নেটওয়ার্ক

INTEGRATED RESOURCES MANAGEMENT PLANS

FOR

THE SUNDARBANS

(2010-2020)

VOLUME I

Forest Department

Ministry of Environment and Forests

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List of Abbreviations

AAC : Annual Allowable Cut
ACF : Assistant Conservator of Forest
ACR : Annual Confidential Report
ADB : Asian Development Bank
ADP : Annual Development Plan
AIG : Alternative Income Generation
AWB : Asian Wetland Bureau
BA : Basal Area
BBS : Bangladesh Bureau of Statistics
BCDP : Biodiversity Conservation Development Project
BCIC : Bangladesh Chemical Industries Corporation
BFRI : Bangladesh Forest Research Institute
BGD : Bangladesh
BIDS : Bangladesh Institute for Development Studies
BLC : Boat License Certificate
BPC : Bangladesh Parjatan Corporation
BSG : Border Security Guard
C : Carbon
cc : cubic centimeter
CCF : Chief Conservator of Forests
CEC : Cation Exchange Capacity
CEGIS : Centre for Environmental and Geographic Information Services
CF : Conservator of Forests
CFI : Continuous Forest Inventory
CFIU : Continuous Forest Inventory Unit
cft : Cubic Feet
CIFOR : Centre for International Forestry Research
CITES : Convention of International Trade on Endangered Species
cm : centimeter
CMC : Co-Management Committee
CMO : Co-Management Organization
CMP : Conservation Management Plan
CO_2 : Carbon dioxide
CPG : Community Patrolling Group
dbh (or DBH) : diameter at breast height
DANIDA : Danish International Development Agency
DCF : Deputy Conservator of Forest
DCCF : Deputy Chief Conservator of Forest
DFID : Department for International Development
DFO : Divisional Forest Officer
DG : Director General
DOE : Department of Environment
DOF : Department of Fisheries

DPP : Development Project Proposal

DR	: Deputy Ranger
EC	: European Commission
ECA	: Ecoligically Critical Area
e.g.	: for example
EMD	: Environmental Management Division
EP	: Environment Policy
EPDIC	: East Pakistan Industrial Development Corporation
et al.	: and others
etc.	: etcetera
EU	: European Union
FAO	: Food and Agricultural Organization
FAP	: Flood Action Plan
FD	: Forest Department
FG	: Forest Guard
FGD	: Focus Group Discussions
FMD	: Forest Management Division
Fr	: Forester
FR	: Forest Ranger
FRMP	: Forest Resource Management Plan
FMSY	: Fisheries Maximum Sustained Yield
FSP	: Forestry Sector Project
GDP	: Gross Domestic Product
GIS	: Geographical Information System
GoB	: Government of Bangladesh
GMM	: Gross Marketing Margin
GPA	: *Gewa* Production Area
GRWC	: Gross Returns over Working Capital
ha	: hectare
HCR	: Head Count Ratio
HH	: Household
HIS	: Habitat Suitability Index
HQ	: Head Quarter
i.e.	: that is
IEC	: Information, Education and Communication
IFM	: Improved Forests Management
IFMP	: Integrated Forests Management Plan
IPAC	: Integrated Protected Area Co-Management Project
IPCC	: Intergovernmental Panel on Climate Change
IRMP	: Integrated Resource Management Plan
IRG	: International Resources Group
IUCN	: International Union for the Conservation of Nature
KEMD	: Khulna Environmental Management Division
KFD	: Khulna Forest Division
KHBM	: Khulna Hardboard Mill
km	: kilometer
km^2	: square kilometer
KNM	: Khulna Newsprint Mill

LDF	: Landscape Development Fund
LGI	: Local Government Institution
LR	: Long Rotation
m	: meter
m^2	: square meter
MARC	: Multidisciplinary Action Research Centre
MLSS	: Member of Lower Subordinate Staff
MOEF	: Ministry of Environment and Forest
MPD	: Management Plan Division
MSc	: Master of Science
MRV	: Monitoring, Reporting and Validation
MSD	: Mangrove Silviculture Division
MSY	: Maximum Sustainable Yield
NACOM	: Nature and Conservation Movement
NCS	: National Conservation Strategy
NDVI	: Normalized Difference Vegetation Index
NGO	: Non-Governmental Organization
NIC	: Nature Interpretation Centre
N	: Number
No.	: Number
nos.	: numbers
NM	: Newsprint Mill
NMM	: Net Marketing Margin
NP	: National Park
NRWC	: Net Returns over Working Capital
NSP	: Nishorgo Support Project
NTFP	: Non-Timber Forest Product
ODA	: Overseas Development Administration
OIC	: Officer in Charge
OM	: Organic Matter
PA	: Protected Area
PBSA	: Participatory Benefit Sharing Agreement
PhD	: Doctor of Philosophy
PL	: Post Larvea
PP	: Project Proforma
pp.	: pages
PRA	: Participatory Rural Appraisal
PSF	: Pond Sand Filter
PSP	: Permanent Sample Plot
QA	: Quality Assurance
QC	: Quality Control
REB	: Rural Electrification Board
REDD	: Reduction of Emissions from Deforestation and Forest Degradation
RF	: Reserve Forest
RIMS	: Resource Management Information System
RoW	: Right of Way
RRA	: Rapid Rural Appraisal

RRI	: River Research Institute
SBCP	: Sundarbans Biodiversity Conservation Project
SD	: Survey Department
SEALS	: Sundarban Environmental and Livelihood Security Project
SFBZ	: Sundarbans Forest Biogeographic Zone
SME	: Small and Medium Enterprise
SMP	: Strategic Management Plan
SoNG	: Swatch-of-No-Ground
SPA	: Sundari Production Area
SPARRSO	: Space Research and Remote sensing Organization
spp.	: species (plural)
SR	: Short Rotation
SRF	: Sundarbans Reserved Forest
SWC	: Sundari Working Circle
SWMC	: Surface Water Modeling Center
SWOT	: Strength, Weakness, Opportunity and Threat
TA	: Technical Assistance
TDS	: Top Dying Sundari
Tk	: Taka
TV	: Television
UNDP	: United Nations development Program
UNESCO	: United Nationa Education, Scientific and Culture Organization
UP	: Union Parishad
USA	: United States of America
USAID	: United States Agency for International Development
USFS	: United States Forest Service
US$	: United States dollars
V	: Volume
VGD	: Vulnerable Group Development
VGF	: Vulnerable Group Feeding
WB	: World Bank
WC	: Working Circle
WMNC	: Wildlife Management and Nature Conservation
WNCC	: Wildlife and Nature Conservation Circle
WS	: Wildlife Sanctuary
WTB	: Wildlife Trust of Bangladesh
WTO	: World Tourism Organization

Executive Summary

A basic principle of forests management, including protected areas (PA) management, is that every forest area should have a management plan that guides and regulates the management of its encompassing resources, the conservation of both terrestrial and aquatic biodiversity, the sustainable land-uses, development of required facilities, supporting administration, and adequate budget resources. The Integrated Resources Management Plans (IRMP), developed based on in-depth analyses of the current resources status and management situation, provides for ten-year ten strategic programs with specified goals and objectives, targeted outcomes/outputs with verifiable success criteria, framework activities, and appropriate guidelines for sustainably managing the Sundarbans Reserved Forests (SRF) and its interface landscape. The IRMP is a result of numerous discussions and meetings between staff of the Forest Department (FD), relevant Government Agencies including Department of Fisheries (DOF); local stakeholders including Co-Management Organizations (CMOs); civil society; United States Agency for International Development (USAID); United States Forest Service (USFS); and Integrated Protected Area Co-Management (IPAC) Project staff.

The following vision statements are proposed by the FD as the long-term vision for the management of the SRF and its interface landscape:

- The Sundarbans shall continue to provide subsistence resources including forest produce and fish at a level in which the sustainability of the resource is ensured, though emphases will be on reducing dependency and improving current resources management practices.
- Traditional users will acquire a greater awareness and shared responsibility and a share in the financial benefits as a result of co-managing the resources and will act accordingly to help conserve them.
- The FD will involve local people in the SRF co-management, and other relevant government agencies such as the Department of Fisheries and the Department of Environment (DOE) will be consulted, whenever required.
- The FD will develop its capacity including infrastructure, logistics and technical capacities and seek technical assistance where appropriate in the SRF management.
- Development and efficient operation of alternative income enterprises in the landscape will help adapt the local community to climate change.
- Wildlife and fish resources will prosper throughout the SRF where populations will thrive at optimum carrying capacity. The SRF landscape will be managed to ensure that essential ecological services are maintained and terrestrial and aquatic ecosystems are well adapted to climate change. The wildlife sanctuaries and wetlands will be managed to provide secure habitat for wildlife and fish resources.
- Specific sites, infrastructure and routes in designated areas of the SRF will be developed and/or maintained to provide for quality ecotourism experiences.
- In order to take advantage of the increasing nature tourism, the Forest Department will seek public private partnerships, consistent with the guidelines and principles established by the GOB to improve the ecotourism services and facilities.
- The effects anticipated to result from climate change will be recognized, and mitigation and adaptive management strategies developed and implemented in order to ensure the maintenance of ecosystem goods and services.
- Restoration and maintenance of essential ecological functions including restoring streamflows will be recognized.
- The Sundarbans, as the largest contiguous mangrove system in the world and befitting its world heritage site designation, will become the international recognized example

of collaborative management of a mangrove ecosystem, with provisions for sustainable carbon financing for more effective conservation efforts in the SRF in tandem with a broad range of programs supporting poverty reduction and sustainable socio-economic development in the landscape.

Ten interlinked strategic management programs developed in this ten year IRMP will contribute to the achievement of the following five planning goals and outcomes for the sustainable management of the Sundarbans Reserved Forests and its surrounding landscape:

Goal 1: Protect, restore, sustain and enhance the biodiversity of the SRF and its interface landscape.

Outcome: Forests and terrestrial resources, and wetlands and aquatic resources with the representative capacity to maintain their health, productivity, diversity, and resilience.

Goal 2: Provide for resilience-based food security through provision of a variety of subsistence uses inbcluding fisheries, values, benefits, products, and services, while ensuring the sustainable supply of these resources for future generations.

Outcome: Resources use is managed on the basis of sustainability and co-management based on best available science and through the consultation of stakeholders.

Goal 3: Provide for and enhance eco-tourism and visitor recreation opportunities.

Outcome: Eco-tourism revenues are sufficient to provide enhanced alternative incomes as well as provide for increased emphases on biodiversity conservation.

Goal 4: Support and improve community based co-management approaches for the activities taking place in the SRF and its surrounding landscape.

Outcome: The FD facilitates and engages with the landscape communities and stakeholders in determining appropriate co-management practices and benefits sharing.

Goal 5: Provide for and implement appropriate climate change mitigation and adaptation options and opportunities.

Outcome: The FD ensures the continuation of the Sundarbans as carbon sink (both for green carbon and blue carbon), and contrtibutes in enhancing the ecosystems resilience for improved adaptation of local communities to climate change impacts including cyclones and storms.

The Plan, a revision of the existing Integrated Forests Management Plan (IFMP) for the SRF and the Conservation Management Plan (CMP) for the three wildlife sanctuaries, comprises two volumes: The Volume 1 is divided into Part I and Part II, whereas the Volume 2 provides support materials. In-depth analyses of the present management situation (the SRF including wetlands, forests and three wildlife sanctuaries; strategic goals and objectives; biodiversity protection and management; natural resources use patterns; past management review, interface landscape, etc) with documentation of main findings and issues are provided in Part I of the Plan. Keeping in view the identified goals and objectives and based on the main findings of the Part I, the Part II of the Plan designs and recommends ten interlinked strategic programs for sustainable management of the SRF and its interface landscape. A mid-period review of the Plan is suggested to take on board lessons learnt and changing context. Annual development plans (ADP) with specific activities and budget lines will be drafted each year with due consultations.

Of the four distinct biogeographic zones in Bangladesh, Sundarbans Forest Biogeographic Zone (SFBZ) is of immense importance. It encompasses the mouths, deltas, alluvial pans and coastal tributaries of important rivers such as Baleswar river on the east, and the Sela Gang-Bangra rivers, the Pasur-Shibsa-Kunga rivers, the Arpangasia-Manalcha rivers, and the Jamuna-Raimongal-Harinbhanga rivers on the west. With the depository pan of these rivers (which drain with immeasurable amount of silt from the vast mountainous watersheds in the Himalayas and Meghalaya), this zone keeps on expanding in land area outward onto the Bay of Bengal due to land accumulation. It is generally characterised by thick vegetation, dominated by well-known mangrove tree species such as sundari, gewa and keora, mixed with other species including goran, pasur, kankra, baen, dhundal, and palms such as golpata and hantal, and patches of grassland dominated by sungrass. This zone harbors the famous Royal Bengal tiger and many other important mammal species which include the Spotted Deer, Rhesus Monkey, Jackel, and Civet; reptile species such as the Estuarine Crocodile, and Monitor Lizard; bird species such as White-breasted Water Hen and Emerald Dove; and amphibians such as Bull Frog. A good number of aquatic resources including fishes, crabs and ceteaceans such as dolphins and porpoises are found in this zone.

The Sundarbans is intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests. Within the largest mangrove forests in the world lie three wildlife sanctuaries (the Sundarbans East, West and South, totaling 139,698 ha) that were gazetted in 1996. The SRF serves as coastal protection to huge population in the interface landscape from cyclones and tidal surges. The SRF (6,017 square km) interfaces with cultivated lands, intersected by tidal rivers, canals and streams. The waves and tides with changes in water depth and its biochemical constituents, and fresh water from rivers are the basis on which the life and ecosystems depend. The SRF also represents the largest single carbon asset pool for the counttry to market in appropriate carbon markets. Timber harvested from the SRF has in the past been a major resource, but currently a commercial logging ban is in place until 2015.

A variety of non-timber forest products such as honey, wax, medicinal plants, golpata and grass are extracted from the SRF. The 12,000 km of rivers and streams in the SRF produce a large quantity of fish, shrimp and crabs. In addition, the Bay of Bengal is home to an important marine fishing industry whose stocks originate in the Sundarbans. The ecological and socio-economic importance of the SRF is associated with its rich biodiversity and the ecosystem's valuable ecological services and products. It is estimated that the SRF is home to 425 species of wildlife, including 300 species of birds and 42 species of mammals. The area serves a vital role in a variety of ecosystem functions including (1) trapping of sediment and land formation, (2) protection of human lives and habitation from regular cyclones, (3) acting as a nursery for fish and other aquatic life, (4) oxygen production, (5) waste recycling, (6) timber production, (7) supply of food and building materials, and (8) climate change mitigation and adaptation through carbon sequestration, storage and cycling. These functions are increasingly at risk from the effects associated with climate change and sea level rise.

Integrated management of both forests and wetlands of the Sundarbans for producing products and generating services while maintaining their environmental roles and functions is feasible but ecologically complex. An important process responsible for the sustainability of the Sundarbans is the biogeochemical cycling of nutrients both in forests and wetlands. The leaves, twigs, small branches and fruits make the litter falling on the forest floor and in wetlands, and the decomposition of humus through micro-organisms (bacteria and fungi) helps in adding nutrients to wetlands and forests soils for plant and aquatic growth and also in storing soil carbon through organic matter. Appropriate forests and wetlands management needs to be part of biodiversity and land management strategy so that perennial vegetative cover can be maintained in perpetuity. Such a management system should be perceived as husbandry of renewable forests and wetland resources with attention to the protection of conservation, recreational and other values. Similarly adequate cycling of nutrients through flow of freshwaters and tidal ingress of saline waters is important for the sustainability of both wetlands and forests.

Nearly one-third of the Sundarbans is composed of a network of tidal and fluvial waterways ranging from a few meters to a few kilometers wide and carries substantial sediment load with a large amount of nutrients. Salinity levels in the Sundarbans are determined by physical forcing from freshwater flows and to a lesser degree by diurnal tides. Freshwater discharge from the Ganges-Brahmaputra-Meghna rivers, which are fed by snowmelts in the Himalayas and monsoon rains, is maximum during monsoon season (June-September), which coincides with the formation of a counter-clockwise gyre in the Bay of Bengal. This gyre is responsible for the wide distribution of nutrients but their availability remains limited because coastal upwelling is suppressed by freshwater inputs along the coast, especially at the system mouth. The northeast monsoon during December-February drives a clockwise gyre which persists until May and reduced freshwater discharge during this time allows for upwelling of nutrients that were transported to the delta by counter-clockwise gyre formed during the previous months of the southwest monsoon. The high amount of nutrients, along with light winds, results in intensive coastal fisheries, which supply much needed food security including protein to local community and beyond. The process of accretion and erosion within the Sundarbans is highly complex due to large number of interconnecting waterways, and the sediments of both tidal and river waters are distributed on the forest floors.

As per the provisions of Environmental Conservation Act, 1995, the 10-km wide band surrounding the northern and eastern boundaries of the SRF, with an approximate area of 175,000 hectares, was declared by the Ministry of Environment and Forests as ecologically critical area (ECA) with the main objective of providing protection to the SRF and conservation of its biodiversity. This 10km band is designated as the interface landscape zone in the context of climate change adaptation through value chain and livelihood enterprises and support for environmental and biodiversity conservation. There has been a great deal of change in the land use patterns of the ECA and agricultural lands have been transferred to *gher* that are developed for fish and shrimp culture. The interface landscape and the local people are characterized by poverty, natural calamities, poor education and health services, drinking water scarcity, and little income opportunities, all of which contribute to high biotic pressure on the natural resources of the SRF and its interface landscape zone.

Based on the above-analyzed resources management situation, the following ten strategic and mutually interlinked programs are developed for their implementation over the Plan period of ten years:

1. Habitat Protection Programs

Heavy biotic pressure, brought by manifold increase in human population has in past resulted in forests degradation in the SRF. Effective protection of the SRF is necessary for ensuring the country's food security, conserving biological diversity and controlling adverse impacts of climate change. Main objective of the habitat protection programs is to provide effective protection to the entire SRF including forests and wetlands and their constituent flora and fauna by following a co-management approach that will focus on establishing gainful partnerships with key stakeholders but also simultaneously strengthening FD protection and communication infrastructure and related mechanisms. The forests and wetlands within the SRF and its surrounding landscape will be managed based on sound co-management practices that will conserve biodiversity and benefit local community. The existing levels of land-use will be managed by means of suitable zoning in ways that do not result in major adverse environmental or irreversible ecological impacts. This includes co-managing sustainably the existing and expected land-uses with some controls on location and use-intensity. Sustainable landscape management zoning is done to implement relevant management practices in identified areas of the SRF based on the above-stated management objectives to be achieved spatially. In order to provide a basic spatial framework for protecting the areas of highest conservation value and maintaining the maximum possible area under natural forest cover, the SRF is categorized into two zones, core zone and buffer zone, based on existing biodiversity and management objectives.

The identification of an interface landscape zone influencing the designated core and buffer zones is necessary for sustainable development of neighboring forests/wetlands and adaptation of local community to climate change. The core zone will have the highest biodiversity conservation and climate change mitigation values followed by the buffer zone, which would adjoin the interface landscape zone comprising local stakeholders and impacting land-uses. All the notified area of the three Wildlife Sanctuaries is designated as the core zone, and the remainder SRF is its buffer zone. The 10-km wide band spread along the northern and eastern boundaries of the SRF will function as interface landscape zone. However, in near future it can be expanded to include another 10km wide extended landscape zone to the north and east of the present interface landscape zone.

Main recommendations for strengthening the protection of forests and wetlands are detailed in this program. Under patrolling component main recommendations focus on, i) updating roles of camps and stations, and ii) updating numbers and locations of FD posts and their patrolling jurisdictions. Three types of patrolling posts as recommended are boundary patrol camps, interior patrol camps and long-range patrol camps. Range Offices will continue to be operational forests/wetlands/wildlife management and administration units which will be better equipped (through improved communication and a striking force with arms) to deal with organized smuggling of timber and poaching of wildlife including tigers. Forest Stations will continue to be responsible with revenue collection but will increasingly shoulder patrolling duties with better equipments and manpower. Boundary Camps will be established near designated stretch of forest boundary and neighboring villages with responsibility of checking boats at entry and exit levels. Interior and long-range camps will continue to be responsible for normal and mobile patrol by employing FD boats and improved communication equipments. Thirty two Forest Camps are to be closed down but 8 new Camps are to be set up at strategic locations and 2 Camps are to be upgraded as Forest Stations. Overall there will be existing 4 field Range Offices (in addition two Ranges are at the Divisional headquarters), 18 Station Offices, 26 Boundary Camps, 18 Interior Camps and 7 Long-range Camps.

Field monitoring will be employed as a tool for effective protection by employing selected indicators and taking corrective actions. Under monitoring component, main interventions will focus on, i) improving monitoring of field staff patrolling activities for controlling illicit felling and fishing and poaching of predators (tiger) and prey (deers), and ii) establishing monitoring units in identified canals in selected compartments. Monitoring by senior FD staff such as DFO and ACF will be strengthened by providing adequate motorized boats and equipments including GPS, life saving devices and arms. Suitable monitoring indicators would include patrolling frequency, and patrolling coverage and distance from the posts.

A number of existing posts are lying vacant due to frozen recruitment. Under staffing component, main recommendations focus on, i) updating the existing SRF organogram by reposting existing staff in line with redistributed posts, ii) recruiting field staff to fill all the existing vacancies, iii) and promoting all the Boatman and filling up existing vacant posts. Under physical work component, main recommendations would focus on, i) to establish adequate number of FD boat fleet and jetties, and provide for their regular maintenance and running costs in annual budget, and ii) to improve infrastructure including drinking water facilities, and patrolling equipments such as GPS, flashlight, uniform, footwear, map and stationary, first aid box, and arms for defense. Under telecommunication component, main recommendations will focus on, i) strengthening and maintaining existing walkie-talkie system, and ii) providing GPS and laptops for internet access, wherever feasible.

It has been agreed to implement a co-management approach for managing the Sundarbans by involving key stakeholders. Accordingly, two co-management committees (CMCs) have been functioning to manage the Sundarbans comprising Chandpai and Sarankhola Forest Ranges in the Sundarbans East Division. Two more CMCs are being formed for Khulna (with HQs at Nalian) and Satkhira (with HQs at Burigualoni) Forest Ranges of the Sundarbans West Division. An equitable sharing of benefits and responsibilities of the Sundarbans protection and management among the stakeholders is an important part of this program. Establishing effective linkages of socio-economic and ecological incentives and biodiversity conservation is instrumental in eliciting stakeholders' participation in protecting, rehabilitating, conserving and sustainably managing the Sundarbans by building gainful partnerships based on shared benefits and responsibilities. The strengthening of protection infrastructure and redistribution of posts with enhanced presence of field staff will help control organized smugling. However, long-term protection of the Sundarbans cannot be ensured without gainfully involving key stakeholders including local community in the interface landscape and floating forests/fisheries dependent community.

Community Patrolling Groups (CPGs) will be formed particularly on the northern and eastern side of the SRF including eastern wildlife sanctuary where population pressure is currently high. In the absence of biotic pressure in the south and west sanctuaries, CPGs may not currently be formed. Conservation-oriented management of the Sundarbans with restrictions on the harvesting of forests and fisheries through enhanced protection will result on high opportunity costs to local poor in terms of their foregone benefits, which they were deriving from the forests and wetlands before the implementation of strict protection/enforcements practices. Sustainable use of identified non-timber forest products (NTFPs) including grasses, golpatta, honey, wax and fish will be allowed for bonafide subsistence consumption *in lieu* of their increased protection efforts. The protection efforts will be augmented through communication and outreach activities, public awareness, stakeholders' access to conservation-linked livelihood and value chain activities in the interface landscape zone.

2. Wildlife Sanctuaries Management Programs

With the promulgation of the Wildlife (Preservation) Act in 1974, the Forest Policy in 1994 and the amendment of Forest Act in 2000 and the Social Forestry Rules in 2004 and 2010, the emphasis of forests management has gradually shifted from timber production to ecological requirements, conservation of biological diversity, meeting bonafide subsistence consumption needs of local people and climate change mitigation and adaptation functions and services of forests. Main objectives of the sanctuaries management program are to, i) co-manage the three wildlife sanctuaries in as natural ecosystem and undisturbed condition as possible as source of important genetic and biological resources, and carbon sink ii) provide effective protection to the constituent biodiversity including wildlife and aquatic resources against all forms of biotic interference, iii) rehabilitate, maintain and develop good quality forest cover and productive wetlands with natural structure and composition, iv) reduce and shift subsistence use of forests, wildlife and aquatic resources by local community to the buffer zone and the interface landscape zone, v) ensure protected habitat and prey base for tiger as a flagship species, and vi) regulate high impact visitor use for outdoor recreation, research and educational purposes by mounting an awareness and motivation campaign.

The notified areas of the East, West and South wildlife sanctuaries constituting the respective core zones of the three gazetted PAs comprise the areas of high biodiversity values. A new wildlife sanctuary comprising the compartments 1 and 2 will be gazetted by the MoEF and a proposal to this effect will be sent by the FD. The management in this zone will focus on conserving natural forests and wetlands by providing long-term protection (as above-described) against biotic pressure. This will be achieved by providing protection through co-management against illicit removals of forests and aquatic resources, and controlling poaching and poisoning of fish. Effective protection against biotic pressure will allow natural processes of regeneration of the indigenous trees, shrubs, grasses and other mangrove vegetation required for creating a favorable habitat for wildlife.

As per the latest census, there are 440 tigers in the Sundarbans, the only significant tiger habitat left in Bangladesh. Being an umbrella species, effective management of tigers would automatically result in securing the management of its habitat and other lower pyramid wildlife including its prey, the deers and boars. The tigers are threatened due to a number of factors that in the Sundarbans include poaching, habitat degradation and loss, prey (deer and wild boar) depletion, tiger-human conflicts, disease, increase in salinity and consequent vegetation patterns due to reduced amount of freshwater and adverse impacts of climate change including sea level rise. The requirements of tiger as a flagship and umbrella species will guide management decisions and monitoring of habitat. Adequate predator-prey ratio will be maintained through selective management interventions while preserving and increasing the diversity of interspersion of habitats. Existing grasslands will be maintained and degraded grasslands will be rehabilitated in identified gaps. Breeding sites of animals and fish and other important sites (e.g. burrow) harboured by nocturnal animals will be protected and maintained. An animal clinic with rehabilitation pen will be established at Mongla for rehabilitation and treatment of wounded animals.

Co-management practices, implemented through co-management organizations such as CMCs, will be tailored to strengthen protection efforts against illicit felling and fishing, and poaching. The SRF dependent communities will be motivated to considerably reduce their removals and *in lieu* they will be provided conservation-linked livelihood opportunities through value chain and income generation activities to be implemented for the local community through the CMCs. In order to reduce human interventions inside the sanctuaries, the harvesting of non-timber forest products including honey, wax, hantal and bark will not be allowed. The visitor use of the core zones will be regulated and only low impact activities such as hiking, sightseeing, jungle boating, cruising and wildlife watching will be allowed; high impact visitor activities such as motorized vessels and group picnics will be controlled significantly and will be allowed only in identified routes.

As all the three wildlife sanctuaries are located adjoing to the Bay of Bengal, a total ban on fishing in the waters inside the three sanctuaries will be enforced by involving CMCs to ensure the sanctuaries as protected breeding/spawning areas for marine fish and other aquatic fauna. Throughout the year, all types of fishing including fin fishes, crustaceans (shrimps, prawns, crabs) and sea snakes, catching fries of fin fishes and prawns, and collecting mollusk shall be banned. Special efforts will be taken for the protection of Olive Ridley turtles on Putney Iseland and Dimer *Char*. Unauthorized fishing, poaching, hunting and poisoning will be checked through CMCs as part of co-management activities. No temporary or permanent settlements of fishers will be allowed inside the three sanctuaries. River banks will be stabilized by protecting natural regeneration that generally comes up below the convex sections of the curves on meandering rivers. Water pollution inside the sanctuaries due to cargo vessels and boats will be minimized by taking help from the Port Harbour Authority for enforcing no-dumping of pollutants regulations.

Cetaceans abundance and habitat in Bangladesh are found in a 120-km wide belt of estuarine, coastal and deep-sea waters across the SRF and offshore to a 900+ meter deep under-sea canyon known as the Swatch-of-No-Ground (SoNG). The sustainable existence of cetaceans is threatened by incidental killing in gillnet fisheries, depletion of prey due to loss of fish and crustacean spawning habitat, trawl fisheries, sea-level rise due to climate change, and massive non-selective catch of fish fingerlings and crustacean larvae in small mesh mosquito nets and toxic contamination from large, upstream human population centers. Addressing these threats by implementing above-discussed habitat protection measures will help protect the habitat and conserve cetacean biodiversity. Additional protection measures focused on wetlands and deep-sea waters having cetacean abundance would include identifying and protecting their regular routes, controlling illegal fishing activities and use of damaging fish nets, reducing toxic contamination and water pollution, addressing climate change, and community awareness through CMCs. In addition to the three existing sanctuaries and the proposed fourth wildlife sanctuary, further southward sea-waters including SoNG may be considered to be designated as no-fishing zones by declaring a marine sanctuary.

3. Sustainable Forests Management Programs

The recommended forests management programs will be implemented in the remainder SRF (except the core zone comprising the three wildlife sanctuaries) which is designated as buffer zone. Main objectives of the forests management program include to, i) maintain ecological succession in the constituent forests in order to ensure long-term existence of the Sundarbans complex ecosystem, ii) develop and maintain mangrove forests as carbon sinks and good habitat favoring the conservation of both terrestrial and acquatic fauna and flora, iii) improve regenerative capacity of the Sundarbans by conserving forests and wetlands and constituent biodiversity through co-management approach that benefits local community, iv) maintain mangroves and wetlands as breeding ground of aquatic resources including fisheries, and v) manage the Sundarbans for their protective and food and ecological security functions and services through climate change mitigation and adaptation.

In view of the felling moratorium currently in place (until 2015) it is not expected that in near future (at least during the plan period of ten years) any tree felling will take place. Moreover, the present emphasis on the Sundarbans forests functions and services including the mangroves as carbon sinks under the reduction of emissions from deforestation and forests degradation (REDD+) mechanism means that the present ban on tree felling is expected to continue. Keeping in view of a conservation-oriented management of the SRF, most of the management prescriptions detailed in the previous program for managing the core zone will equally be applicable for managing the buffer zone as well. However, limited harvesting of NTFPs including fisheries resources and golpatta will continue as per the prescriptions detailed in the Plan. The FD has designated 18 khals inside the SRF (but outside the 3 wildlife sanctuaries) as fish sanctuaries where no fishing is allowed. All the forests/wetlands protection recommendations including control of illicit harvesting of forests and wetlands resources, as enumerated in the habitat protection program will be applicable for this program as well.

Appropriate regulatory prescriptions are provided in this program, in case the Government of Bangladesh decides to lift the felling moratorium and as a result the FD takes recourse to timber harvesting in the identified felling series of the buffer zone. The results of the temporal analyses of the SRF vegetation show that 53,806/ha number of seedlings naturally regenerated in 2009 compared to 34,723/ha seedlings in 1996. Main reason for this increase is due to commercial ban on harvesting and improved protection. The total number of saplings for all the species survived 5,545/ha in 2009, which is less compared to 8,088/ha in 1996. During this period the total number of poles for all the species of sizes 2.5-5.0 cm and 5.0-10.0 cm DBH classes increased from 1008 to 5003 and 1133 to 4364 per hectare. Similarly, the number of poles of size 10-15 cm DBH classes and number of trees for all the species have also increased from 384 to 507 and 142 to 297 respectively.

The basal area per hectare (BA/ha) and volume per hectare (V10/ha) for poles (of DBH class 10-15 cm) and trees increased during the period by about 285, 32, 113 and 135 percent respectively. The tree number per hecrare (N/ha,) basal area per ha (BA/ha) and volume per ha (V10/ha) have increased for all the DBH classes. The volume increment for sundari was 29 m^3/ha (from 19 m^3/ha in 1996 to 48 m^3/ha in 2009). Similarly, the volume increment for the species gewa was 5.6 m^3/ha (from 2.2 m^3/ha in 1996 to 7.8 m^3/ha in 2009). The species compositions of the SRF are dynamic and, therefore, an attempt was made to make a realistic assessment of the present situation. The number of trees of sundari, gewa and others (keora, baen and others) were estimated and converted into percentages of the total. The results show that the percentage of sundari trees has reduced by 4.6% but the percentage of gewa trees has increased by 8%.

An attempt was made to compare the results as inferred from the current inventory with those of the previous inventories. The results as summarized in Table 1, show that the number of stems/ha and volume/ha had decreased after the Forestal inventory (in 1959-61) but the growing stock condition has improved after ODA inventory (in 1983).

Table 1: Comparative estimates of no. of trees/ha and volumes (cum) of trees per ha

	Species					
Year	**Sundari**		**Gewa**		**Others**	
	N/ha	**V10/ha**	**N/ha**	**V10/ha**	**N/ha**	**V10/ha**
2009	205	48.2	62	7.8	30.4	11.2
1996	106	17.8	20	2.1	20	7.5
1983	125	19.9	35	2.7	20	7.1
1959	211	33.6	61	5.0	24	5.9

The IFMP came into effect after its approval (in January 1998) for a period of 12 years, until 2010. But the plan for the purposes of sustainability analysis carried out timber harvest planning over a period of 22 years, to the year 2020. Accordingly, the IFMP, based on the forest inventory of 1205 plots and growth statistics, formulated regulatory prescriptions over a period of 22 years, including an initial 2 year interim period (1998-2000) and the remainder period of 20 years (divided into four 5-year periods). The regulatory prescriptions for main tree species including sundari could not be implemented as the tree felling ban continued during the plan period. In case the ban on tree felling is lifted, the felling prescriptions of the IFMP can still be implemented during the remainder ten years as their applicability has been validated by employing the data from the forest inventory that was carried out by FD during 2009-10 by enumerating 150 plots. In view of similar results obtained by analyzing the inventory data of the two periods, it was confirmed that the Annual Allowable Cuts (AAC) prescriptions of the IFMP, can still be employed for carrying harvesting in case the GOB decides to lift the moratorium on commercial tree felling.

Annual Allowable Cuts (AAC) for different species in the Sundarban Reserved Forest was estimated using the following two formulae:

a) AAC = (Present standing mature volume+ ½ growth during the period)/Period of cutting cycle

For sundari the estimated AAC is about three times of the prescribed value as per the IFMP (see Table 2, column 7). The AAC is nearly same for "others" species but about1/5th and 1/7th for gewa and keora. Keeping in view a conservation-oriented management, the IFMP volume recommendations are validated to be largely acceptable and can so be implemented in case the GOB decides to lift the present ban on commercial felling.

b) As per the Austrian formula: AAC = I + (Ga – Gr)/A
where, I = Annual increment,
Ga = Present growing stock,
Gr = Desired growing stock (indicated by yield table or some other empirical standards)
A = Adjust period, which may be a full rotation or any selected period

Here, if Ga = Gr, then only the increment can be harvested and the AAC estimated following this assumption is given in Table 2 (column 9). It is evident that the figures for AAC are close to the IFMP prescriptions, except for keora. Thus both the above-mentioned methods justify the implementation of harvesting prescriptions of the IFMP during the ten year period, 2010-2020.

Table 2: Annual Allowable Cut for different species

Species	Growing Stock (V10/ha) (cum)	Increment (V10/ha) (cum)	AAC (V10/ ha/yr) (cum)	DBH limit (cm)	Total area (ha)	Estimated AAC (V10/ ha/yr) (cum)	IFMP AAC (cum)	Removal of increment (cum)
1	2	3	4	5	6	7	8	9
Sundari	8.815	7.165	0.620	30	231159	143285	54000	82808
Gewa	0.462	0.410	0.033	15	296698	9887	53000	6081
Keora	0.945	-1.335	0.014	25	319201	4424	29852	-21308
Baen	4.601	2.914	0.303			0		0
Others	2.313	1.092	0.143	25	231159	33041	23000	12626
Goran (Volume)	1.357	0.346	0.077	2.5	-	-	-	0
Goran (kg)	1458	402	82.96	-	-	-	-	0

The Sundari Production Areas (SPA) comprise the compartments 3 to 40 (the remainder compartments contain very little or no sundari at all), except the existing and proposed wildlife sanctuaries. The forests will be managed by following Selection-cum-Improvement Silvicultural System with the recommended minimum exploitable diameter 30cm in all the compartments with a cutting cycle of 20 years. Three felling series (Sarankhola, Chandpai and Khulna) will continue over a 10 year felling schedule and the annual cutting area and AAC details to be applicable in the various compartments where sundari is available, have been indicated. An area control method will be followed as whole compartments are scheduled to be worked during specified periods. The annual scheduling of compartments in terms of annual coupes will jointly be done both by the DFOs of Sundarbans and the DFO, Khulna Management Plans Division. The dead pasur and kankra trees will be removed during the felling operation.

The gewa production areas comprise all the compartments, except the existing and proposed wildlife sanctuaries. The forests will be managed by following Selection-cum-Improvement Silvicultural System with the recommended minimum exploitable diameter 15cm (15 diameter class and above) shall be followed in all the compartments with a cutting cycle of 20 years. The felling series will be worked over a period of 10 year felling schedule and annual cutting area and AAC details to be applicable in the various compartments where gewa is available, have been worked out. All the trees of and above the exploitable diameter of 15cm and above shall be marked and a list of marked trees will be prepared. But at least 20 healthy and sound phenotypes of 15cm and above diameter will be marked and retained per ha as mother trees for encouraging natural regeneration of gewa. While felling, attention be given to the fact that permanent blanks are not created by removing a group of trees.

The pure keora production areas comprise the compartments 40, 41, 42, 45, 46, 47, 50 and 51, and the remainder compartments contain keora in mixture with other species including sundari. An AAC of 23,000 cum is prescribed and the forests will be managed by following Selection-cum-Improvement Silvicultural System with the recommended minimum exploitable diameter 25cm in all the pure keora and mixed compartments with a cutting cycle of 20 years. Only one overlapping felling series with a 10 year felling schedule and with the prescribed annual cutting area and AAC details will be taken up in the pure keora compartments. In mix species compartments (with other species including sundari) the felling of keora trees of 25 cm and above diameter will be taken up simultaneously with the felling of other trees species such as sundari and gewa.

All the sundari production areas comprising the compartments 3 to 40 have trees species such as baen, dhundal, passur, kankra, etc. These species clubbed under other timber species will be managed simulteneously with the sundari by following Selection-cum-Improvement Silvicultural System with the recommended minimum exploitable diameter 25cm in all the SPA compartments with a cutting cycle of 20 years. Three overlapping felling series (coterminus with the Sarankhola, Chandpai and Khulna felling series for sundari) will continue with a 10 year felling schedule. A similar analysis has been done in detail for goran but except goarn, no other fuelwood species will be harvested. Harvesting prescriptions for various NTFPs as detailed in the Plan will be implemented meticulously.

4. Food Security and Wetlands Management Programs

Food security programs in the context of the Sundarbans would focus on enhancing the ecosystems resilience functions and increasing access and availability of food through improved wetlands and fisheries management, as well as ensuring an equitable benefits sharing from identified NTFPs to local community. As a result of improved habitat protection and sustainable forests and wetlands management, the resilient ecosystems of the Sundarbans would ensure a coping mechanism to impoverished local community. The Sundarbans, designated as a wetland of international importance under Ramsar Convention, is endowed with a high concentration of ichthyo fauna, which makes its coast a unique nursery ground for many species of marine fish and shrimp. The spawning ground of most of the marine fish and shrimp is associated with the mangrove forests.

Under this program, main objective is to ensure the long-term food security through improved wetlands and fisheries management by following a co-management approach. Other objectives include, (i) to provide guidelines for managing the fisheries resources and implementing co-management activities for long-term sustainability of the Sundarbans fisheries by enhancing environmental preservation and conservation; (ii) to introduce rational harvesting of wetlands resources, (iii) to increase public participation and benefits from fisheries resources management (iv) to expand the biological base; (v) to improve management performances; (vi) and to undertake effective wetlands resources management. The following two-fold recommendations are made for the sustainable management of the fisheries resources:

a. Resource Conservation Measures: Maintain the fisheries resources to a level that does not degrade from the present level (i.e. ensuring sustainable harvest) by controlling the number of fishers and checking the type of gears used.
b. Resource Improvement Measures: Improve the fisheries resources through different management and conservation interventions

The following measures are suggested for the fisheries resources conservation:

1. Fishing area ban all year round in all the water bodies in the core zone comprising the three wildlife sanctuaries and the identified 18 canals in the buffer zone.
2. Fishing ban in the all canals during the months of July and August and in the Beels/*Chatals* during February-May.
3. Seasonal gear ban : Ilish jal/Fash jal during September and October.
4. Complete Gear Ban: i) Bhendi/bebdi/bendi (set bag net), ii) no fishing by de-watering, particularly in the Beels/*Chatals*., and iii) Net jal and current jal for post larvae collection of Golda and Bagda.
5. Fishing net with mesh below 15mm/1 inch (knot to knot at stretch condition) will not be allowed for fishing. However, fishing traps and hooks will not have any limit.
6. Use of insecticides and poison for catching fish will be controlled and eliminated gradually.
7. Boat License Certificate (BLC) Limit: The maximum number of BLC issuance will annually be 12,000 for the Sundarbans and it will be equally distributed for the two Divisions of East and West (6,000 each). The respective Range will determine and distribute BLC numbers among the Station Offices under its jurisdiction. Renewals priority will be given to those boat owners who live within 5km area in the interface landscape. If 5km area does not fulfill the targetted BLC, then 10 km area in the interface landscape should be considered. The BLC number fixation should be done on yearly basis. Each year a review should be made on the production/catch amount based on information from the fisher and observation of the Forest Department personnel (Forest Guard, Station Officer and Range Officer). If the production goes down, the BLC number would be reduced and if it increases the BLC number would be increased. The number of BLC increase or decrease would be selected based on the estimation of production change. However, the changes of BLC number should not be more than 10% compared to the previous year. The maximum sustainable yield

(MSY) for the fisheries production is estimeted, based on the catch and effort (nos. of permit) data (for the period 2000-01 to 2009-10) from the SRF.

8. Fishing Permit Limit: One BLC holder boat will get fishing permits a maximum of 8 times in a year for all gears or fishery type. The maximum limit of permit for a month will be 3 times. At the time of BLC issuance/renew the fisher should be informed about the conditions and he should be advised for his fishing planning of the year. The respective Station Office of FD will keep records of permit issuance number to track down and control the specified limit. A regular monitoring of fish catch will be implemented.
9. Fishing Duration: The maximum fishing duration against a permit will be 7 days. The days will be counted from the date of permit issue and ends on the day of permit submission. Moreover, the frequency of harvest and number of fishers against permit needs to be reduced.
10. Species Ban: The species under fishing/catching ban will include Pangas, Sea bass, Ilish Fish and Mussel.
11. Fish Size Limit**:** Catching of Ilish and Pangas below 23 cm is prohibited during November-April and for male crab, the minimum weight size for catch is 200gm and for female as 120 gram.

The following fisheries resources improvement measures will be taken by the FD field staff:

1. Habitat Restoration: The eventual goal of the fisheries resource conservation and resource harvesting should be focused on either water body base or compartment base. In order to do so, identification of the water bodies is required for all the rivers, canals and chatals/beels.
2. Wetlands and Fish Sanctuaries: In addition to 18 khals in the buffer zone where fish catching has been banned by FD, more fish sanctuaries should be identified and established with the help of CMCs. Effective fish sanctuaries may be set up and maintained in each compartment of the SRF.
3. Pond Fish Culture: More fish ponds should be encouraged in the interface landscape in order to lessen biotic pressure on the wetlands of the Sundarbans.
4. Awareness Raising: Effective awareness and motivation efforts will be taken amongst the fishers and local people. The Forest Department will use the co-management organizations for their assistance in this campeign.
5. Capacity Building: The FD field staff, who are in charge of regular monitoring of the fishing activities at station and camp level, should be oriented on the fishing rules, ban areas, etc.
6. Fisheries Stock Assessment: The concept of catch per fisher per year was used to estimate the maximum level of fisher density per sq.km. The catch/fisher/year versus fisher density showed that in the SRF, fisher density showed an increasing trend. The annual catch/fisher decreased from 2001 to 2005, but increased from 2006 to 2008, and again decreased in 2009. The primary analysis indicates that prior to over-exploitation, the SRF could have supported fisher density not exceeding 125 fishers per sq km. A comprehensive study should be done at five years interval to look at important issues including total production of fish and other aquatic organisms, fishery-wise production, gear-wise production, species wise production, and fish population dynamics.
7. Fisheries Service Providers: Main activities for providing services for local fishers would include hatchery development, more feed and medicine, skill development, ice industry development, transport facilities, storage facilities, linkages with micro-finance institutions and coordination with the extension field officials of the Department of Fisheries.

8. Fisheries Marketing: Possible activities for developing fisheries markets would include forming marketing groups of fishers, and linking with fish markets at local, upzila and zila levels.
9. Fish Value Chains Development: Main activities will include value chain analysis, fishers selection and group formation, service/input provider/seller selection, monitoring of production and growth, skill development training for fishers and service providers, product development (grading, packaging, branding, etc.) training for fishers, exposure visits to demonstration sites, marketing group formation, and field tours for establishing market linkages.
10. Regular Monitoring and Research: The Forest Department should have a regular fish stock and catch monitoring on production and biodiversity measures, which will generate basic information for management decisions. This will help in allocating the number of BLC, permit issue, restriction of gear use, species caught, etc. Important aspects to be considered for periodic studies and long-term data collection include, i) long-term data collection for monitoring salinity changes; ii) impacts of poison fishing on the fisheries and human health; iii) status and changes in water chemistry, hydrology, and ecology of the waters of the Sundarbans and their impacts on fisheries; iv) assessment of the presently fishing ban areas to determine how effective they are for fisheries conservation; and v) fisheries mari-culture and cage-culture on pilot basis.
11. Livelihoods Opportunities: The people in the SRF landscape, who are dependent on fisheries should be supported with conservation-linked livelihood opportunities. It may include fish culture and other land-based opportunities, and VGF card ensuring food supply. A gainful partnership of local people is required for long-term management and sustainability of the fisheries. The local people through CMCs will be involved with activities like fisher selection for BLC, permit issue, etc.
12. Resource Ownership: While issuing BLC, priority should be given to the people living around the vicinity of the Sundarbans. The CMC and its members can help identify the real fishers and for long-term consideration, a fisher list and ID cards can be prepared for the landscape.
13. Fish Preservation and Marketing Opportunities: The fishers depend on money lenders and are deprived of fair price of their perishable fish as oftenly they are bound to sale their catch to/through the money lenders. They have to take credit with high interest rate. The Forest Department can consider establishing few fish landing and marketing centers on the landside of the Sundarbans, and also some ice factories through private public partnerships.

5. Climate Change Mitigation Programs

Although Bangladesh is a low carbon emission country due mainly to low level of industrialization, its vulnerability to climate change is very high as a sea rise of 1-2 meter would inundate the country’s substantial area including the Sundarbans, thereby adversely affecting coastal ecosystems and a large coastal population. Natural resources including forests and wetlands of the Sundarbans are getting severely degraded due mainly to heavy biotic pressure brought by rapidly increasingly population. So the conservation of the Sundarbans by protecting its comprising forests (green carbon sink) and wetlands (blue carbon sink) will help ameliorate climate change impacts as both mangroves and wetlands act as carbon sinks by sequestrating CO_2 from the atmosphere.

Main objectives of this program are, i) to review possible climate change impacts on the Sundarbans ecosystems, and ii) to quantitatively assess climate change mitigation potential of the SRF in terms of carbon sequestrated and stored in the mangrove forests. The role of forests in carbon cycle is vital as they account for approximately 80% of CO_2 exchanged between land and atmosphere through the process of photosynthesis. As trees grow the carbon is stored in biomass by converting CO_2 and water (by using solar energy) into sugars and oxygen (released through leaves). Forests also release CO_2 during the process of respiration. However, mangrove forests that are growing (increasing in biomass) will absorb more CO_2 than they release. So the climate change mitigation in terms of sequestration and storage potential of the SRF depends on growing, conserving and sustaining mangroves and wetlands.

Bangladesh has a unique climate system dominated by monsoon, and the major physio-graphic features that drive this monsoon are its location (in terms of latitude, longitude and altitude) in the globe, the Himalayas, and the Bay of Bengal and the Indian ocean surrounding it. Climate change (green house gases and their concentration are one of the main dirvers of climate change) impacts on forests have been highlighted in a number of studies including vaarious reports of the Intergoverenmental Panel of Climate Change (IPCC). Climate change projections include sea level rise, temperature rise, and increased frequency of drought, cyclones, storms and other water-induced extreme events. The SRF has a long coastline where the impacts of climate change occur at long-term scales. As a result of climate change in this coast, the sea-level may rise and there may be changes in the occurrence of frequency and intensity of storm surges.

Recently the Sundarbans experienced *Sidr* and *Aila* cyclones, indicating that the committed (as a result of past changes in GHG concentration) climate change is already impacting it and future climate change will further aggravate this situation. The regional variations in sea-level rise in Bangladesh with respect to global sea-level rise are manifestations of tectonic changes and ocean density. For instance, a significant number of cyclones have occurred in the Bay of Bengal as compared to the Arabian sea (at the ratio of 4 to 1). The cyclonic disturbances are 5 to 6 times more frequent over the Bay of Bengal than over the Arabian sea, and one third of the Bay disturbances intensify into tropical storms. This may be due to the fact that the surface sea temperature over the Arabian sea is cooler than over the Bay of Bengal. The shallow depth of Bay of Bengal and the low flat coastal flat terrain produce much larger storm surges and takes a very heavy toll of human and animal life. The Sundarbans coast having a gentle topography is more vulnerable to sea-rise and the adverse impacts of cyclones.

Important changes in the Sundarabans may be due to its coastal location but more importantly due to relatively high sensitivity of natural ecosystems including mangrove forests and wetlands to temperature rise. Possible changes may include shifts in forests and wetlands boundary, changes in species assemblage or types in forests and wetlands, changes in net productivity of forests and wetlands, forest die back (e.g. die back of sundari), and loss of forest and wetland biodiversity. Although enhanced level of CO_2 in the atmosphere may increase net productivity over forests and wetlands, but the forests biomes may be vulnerable to climate change, as a result of which the existing vegetation may be less than optimally adapted to its existing location, thereby making it more vulnerable to the adverse climate conditions as well as to the increased biotic stresses. The effects of climate change are expected to be substantial in the country's agrarian economy as a large majority of its population is reliant on land-based primary production (e.g. agriculture, fisheries) as a major source of income.

Conspicous changes in annual trends in both minimum and maximum temperatures have already been noticed both globally and nationally. Variability in monsoon rainfall has been recorded in recent years. Most of the observed increase in global average temperature is due to the observed increase in anthropogenic GHG emissions. Discernable human influences now extend to other aspects of climate including ocean warming, continental average temperatures, temperature extremes and wind patterns. Global mean sea level change results mainly from two processes, mostly related to recent climate change, that alter the volume of water in the global ocean : i) thermal expansion, and ii) the exchange of water between oceans and other reservoirs (glaciers and ice caps, ice sheets, other land water reservoirs) including through anthropogenic change in land hydrology, and the atmosphere. Regionally, oceanographic factors such as changes in ocean circulation or atmospheric pressure cause changes in sea level. Sedimentation and vertical land movements influence local level sea variations.

Increasing temperatures may have negative impacts on the physiology of fish because oxygen transport to tissues will be limited at higher temperatures, and this constraint in physiology will result in changes in distribution, recruitment and abundance of fish in the Sundarbans. Fish have strong temperature preferences to spawning as the process of spawning is known to be triggered by pivotal temperatures. Phenological changes are expected with climate change and species with short life spans and rapid turnover of generations such as planktons and small pelagic fish are most likely to face such changes. The changes in distributions, recruitment and abundance of many species will be acute at the extremes of species' ranges. Changes in abundance will alter the species' composition and result in changes in the structure and functions of the Sundarbans ecosystems.

Changes in the net primary production and its transfer to higher trophic levels are possible. The eggs of most of the fish species are pelagic, directly exposed to higher temperatures and currents. With temperatures increase, the development duration of eggs and larvae size decrease. The adults may grow faster in warmer years but afterwards the growth rates would start decreasing as metabolic cost continue to increase. The more mobile fish species will be able to adjust their ranges over time, but less mobile and sedentary species may not. Depending on the species, the area it occupies may expand, shrink or be located and this will include increases, decreases and shifts in the distribution of the Sundarbans fish including marine fish, with some areas benefiting while others losing.

The mangrove forests of the Sundarbans, like any other ecosysem, are able to tolerate some level of climate change and so will continue to persist in short-term as they have done in past. However, in long-term, whether its resilience will be sufficient enough to tolerate future anthropogenic climate change is not known. The understanding of time-lags in ecosystem responses is not adequate, and they may take several centuries before responses to climate change are played out. However, there is a likely link between biodiversity and ecosystem functioning in the maintenance of ecosystem services, and thus extinctions critical for ecosystem functioning may reduce societal options for adaptation responses. Sea-level rise along the Sundarbans coast may partially submerge the mangroves but would also increase the salinity of its wetlands. This would favor salinity tolerant plants but will reduce the vegetation and aquatic diversity. On the other hand increased snow melt in the Himalayan glaciers (releasing more water in a drought year and less water in a flood year) could bring large quantity of fresh water, with important consequences for the composition of the mangroves, favoring species that have the least tolerance to salinity. Changes in local temperature and rainfall will also influence the wetlands salinity and plant composition.

The total forest carbon stocks in the Sundarbans mangrove forests were estimated based on the forest inventory done in 2009-10 and compared with similar parameters estimated by using 1997 inventory data set. Based on 2009-10 carbon inventory, the total SRF C stock (total of forest C stock and soil C stock) is estimated at 105.06 Megatonnes (equivalent to

385.57 Megatonnes of CO_2e), which works out to be 255.20 Megatonnes/ha. If only the Carbon stock in forests are considered, the total C stocks are estimated at 55.8 Megatonnes. Mean carbon density in 1997 was 76 Mg/ha. Multiplying by land area to obtain total carbon stock, the 1997 inventory indicates a carbon stock of 31.4 Mt at that time. Molecular conversion to CO_2 yields an estimate of 115 Mt CO_2 equivalents stored in SRF in 1997. Comparing the two time points, the 2010 tree carbon pools are found significantly higher than those from the same plots in 1997, suggesting an increase in carbon storage over this time period. The estimated total increase, accounting for trees only, was 41 Mg/ha. The majority of plots, 68%, showed an increase in carbon density between the time points, while 32% showed a decrease. Converting this difference to changes in carbon stocks indicates an increase of 16.9 Mt of forest carbon storage over this time period. It is suggested that based on the IRMP the FD will develop a REDD+ Improved Forests Management (IFM) proposal for attracting carbon finance. An appropriate monitoring, reporting and validatation (MRV) system in suggested in the Plan.

6. Climate Change Adaptation Programs

The Sundarbans provide ecosystems services in terms of life supporting, provisioning and regulating functions and services and so has tremendous impacts on the climate change adaptation of local community. Main objective of the climate change adaptation program is to quantify the economics of harvest and sale of various products marketed from the SRF and develop appropriate economic interventions for improved management of the Sundarbans ensuring economic and climate change resilience benefits to local community. Main climate change adaptation programs thus comprised analyzing and developing appropriate value chains and conservation linked livelihood options that will be implemented in the interface landscape.

The climate change adaptation role of the Sundarbans stem from the fact that nearly one million people depend on the Sundarbans for its resilience functions but also for their livelihoods, thereby reducing their vulnerability by providing a coping mechanism. A large portion of the landscape population along the Sundarbans coast is dependent on climate-dependent activities such as fisheries, agriculture and forestry. In view of physical homogeneity of the Sundarbans, climate is one of the most important determinants of its vegetation and has significant influence on the distribution, structure and ecology of natural eco-systems including mangroves and wetlands. Although climate change, as a global public good, is global in its causes and consequences, its adverse impacts are being borne inequitably in different regions and communities of Bangladesh. Climate change thus has potential of altering the configuration by impacting both the Sundarbans ecosystems and its landscape human population and so it is important to understand vulnerability and adaptation issues arising as a result of climate change. Vulnerability to the impacts of climate change is a function of exposure to climate variables, sensitivity to those variables and the adaptive capacity of the affected ecocystem and community. Adapting to climate change would involve reducing exposure and sensitivity and increasing adaptive capacity of local community and ecosystems.

The Sundarbans provide livelihoods to the local and national economy. In view of presently no commercial harvesting in the SRF, minimum direct benefits (mainly from NTFPs) currently flow to local community who are being increasingly tasked to provide community forests protection that will involve opportunity cost in terms of foregone benefits from illegal felling but also their labor spent in voluntary patrolling efforts. So other relevant mechanisms of benefits flows to local communities need to be explored. Additional benefits need to be mobilized through off-PA activities including value chain development and alternative income generation activities that will generate both wage and self-employment. A number of livelihoods opportunities are identified and conservation-linked interventions designed for providing alternative income to local community in order to reduce extractive harvesting of the Sundarbans resources. The economics of harvesting of wood and non-wood products has been discussed in detail in the context of severe poverty situation that prevails in the interface landscape.

Value chains mapping has been done by identifying all possible actors and factors. The increased population with few alternative livelihood opportunities poses a serious threat to the Sundarbans, which is one of the main cause of mangrove degradation. Moreover, the livelihood dependence of local people on the forest is high (28% of the population in landscare zone are dependent on the forests) and in future this dependence will increase. There are more than one million people directly involved with the resources extraction from the SRF. The pressure on SRF for resources extraction has increased tremendously as the number of collectors has increased many fold over the last decades, resulting in huge reduction in per capita resource collection from the SRF.

A climate change vulnerability analysis demonstrates a very dismal picture on poverty levels in the region. The landscape upazilas have a much higher (extreme) poverty rates (0.42) compared to an average non-landscape upazilas in Bangladesh (0.26). In fact, nine out of ten landscape-upazilas (except Patharghata, Barguna), have a much higher extreme poverty levels than the corresponding non-landscape upazilas of five landscape districts, in terms of Head Count Ratio (HCR). The average monthly income of the SRF harvesters is in the range of Tk 5,000 to 6000 only during harvest seasons, and there are months when they hardly have any income at all. The analysis demonstrates huge income inequality among actors. The empirical evidence also suggests that the top 10 percent of the SRF actors earn as high as up to 43 times as much income as the bottom 10 percent (estimated Gini coefficients for various SRF products range from 0.42 to 0.53, which are on a much higher side in Bangladesh context). Thus, the poverty situation in the landscape is severe, which has immense climate change adaptation policy implications. The foremost intervention, therefore, will be to address the poverty of the bottom layer forest and wetland resource actors which will effectively help the management and conservation of the SRF.

Accordingly, two priority value chains (fisheries value chain and tree nursery value chain) have been designed for their implementation as climate change adaptation initiatives in the landscape villages. Additionally, a number of adaptation policy measures are suggested for taking up appropriate interventions by different Government agencies including FD. It is pertinent to mention, however, that many of the suggested interventions would, in addition to FD, require a multi-sectoral approach wherein resources would be ploughed in from different sources and integrated implementation responsibility to be shouldered possibly by a project based inter-agency/authority/board constituted under the leadership of Forest Department by drawing experts from the concerned Government Departments.

Access to capital has been the most crucial issue, especially among the collectors. Specialized banks or specialized micro-finance organizations may help the harvesters of the Sundarbans. Like agriculture loans, share cropper loans and small and medium enterprise (SME) loans programs and other suitable micro-finance programs need to be launched where the SRF actors should be given a special attention. Pending the establishment of the Specialized Banks, a few selected public and private banks in the landscape should be requested to set up the SRF service centers/cells to channel funds and to cater the special needs of the SRF actors, especially the harvesters in a better way and on softer terms. Targeted programs to providing social securities and safety-nets to the collectors, along with adequate amount of credits for the collectors on favorable terms should be initiated. There is a need for improving terms of trade and marketing systems. Enhancing bargaining power of the harvesters is imperative. Better access to the current market information has to be ensured. One way of reducing climate change vulnerability of the lower layer actors of value chains is to organize production and marketing Groups or Cooperatives. This would help create storage, post-harvest processing, refrigeration facilities, and encourage shared transportation on a collective basis. Not only these cooperatives will prove beneficial in income generation, but they also will contribute to their confidence building, empowerment, awareness and overall sustainable harvest management of the SRF and in coping with natural disasters. Improving the socio-economic conditions of the vast bottom-layer actors should be a major policy concern.

A range of options may be available to improving the socio-economic conditions of bottom layer. As a rationing system for foods for collectors will be beneficial, designing and implementing VGD, VGF or Food for Employment during lean seasons may be good initiatives to benefit the marginal collectors. Obviously, this will also facilitate sustainable resource management of the SRF. As the per capita collection quantity of NTFPs from the SRF has tremendously declined, efforts should be made to enable collectors to switch over to other economic activities. Less investment oriented activities may include fisheries, handicrafts, crab culture, crab fattening, fish feed production, hogla and mat making, bee-keeping, coir industry, tree plantation, horticulture, tailoring, knitting, livestock, small and medium industries and social forestry for the bottom layer actors. Developing a welfare fund for the collectors of various products would be a step forward.

7. Eco-Tourism Programs

The importance of tourism is emphasized in the National Tourism Policy (1992) as a means of outdoor recreation, and eco-tourism in particular focuses on low-impact nature-based outdoor recreation. The Forest Policy (1994) recognizes eco-tourism as a forestry-related activity, which needs to be promoted taking into consideration the nature’s carrying capacity in the Sundarbans. However, it is important to realize that nature tourism exists for the ecosystems including wetlands and forests and not other way round, and so nature tourism facilities and visitors management must be compatible with nature conservation. Environmentally sound and socio-economically inclusive eco-tourism will be an important goal to be achieved under this Plan. Regulated eco-tourism in terms of nature education and interpretation tours in and around the SRF, for promoting biodiversity conservation and educating visitors as enlightened nature tourists, will be a main objective of the proposed eco-tourism programs. Based on stakeholder consultations on the opportunities for eco-tourism to improve conservation awareness, generate more revenue, and provide more community benefits in the Sundarbans, the appropriate recommendations are made in the Plan. Nature tourism will help inculcate amongst visitors love for biodiversity conservation by providing a communion with nature. Socio-economic benefits of nature tourism accruing to local people will be catalyzed by leveraging forward and backward linkages of eco-tourism, and so enhancing socio-economic benefits accruing to local community in the interface landscape zone will be another important objective.

The opportunity to raise awareness of domestic travelers is very high and should be pursued as a priority. There are no local guides presently working on the local tourism boats and there has been no guide training in the Mongla region, where the majority of domestic tourism transpires. The existing interpretation centers at Khulna and Mongla need to be improved and better promoted, and the visitor center at Karamjal needs an overhauling. A special section on mangroves and their role in climate change mitigation and adaptation may be added. The opportunity to raise conservation awareness of international visitors was perceived to be a lower priority, as most arrive already with a high environmental awareness. The publicity of the Sundarbans should be improved for propagating biodiversity conservation, climate change mitigation and adaptation, environment and wildlife including tigers and dolhpins, and the cause of its habitat by employing both electronic and print media. Schools and colleges will be targeted for conservation education and building an informed constituency. Conducting talks, essays writing and competition will be included in local schools as a part of publicity campaign. Green Brigades (Sabuj Vahinis) and Nishorgo (Youth) Clubs will be formed in nearby schools and madrasas. Professional publicity and communication personnel will be engaged for such tasks. At the community level, conservation awareness has to be tied to revenue generation for local livelihoods. Nature interpretation will, as an educational activity, focus on revealing meaning and relationships of the Sundarbans ecosystems, biodiversity and landscapes.

The opportunity to increase revenue for conservation is very high, given the entry fees being generated and the number of tourists visiting key tourism sites. Entry fee sharing with the CMCs as per the approved guidelines should be immediately implemented. The opportunity to increase revenue generation for border communities is good, but remembering that tourism season is only 3-4 months a year and cannot become a full-time activity for community members. In addition, the severe problems with resource protection at existing eco-tourism sites would make any large scale efforts to increase revenue generation to communities a problem for the protection of tourism sites already under great threat. Currently eco-tourism does not make a serious contribution to the revenue required for the millions of stakeholders dependent on the Sundarbans ecosystem. However, in specific border communities the opportunity to generate more revenue appeared to be good. For example in Mongla, hundreds of buses are arriving and the community remains poorly organized to take full advantage of this economic opportunity. Much more could be done to enhance local revenue generation opportunities in Mongla. Increasing the capacity of the border communities to provide goods and services to tourists is equally important. Food vendors and pharmacists are important recipients of tourism expenditures. It is important to develop a full complement of goods and services that domestic travelers seek in small villages.

The opportunity to increase community benefits is high, and more can be done to develop border community’s rights to undertake activities that can support their families. At present nearly all community members interviewed are willing to have access to resources for protection based on an equitable benefits sharing arrangement. Some gathering and harvesting of natural resources is an integral part of border community’s livelihoods for their subsistence consumption. Enhancement of their destitute livelihoods based on appropriate activities via eco-tourism seem to be the appropriate answer to these problems. In addition to limited gathering of some identified NTFPs in the buffer zones where local people can legally harvest what is required to survive, eco-tourism would provide a fine complement to these activities. In towns like Mongla or Burigoalini, where a broader range of legal activities are taking place, it would be appropriate to levearage development activities to improve the full range of community benefits, which can also include access to education, communication technologies, health care, and transportation.

8. Facilities Development Programs

The development and maintenance of facilities is needed to support the long-term administration and management of the SRF. Main objective of this program is to improve the image, aesthetics, function and overall quality of the eco-tourism and other facilities in the Sundarbans Reserve Forest. One of the ancillary objectives of the infrastructure development is to minimize the adverse environmental impacts of the activity while maintaining the setting for the staff, visitor and wildlife. A review of the existing facilities in general and eco-tourism infrastructure in particular is provided in this program. Future development scope is identified with detailed generic site plans and recommendations. This includes litter, water pollution, economic inequity and instability, and any long-term social and cultural changes of the population. A recommended list of 26 sites that should be considered for future site development and suggested priorities is identified.

A description of each element, feature and component that are needed for a positive eco-friendly experience and their spatial relationships with one another is provided. Also included for each element, feature, component is a brief set of architectural characteristics that, if followed, will give the SRF a true and unique "sense of place". A schematic representation of infrastructure development for destination sites and a generic layout of a typical destination site that could be adapted to other sites is provided. A detailed site plan of important eco-tourism sites including Karamjal site is necessary but inventories and condition surveys must be completed at each site before a detailed site plan can be completed and recommended. In addition to built facilities, this program also focuses on the procurement of transport and other equipments required for the Plan implementation.

9. Conservation Outreach, Conservation Research, Participatory Monitoring and Capacity Building Programs

Conservation outreach, conservation research, participatory monitoring and capacity building are tools/mechanisms for a better understanding of the Sundarbans and its functions in order to sustainable manage its biodiversity comprising forests and wetlands. Main objectives of this program are, i) to better understand and communicate the Sundrabans's biodiversity resources, ecosystems and landscape environment, ii) to identify priority research themes, iii) to establish a participatory monitoring mechanism to help guide the Sundrabans development, and vi) to build capacity of key stakeholders. Expected behavior patterns need to be inculcated among the stakeholders for which a range of communication tools can be used. An appropriate branding framework comprising a brand name, logo, messages, communication briefs and guidelines will be developed. Specifically the publicity of the Sundarbans management activities will be improved for propagating the biodiversity conservation, climate change, wetlands, environment, and wildlife and the cause of its habitat degradation. Electronic and print media will be employed for this purpose.

Schools and colleges will be targeted for conservation education and building an informed forests, wetlands and wildlife constituency. Nature interpretation will, as an educational activity, focus on revealing meaning and relationships of the Sundarbans complex ecosystems and landscapes. Public awareness of the laws related to forests, wetlands, climate change and wildlife will be enhanced and prosecutions under the laws will be publicized. Landscape features of the Sundarbans will be depicted in pictorial forms including topographical and biodiversity patterns. Socio-cultural traditions/features of local people will be added with proper leveling and description. Appropriate signages will be used for the benefits of tourists in finding their ways without any enquiry. A video film on wildlife and its habitat and cultural aspects will be developed for showing to visitors at Nature Interpretattion Center (NIC). The concept of public-private partnership will be applied in soliciting the inputs/contributions from private sector particularly for the facilities development in the SRF.

Conservation research may include aspects such as diverse types of both terrestrial and aquatic flora and fauna, status of endangered species, wildlife behavior, wetlands management based on an ecosystem approach, sustainable fisheries management, tiger management, resolution of man-animal conflicts, socio-economic issues, silvicultural aspects, man-tiger conflicts, impact of anthropogenic pressures and climate change on eco-systems, etc. Management driven studies for conservation research will be taken up on priority basis. Possible topics of investigation may include the institutional development and financial sustainability of co-management organizations, climate change impacts, vulnerability, and adaptation of local people, ethnic knowledge on local biodiversity, impacts of human activities on natural habitats, forward and backward linkages of eco-tourism, and sustainable collection, harvesting, storage and processing and marketing of NTFPs. Some relevant topics of biological research may include wildlife-population viability analyses, population dynamics and feeding behaviour, wildlife habitat/niche use behavior, fish stock assessments, establishment of fish sanctuaries, prey-predator balance, wildlife seasonal variability and movements, tiger habitat and management, tiger tranqualizing and its effects, deer management guidelines, sundari die-back, impacts of increased salinity on vegetation composition, impacts of climate change, and wildlife health and diseases.

Main topics of silvicultural research may include impact of climate change on forests and wetlands restoration/regeneration and wildlife, canopy manipulation for improvement of habitat through natural regeneration, and monitoring of floristic composition and structure. Main research findings from different silvicultural studies carried out by BFRI will be reviewed in order to draw relevant inferences and frame appropriate recommendations for managing forests and wetlands. Further research will be required on the effects of selected silvicultural and forest management practices on forest growth, structure and species composition, regeneration of NTFPs and edible fruit bearing plant species, sustainable collection and harvesting of NTFPs. Main topics of ecological research will include identification of fragile habitats and ecosystems, environmental impact and climate change studies, forests-wetlands interactions, ecological niche of key organisms (e.g. tiger) ecological succession, fisheries studies, assess the contribution of forests in water yield and conservation, and impacts of habitat changes and eco-tourism on wildlife. Adequate dissemination and utilization of the results/findings of research studies are very important. Useful research outputs will be included in annual development plans of FD for their implementation.

Main species considered for purposes of macro-level habitat management while implementing the Plan is tiger as umbrella species. The long-term aim will be to maximize gains in quantity and quality of habitat for tiger conservation. A survey of natural regeneration (density of seedlings and saplings per ha) in the forests will be taken. This will be complemented by photo monitoring technique, focusing on changes in plant height as a visual evidence of success of the interventions. Forests and wetlands dwelling bird species will be used for assessing biodiversity status. A critical review of the long-term habitat management strategy based on a detailed inventory of biodiversity will be taken up during the mid-period of implementation of this Plan and the future management practices will accordingly be adjusted.

Enhanced focus is required on capacity building of all the stakeholders including the local communities and CMCs, the leaders and staff of the Government agencies including the FD, and the representatives of the local NGOs and private sector engaged in activities related to the Sundarbans. This will help in strengthening and empowerment of stakeholders, and widespread adoption of a conservation and co-management approach with communities and the technical departments. Capacity building will thus expand to include a much wider range of key groups of stakeholders and themes. Main elements of an appropriate capacity building strategy to be implemented during the Plan period are identified as below:

a. Identifying the skills and capabilities: There is a necessity of imparting conservation and co-management training to the FD field staff responsible for managing the Sundarbans. Of the many forestry subjects, only one paper relates to wildlife management being taught to officers at the Forest Academy, Chittagong. Other subordinate staff do not receive any significant training on PA management, although wildlife management is one of the many taught subjects. There is a lack of permanent faculty on *in-situ* conservation at ecosystem and landscape levels by involving local communities. However, some forest officers have undergone overseas training on wildlife and PA management. Other stakeholders including the beneficiaries and NGO staff also need conservation training. A conservation training plan will be developed by focusing on main skills that can be categorized as technical skills - those related to actual technical management of the Sundarbans, and community skills – those related to dealing with people in a co-management and conservation setting. Conservation of the Sundarbans would include application of social and management principles with the desired outcome focusing on modification of human behavior to ensure protection and sustainable use of the forests and wetlands.

Possible themes under community skills category would include:

- Communication skills, essential for sharing views and responsibilities for improved governance
- Extension and outreach skills to facilitate interactions with a large number of local stakeholders
- Organizational development skills required for organizing and motivating co-management organizations
- Inter-sectoral coordination skills for facilitating an integrated approach among different government agencies, local stakeholders, and the members of relevant NGOs and private sector
- Natural resources economics and business management skills to be applied particularly in ensuring sustainable and equitable flow of benefits to local community
- Eco-tourism and visitors management skills to promote economic growth and to retain entry fee benefits locally
- Conflict resolution skills to deal with inevitable conflicts that may arise as enhanced benefits are shared among key stakeholders

Technical skills in the area of the Sundarbans conservation and sustainable management would include as below:

- Sustainable management of the Sundarbans natural forests and wetlands with focus on habitat restoration and natural regeneration for enhancing both terrestrial and aquatic biodiversity
- Protected area management and planning
- Ecotourism and outdoor recreation with focus on visitor management and PA planning and implementation
- Community-based natural resources management skills in forestry, wildlife, wetlands and fisheries
- Climate change adaptation and mitigation, and developing carbon proposals for sustainable conservation financing
- Innovative technologies including alternative energy such as improved cooking stoves, pond sand filter devices for drinking water, solar energy devices, etc.

b. Imparting new skills and capabilities: Obtaining and imparting the above-identified skills and capabilities can be accomplished either in house by FD at training institutions such as Forest Academy at Chittagong by mobilizing suitable resource persons nationally or this may be outsourced by establishing partnerships with universities and other relevant institutions. Professional cadre staff starting from ACF onwards can be trained/oriented in higher technical and managerial subjects whereas subordinate staff can be trained more on field oriented themes with more focus on community people skills.

c. Using new skills and capabilities: Field implementation of the aquired skills and capabilities will be done by regularly interacting with local stakeholders and visiting forests/wetlands. Listening to local community and instilling a sense of belongingness will go a long way in generating trust that will help bridge the present trust deficiet that has historically developed in view of erstwhile custodial and regulatory approach. Basic facilities, particularly better communication, would help re-establsih link with local community. Trained FD staff should be given postings so that they can use their expertise. A tenure of atleast 3 years should be allowed to the field staff at their respective place of posting. A human resources development plan and a cadre management plan with appropriate provisions for recruitment, training, posting, performance evaluation and promotion will be developed and implemented.

10. Administration and Budget Programs

Main objectives of this program are to ensure that technical and administrative staff required to manage the Sundarbans are effectively developed and posted, and improvements in financial organizational systems are implemented aiming at the financial sustainability of the Sundarbans. The approved organogram will be implemented in both the Sundarbans divisions by filling existing vacancies. Presently the sanctuaries are managed under the existing territorial Ranges of the Sundarbans East and West forest divisions. Each of the three wildlife sanctuaries will be an independent management and administrative unit, headed by an ACF as Range Officer who will have adequate administrative and financial powers. The duties and responsibilities of the field staff have been described in the Plan. The existing financial organization systems of FD are adequate in most cases and so should be continued. However, appropriate guidelines for community benefits sharing from NTFPs, being developed under IPAC, should be developed and implemented.

Table of Measurements and Conversions

Local Measures

1 cu. ft. Hoppus = cft(H)	=	1.2732 cu. ft. (tree) = cft (T)
	=	0.0361 cu. m.
1 Hoppus ton	=	50.0 cft (H)
	=	63.662 cft (T)
	=	1.8029 cu. m.

Weight

1 kg	=	2.204 lbs			
1 Mound	=	88.18 lbs		=	40.0 kg
1 long ton (t)	=	2339.40 lbs		=	1016.06 kg

Length

1 inch	=	2.54 cm	1 cm	=	0.3937 inch
1 foot	=	0.3048 meter	1 meter	=	3.2808 ft.
1 yard	=	0.9144 meter	1 meter	=	1.0936 yards
1 chain	=	20.1168 meters	1 meter	=	0.0497 meter
1 mile	=	1.609 kilometer (km)	1 km	=	0.6214 miles
1 nautical mile	=	1.8520 km	100 cm	=	1 meter
			1000 meter	=	1 km

Area

1 sq. inch	=	6.452 sq. cm	1 sq. cm.	=	0.155 sq. inch
1 sq. foot	=	0.0929 sq. m	1 sq. m.	=	10.764 sq. ft
1 sq. yd.	=	0.836 sq. m.	1 sq. m.	=	1.196 sq. yd
1 acre	=	0.4047 hectare	1 hectare	=	2.47 acres
1 sq. mile	=	2.59 sq. km.	1 sq. km	=	0.386 mile
			1 sq. m.	=	10,000 sq. cm
			1 hectare	=	10,000 sq. m
			1 sq. km	.=	100 hectare
1 sq. ft./ha	=	0.2296 sq. m./ha	1 sq. m./ha	=	4.356 sq. ft./ha

Volume

1 in^3	=	16.387cm^3	1 cm^3	=	0.061 in^3
1 ft^3	=	0.28 m^3	1 m^3	=	35.3147 yd^3
1 yd^3	=	0.7646 m^3	1 m^3	=	1.308 yd^3
1 quart	=	1.136 liters	1 liter	=	0.88 quart
1 gallon	=	4.346 liters	1 liter	=	0.22 gallon
1 US gallon	=	3.785 liters	1 liter	=	0.2642 US gallon
	=	0.8327 gal.			
1 cunit/acre	=	6.997 m^3/ha	1 m^3/ha	=	0.1429 cunit/ha

Mass, Pressure and Density

1 oz	=	28.3495 grams	1 gram	=	0.353 oz
1 lb	=	0.454 kg	1 kg	=	2.2046 lb
1 T	=	0.9072 tonnes(t)	1 tonne	=	1.1023 Tons
1 lb/ft^3	=	16.0185 kg/m^3	1 t/ha	=	0.0624 lbs/ft^3
1 T/acre	=	2.2417 t/ha	1 t/ha	=	0.4461 T/acre
1 ft^3/acre	=	0.07 m^3/ha	1 m^3	=	14.29 ft^3/acre

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Volume I

Integrated Resources Management Plans

for

The Sundarbans

Part I

Analyses of the Management Situation

1 The Context

In August 1997, a five year Conservation Management Plan (CMP) was prepared by Rosario (1997) for the three wildlife sanctuaries, and in January 1998, a twelve year Integrated Forest Management Plan (IFMP) for the Sundarbans Reserved Forest (SRF) was prepared by Canonizado and Hossain (1998), with the technical assistance of the Government of Bangladesh (GOB)/World Bank (WB) supported Forest Resources Management Project (FRMP). The approval periods of both the CMP and IFMP have expired in July 2002 and June 2010 respectively, requiring their revisions that were taken up during 2009-2010 under the United States Agency for International Development (USAID) supported Integrated Protected Area Co-management (IPAC) project.

1.1 Background

Both the CMP and IFMP were prepared with significant specialized project assistance funded by the WB; the resulting documents were then reviewed and adopted by the Forest Department (FD) and the Ministry of Environment and Forests (MoEF). The IFMP includes three parts: Book One (73 pages) covers existing conditions and evaluations with background and descriptive information on the Sundarbans resources and the management setting. Book Two (65 pages) is the Management Plan with goals, objectives, strategies and prescriptions for working programs. Book Three (276 pages) is the bulk of the IFMP document and includes appendices of species lists and tables of growth data and models and harvesting schedules and other supporting details. In Book two, harvest plans are presented for the main timber and non-wood resources (sundari, keora, gewa, other timber species, goran, golpatta, honey, wax, and fish and aquatic resources). Brief write ups and prescriptions are also included for biodiversity conservation, ecotourism and recreation, plantations, forest protection and environmental awareness and education, resource monitoring and research programs. Sections also address market pricing and royalties and other implementation arrangements including staff requirements, field reporting and revenue forcasts.

Beginning in September 2008, an intensive project identification and design effort was organized for the Sundarbans with the support of the European Union (EU) and in collaboration with FD, IPAC and USAID. Substantial documentation was prepared with up to date assessments of the major threats to the Sundarbans, an analysis of ongoing protection and management interventions, as well as needs and opportunities for improved management. In the past two years, discussions have been held with the FD, EU, USAID and others during the preparation of the Sundarbans Environmental and Livelihoods Security (SEALS) project about the need for a strategic shift in the management of the SRF. This was reinforced during a major high level consultative meeting organized in Khulna in April 2009 with the support of IPAC.

As noted in the conclusion of the SEALS project preparation report: “The Sundarbans is beset by a complex network of problems to which there is not one stop quick-fix solution. Nevertheless, enabling the FD to work better will intervene at a critical point in the cycle of fundamental problems… The Sundarbans has been viewed as a revenue generator for the national treasury, but to do that resource extraction [primarily for timber, fuelwood and other forest products] has been unsustainable, while the real value of the Sundarbans lies elsewhere, in the major offshore fisheries it sustains, in the livelihoods of fringe communities and in its moderating influence on the consequences of climate change; whereas an inaccessible semi-saline marshland makes for a production forest that poses enormous practical management problems. A major re-think in the basic strategy of its management is called for, one which considers and involves its true stakeholders, and allows the FD to operate professionally and effectively. A revised Integrated Resources Management Plan (IRMP) is fundamental to turning around management. Such a plan must involve not only professional forest managers, i.e. the FD, the leading line agency in the management of the Sundarbans, but also consultations of professional fisheries managers and the fringe communities for many of whom the SRF represents an important part of their means of livelihood. (Consortium Agrifor Consult Final Report, Appendix 9, Feb 2009, p. 89)

In 2009, additional work was jointly supported by EU and IPAC to assess the specific investment needs for reinforcing protection of the Sundarbans by improvements in FD office and housing infrastructure, boats and jetties, field equipment and other material and logistical support. Details of focus group discussions, workshops and fieldwork related to the needs for strengthening of the FD in its mission to conserve the Sundarbans are included in a final Protection Assessment report prepared by the Wildlife Trust of Bangladesh (WTB, 2009) with funding from the EU. Accordingly, agreement has been reached on a major investment program to be funded by the EU to reinforce the protection of the SRF by the FD, and to increase support for value chain and alternative income generation (AIG) activities among resource users living in the communities around the Sundarbans. The SEALS project is scheduled to begin in 2011 as a Development Project Proposal (DPP) has been prepared by the GOB.

In view of the expiration of the twelve year working period of the current IFMP (1998-2010), the FD requested technical support to revise the IFMP. At the same time, an agreement was reached with USAID, FD, EU and IPAC to move ahead with assistance in preparing a Strategic Management Plan (SMP) as recommended in the SEALS project preparation report. Accordingly, in the past year, USAID mobilized the forest management expertise of a United States Forest Service (USFS) forest planner, to assist with the preparation of a SMP for the SRF. In the course of his first visit in November - December 2009, the forest planner reviewed the IFMP, met with FD and others, and developed an initial proposal for the SMP. He returned in Feb-March 2010, and during that period, he met with IPAC, senior staff of the FD and others, and drafted the full SMP text. The SMP was then reviewed, revised numerous times, taking into account feedback from stakeholders who participated in a consultative meeting organized in Khulna on March 10 with support from IPAC.

As per the recommendations of the March 10, 2010 consultative meeting, the SMP was translated into Bangla and posted on the web for public comments. It included a discussion of the rationale for the SMP, recent trends and major threats to the Sundarbans, a vision of the future desired management conditions, necessary shifts in management, and a detailed discussion of management goals and principles that have been updated from those included in the current IFMP. The draft SMP was then finalized with additional inputs from the FD, IPAC, WTB and others, and presented for final adoption at a meeting of senior GoB staff, chaired by the Secretary MoEF, with CCF and FD staff, USAID, IPAC and others. Chapter 2 of this IRMP is based on the SMP

In addition to forest planner, USFS provided for two short term (Nov-Dec 2009 and again in Feb-March 2010) missions by a Landscape Architect to assist with the analysis and design of infrastructure development to support sustainable tourism in the Sundarbans, and to prepare a

Plan for Infrastructure Development for the SRF. The Architect during the first visit collected information from site visits and consultations with the FD, and reached agreement on an outline for the plan and other deliverables to be completed. During the second visit, he completed consultations on recommended sites for future site development, site design specifications and a generic layout for a typical ecotourism destination site in the SRF, and developed a detailed site plan for proposed infrastructure improvements at Karamjal. These inputs have been used in finalizing Chapter 8 of the IRMP.

Under the terms of the USFS agreement with USAID, several other specialists were mobilized to assist with the identification of carbon finance opportunities in the Sundarbans, and with the organization of practical training in carbon pool assessment/vegetation inventories in a mangrove forest. USFS specialists, with logistical and technical support from IPAC, designed a field inventory and trained FD crews who conducted growing stock and carbon inventory in December 2009 to April 2010. On July 27, 2010 FD formed a working group with three FD officers (CF and DCF of Khulna Circle and DFO, Management Plan Division, Khulna) to coordinate and work with the IPAC team for preparing the draft Integrated Resources Management Plans for the Sundarbans.

The IRMP is prepared over a period of two years by a multi-disciplinary team of resource specialists (from USFS, and IPAC and its partners including World Fish Centre, BIDS and Epler Meganwood), led by the protected area management specialist of the IPAC, who worked closely with the FD, and also consulted with the Departments of Fisheries and Environment, Khulna University, research organizations, interested NGOs, projects and other stakeholders and resource persons. In addition to making use of the large body of existing studies and information about the Sundarbans, including the existing CMP, IFMP and the SMP as its basis, the preparation of the IRMP incorporates additional information generated by the IPAC supported carbon pool assessment and forest inventory, a study of the principal marketed value chains derived from the SRF (BIDS, 2010), a study of the fisheries resources of the Sundarbans (by Khulna University, 2010), a Strengths, Weaknesses, Opportunities of Tourism (SWOT) analysis of ecotourism development opportunities in the Sundarbans (Megan Eplerwood, 2008), the preparation of the Infrastructure Master Plan for the SRF, as well as the Protection Assessment (WTB, 2009) and SEALS Development Project Proforma (DPP) and recent research on cetacean biodiversity compiled by WCS (BCDP, 2008) and on tigers under the Tiger Action Plan (FD, 2010). A first draft of the IRMP was prepared and discussed with the Khulna based FD officials, IPAC staff and the members of co-management committees (CMC) (at Khulna on 20 October, 2010), to whom thanks are due for their full cooperation.

This IRMP is developed through a consultative process that included (1) a review of the available information and issues affecting the management of the Sundarbans; (2) field visits to the SRF as well as other forested areas under co-management; (3) meetings with stakeholders in and around the SRF as well as stakeholders in Dhaka; (4) meetings with FD, DOF and DOE staff; and (5) formal public meetings in Khulna, and forma presentations at the FD, DOF and the MoEF. This IRMP for the SRF and its surrounding landscape is thus the result of numerous discussions and meetings between staff of the FD, Department of Fisheries (DOF) and Department of Environment (DOE); local stakeholders including Co-Management Organizations (CMOs); civil society members; USAID; USFS, and IPAC project staff.

A draft of the IRMP was presented to the senior officials of FD in a meeting (held at Ban Bhaban on 7 November, 2010) chaired by the CCF. A revised draft was again presented on 22 December 2010 in a senior official meeting that was chaired by the CCF at Ban Bhavan. Another senior FD officials meeting took place on 24 March 2011under the chairmanship of the DCCF, Planning. The draft IRMP was presented to the senior DOF officials in a workshop chaired by the DG, DOF on 28 March 2011 at the conference hall of the Matshya Bhawan. Relevant comments as received from these officials have been incorporated in the final Plan. The logistic support and written comments provided by the CF, Khulna circle, who also acted as the chair of the working group (other members being the DCF, Khulna Working Plans Division and the DCF, Khulna Cicle), ACCF (Management Planning), ACCF (Development Planning Unit) and DCF (RIMS) were helpful in finalizing the Plan. The technical guidance and official support provided by the CCF resulted in the enhanced quality of the IRMP.

These discussions led to the development of this participatory IRMP that will guide the development of detailed annual development plans (ADP) with update budgets for implementation of planned activities for achieving targeted outcomes and impacts. The consultation process was comprehensive as it included a wide range of interests involved in the SRF. The participants in the public meeting in Khulna were from different stakeholders including personnel from administration of division, district and Upazila level, GOB departments of forest, fisheries and environment, Khulna University, journalists, NGOs, CMCs, projects working in Sundarbans, law enforcement authority, coast guards and public representatives. The IRMP provides for coordination among the different agencies and stakeholders, and is vetted by the CMCs and the appropriate authorities of FD prior to its final approval by the MOEF. A mid-term revision of the IRMP is suggested in order to take on board relevant lessons learnt over the period and cost escalations.

1.2 Introduction

The Sundarbans (both forests and wetlands) provides life supporting, provisioning, regulating and cultural eco-systems services not only to the people of Bangladesh but also to the region and beyond.

1.2.1 Rationale of an Integrated Resources Management Plan

The Sundarbans is the largest contiguous mangrove forest remaining in the world; nearly 60% of the forest is in Bangladesh and 40% in the neighboring Indian state of West Bengal. A biologically diverse ecosystem, dynamic and complex, it has been used by mankind for generations. The Sundarbans, declared as Reserved Forest (RF) in the 1870’s and managed by the FD, constitutes 52% of the forest estate of the country and contributed about 41% of the total forest revenue. Apart from providing timber and firewood resources, it is a source of food, fish, medicinal plants, crustaceans, palm leaves, honey, wax and shells, as well as increasing environmental, food and climate security, and recreation demands. It provides the last remaining wildlife habitat for some species, notably for the Royal Bengal Tiger. The area is internationally recognized under the Ramsar convention, to which Bangladesh is a signatory, and includes three wildlife sanctuaries, encompassing 139,698 hectares, which were gazetted in 1996 and have been declared as ‘World Heritage site’ by UNESCO in 1997.

Although most of the country's forests have been intimate interspersion of human habitations and cultivation, there are neither settlements inside the SRF and nor the forestland has been subject to encroachment since their gazetting as RF. However, the traditional dependency of floating population from peripheral areas for their livelihood including fishing has been an important aspect of the Sundarbans. Accordingly, livelihoods approach, under the Sundarbans Biodiversity Conservation Project (SBCP) of FD, and co-management approach recently adopted after the implementation of IPAC have recognized the important role of the local community. The proposed benefits sharing with notified 76 villages (Annexure 1.1) in the vicinity of the SRF would have profound impacts on the co-management of the Sundarbans.

The Sundarbans is intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests. The area is known for the world famous Royal Bengal Tiger (*Panthera tigris tigris*), as well as numerous fauna including a large number of species of birds, spotted deer, crocodiles, dolphins and snakes. The fertile soils of the delta have been subject to intensive human use for centuries and it is reported that the Sundarbans was twice than present during the early eighteenth century. The SRF, interfaced with cultivated lands and by tidal rivers and canals, serves as coastal protection from cyclones and tidal surges. The waves and tides with changes in water depth and its biochemical constituents, and fresh water from rivers are the basis on which biotic life and ecosystems depend. The SRF also represents the country's largest single carbon asset pool to market in carbon markets. Timber harvested from the SRF has in the past been a major resource, but currently a logging ban is in place (until 2015). A variety of non-timber forest products such as honey, wax, medicinal plants, golpata, cane, and grass are extracted from the SRF. The 12,000 km of rivers in the SRF produce a large quantity of fish, shrimp, and crabs. In addition, the Bay of Bengal is home to an important marine fishing industry whose stocks originate in the Sundarbans.

The ecological importance of the SRF is recognized both nationally and internationally and its conservation and management is an obligation under a number of international treaties and conventions to which Bangladesh is signatory. The ecological importance of the SRF is associated with its rich biodiversity and the ecosystems' valuable ecological services. It is estimated that the SRF is home to 425 species of wildlife, including 300 species of birds and 42 species of mammals. The area serves a vital role in a variety of ecosystem functions including (1) trapping of sediment and land formation, (2) protection of human lives and habitation from regular cyclones and other climate change impacts, (3) acting as a nursery for fish and other aquatic life, (4) oxygen production, (5) waste recycling, (6) wood production, (7) supply of food and building materials, and (8) carbon cycling and sink. These functions are increasingly at risk from the effects associated with climate change and consequent sea level rise.

The current IFMP for the SRF, developed in 1997 for the period 1998-2010, the CMP for the period 1997-2002, and the Forest Master Plan that was developed in 1993 to cover the periods 1993-2012 do not provide sufficient guidance to address the current issues the FD faces in managing the Sundarbans. Climate change, food security, recreation and tourism, co-management, biodiversity conservation, and carbon financing are a few of the issues for which specific direction needs incorporating into FD's current management practices. One of the major conclusions from a consultative meeting on the conservation and co-management on the Sundarbans organized on April 18, 2009 in Khulna was that an Integrated Resources Management Plan was needed to conserve the Sundarbans. At that meeting, the Secretary, MoEF noted the need to develop and adapt a separate approach for co-management of the unique ecosystem of the Sundarbans. In addition, the project design document for the SEALS project underscored the need for a re-think in the management strategy.

The Sundarbans ecosystem is extremely important both ecologically and economically as a nursery and breeding area for key fisheries including those of the Bay of Bengal. In recent years, concerns have been voiced by fishermen over the apparent declining stocks and productivity of fisheries in and around the Sundarbans. There are also indications of widespread illegal collection of crustacean larvae. Although there is inadequate monitoring of fish stocks, fishermen have noted that they are spending more time and efforts to capture fewer and smaller fish. The resource conditions as well as increasing numbers of resource users are a condition that must be reconciled. The increasing demand for recreation and tourism activities is expected to continue and a system for more effective administration of these activities is necessary. The revenues associated with these activities represent a significant opportunity for community organizations and to increase awareness of the ecological importance of the SRF. The implementation of approved entry fees guidelines for sharing revenues with the CMCs is a priority for sustainable co-management systems to be effective.

According to Bangladesh's Tiger Action Plan (2009-2017), the Sundarbans mangrove forests support one of the largest populations of tigers in the world with an estimated 440 tigers. A recent assessment of the FD, however, indicates 440 tigers in the SRF. Among many of the factors affecting the tiger populations worldwide, tigers are also threatened in Bangladesh by direct loss, prey depletion, and habitat degradation. These threats may not be as significant in the Sundarbans ecosystem but still do exist to a certain degree. Tigers are directly threatened by poaching to supply the increasing demand for tiger products. In addition, Bangladesh suffers high levels of tiger-human conflict, manifested in human-killing, livestock depredation, and ultimately the retribution killings of tigers by affected local communities.

The IRMP is intended to provide an overall management direction that the FD intends to follow in managing the SRF and its interface landscape. The desired goals outlined in this Plan will be the FD goals, and various program direction and multiple use management recommendations are based upon moving towards compliance with the desired condition and goals. The IRMP for the SRF takes into account of uses and pressures on the SRF originating with human populations residing in the identified surrounding landscape as well as recognize that influences from beyond the SRF are also addressed in order to address effects upon the SRF. The people who depend upon the SRF resources for a significant proportion of their livelihoods live in the interface landscape, a band extending 10km outside the northern and eastern boundary of the SRF.

1.2.2 Resources Trends and Challenges

The history of the Sundarbans area can be traced back to early AD (220-300) as evidenced by the ruins of a city found in the Baghmara forest block. During the Mughal period (12 to 15th century) Raja Basanta Rai and his nephew took refuge in the Sundarbans from the advancing armies of the Mughal Emperor Akbar. Many of the buildings which were built by them later fell to the hands of Portuguese pirates, salt smugglers and dacoits in the 17th century. Evidence of the fact can be traced from the ruins at Netidhopani and other places scattered all over the Sundarbans. The management status of the forests underwent a series of changes, including the distinction of being the first mangrove forest in the world to be brought under scientific management. Systematic management of this forest tract started soon after the establishment of a FD in Bengal in 1865.

Although it is not quite clear about the origin, the name *Sundarban* can be literally translated as beautiful forest in the Bengali language (*Sundar*, "beautiful" and *ban*, "forests"). According to ancient history, the name "Sundarbans" is derived from the sundari trees that are found in large numbers in the SRF. Alternatively, it has been proposed that the name is a correction of *Samudraban* that in Bengali translates to "Sea Forest". Of the total RF area in Bangladesh, 51% is the SRF, which makes 4.2% of the country's geographical area and 44% of the total forest area. It plays an important role in the economic and environment security, and protects the coastal population from cyclones and tidal surge. About one million people are party or fully dependent on the Sundarbans. More than 330 species representing 245 genera of plants are reported to be available in the Sundarbans. Its faunal diversity is even more impressive; as many as 120 species of fishes, 59 species of reptiles, over 300 species of birds and 42 species of mammals have been recorded in the Sundarbans. Tangible benefits from the Sundarbans can be categorized as accruing from wood and non-wood resources. Wood products range from timber, poles and posts to firewood, charcoal and tannin, whereas non-wood products include thatch, honey, wildlife, fish, fodder, salt, medicine, etc. During the fiscal year 2008-09 the Government of Bangladesh earned Tk. 55.17 million from the Sundarbans, mainly from non-timber forest products including fish.

Among the '*intangible*' benefits, often taken for granted, are: (a) coastal protection against wave and wind erosion; (b) moderating the effects of climate change and coastal storms and cyclones; (c) shelter and habitat for diverse wildlife, particularly avifauna; (d) nutrient sink-effect and reduction in excessive amounts of pollutants, and (e) entrapment of upland runoff sediments and thus protecting shore and reducing water turbidity. Mangroves also provide opportunities for education, scientific research, recreation and ecotourism. In addition to wood and non-wood materials, wetlands covering nearly one-third of the SRF provide significant benefits to local people who are fully or partially dependent on the fisheries resources covering about 40 commercially important fish species and several species of crustaceans. Among them hilsa, catfish, other white fishes, prawn, shrimp and crabs are important.

There is no shortage of documentation that describes the concerns related to the sustainability of the resources within the Sundarbans. However, for the most part, the documentation has not conclusively determined the trend information for many of the key habitats, resources and populations. For management purposes, the SRF has been delineated into four Forest Ranges and 55 compartments, guarded by over 90 FD posts. The Sundarbans is classified as a RF, in which some forms of resource extraction are allowed, but it is illegal for anyone to live, cultivate land, or graze livestock in the forest. To ensure additional protection for wildlife habitat and natural resources, three areas within the forest have been designated as Wildlife Sanctuaries: Sundarbans West (715 km^2), Sundarbans South (370 km^2), and Sundarbans East (312 km^2). These wildlife sanctuaries are closed to any extraction of vegetation or wildlife and have been collectively declared as a UNESCO World Heritage Site.

The current management situation includes a moratorium on timber extraction. For fishing, recreation and NTFPs, the use is regulated through permits, fees, and forest patrols. Extraction is prohibited in the wildlife sanctuaries and selected rivers identified (18 streams/*khals*) as key breeding grounds in the buffer zone have been restricted as well. A systematic monitoring and evaluation was identified in the IFMP to ensure timber and non-timber forest products are being maintained. But no monitoring and evaluation framework is being implemented to ensure that resource conditions and uses are within sustainable limits. Given the combination of the intense demand for the resources of the SRF, unsustainable management practices (e.g. shrimp fry collection, use of poison for fishing), lack of forest protection, rising sea levels and increased salinity associated with climate change, it is reasonable to assume that the current and continued extraction represents a threat to the ecological sustainability of the SRF as well as to the economic and social conditions of the dependent communities.

In the past 15 years, land use in the surrounding landscape outside the SRF, has been affected by a significant transformation from rice-based farming systems to shrimp aquaculture, with numerous adverse social and environmental effects, including increased pressure from non-sustainable extraction of resources from the Sundarbans. However, the adverse economic and ecological effects of these practices are being increasingly recognized, resulting in control on further expansion of shrimp aquaculture. A major environmental concern is that the natural drainage, other than the main river channels, is everywhere impeded by extensive embankments and polders that were developed mainly under donor supported projects for the protection of agriculture land from salinity.

1.2.3 Location of the Sundarbans Reserved Forest

The SRF lies in the vast delta on the Bay of Bengal formed by the confluence of the subcontinent's three mighty rivers (Ganges, Brahmaputra and Meghna). The SRF is situated (Figure 1.1) in the south-west corner of Bangladesh, between latitudes 21027'30" and 22030'00" North and longitude 89002'00" and 90000'00" East. It is under Khulna circle and includes parts of Khulna, Satkhira and Bagerhat districts. The western boundary follows the Hariabhanga-Raimangal-Kalindi rivers and adjoins with the Indian Sundarbans. To the south, the Sundarbans meets the Bay of Bengal and two boundary lines (the approximate Curtis line and the national marine boundary line) have been defined in the GIS data since there is no legally tenable description at present. To the east, it is bordered by the Baleswar river and to the north there is a sharp interface with intensively cultivated and inhabited lands.

Historical records reveal that the northern boundary of the Sundarbans during the Mughal period (1203-1538) extended from Hariagarh, south of Dimond Harbour on the Hoogly, to Bagerhat in the southern part of Jessore and Haringhata, along the southern portions of Sirkars Satgaon and Khalifatabad. During the later part of the 18th century and the beginning of the 19th century, the boundaries of the Sundarbans tract extended about 170 miles along the sea face of the Bay of Bengal from the estuary of Hoogly to that of Meghna, and inland to a distance of 60-80 miles. The track was located between 22031' and 22038' North and 8505' and 90028' East, an area of 6,526 square miles. Regular reclamation of the Sundarbans is said to have started in 1830, when a large part of the forest was cleared between 1830 and 1875. Some parts of the forests were declared as RF in 1876 under the Forest Act of 1876. Except two small parcels of deforested areas in the latter part of the last century and early this century, the boundaries of the SRF have not changed since 1875; this area comprises the SRF of today.

The Sundarbans with 55 compartments (Figure 1.2) has an area of some 6,017 km^2 (7,620 km^2 including the marine zone), determined from visual interpretation of multispectral SPOT Satellite data. Of the total area, the land area occupies 414,259 hectare and water areas 186,413 hectares (Runkel, 1996). An updated re-stratification conducted in 1997 under

FRMP found 411,234 hectare land area which is about 3000 ha less than the above. If the area is extended to the national border to the south, stretching 12 nautical miles (22.24 km.) into the Bay of Bengal, a further 1,603 km^2 would be added for a total area of 7,260 km^2 (Table 1.1). Rectification of these boundaries is a national management issue which should be formally addressed since it underlines the importance of the offshore fishery and consequent implications of possible extension of responsibilities in the area for the FD working with other agencies.

Figure 1.1: Location of the Sundarbans in Bangladesh

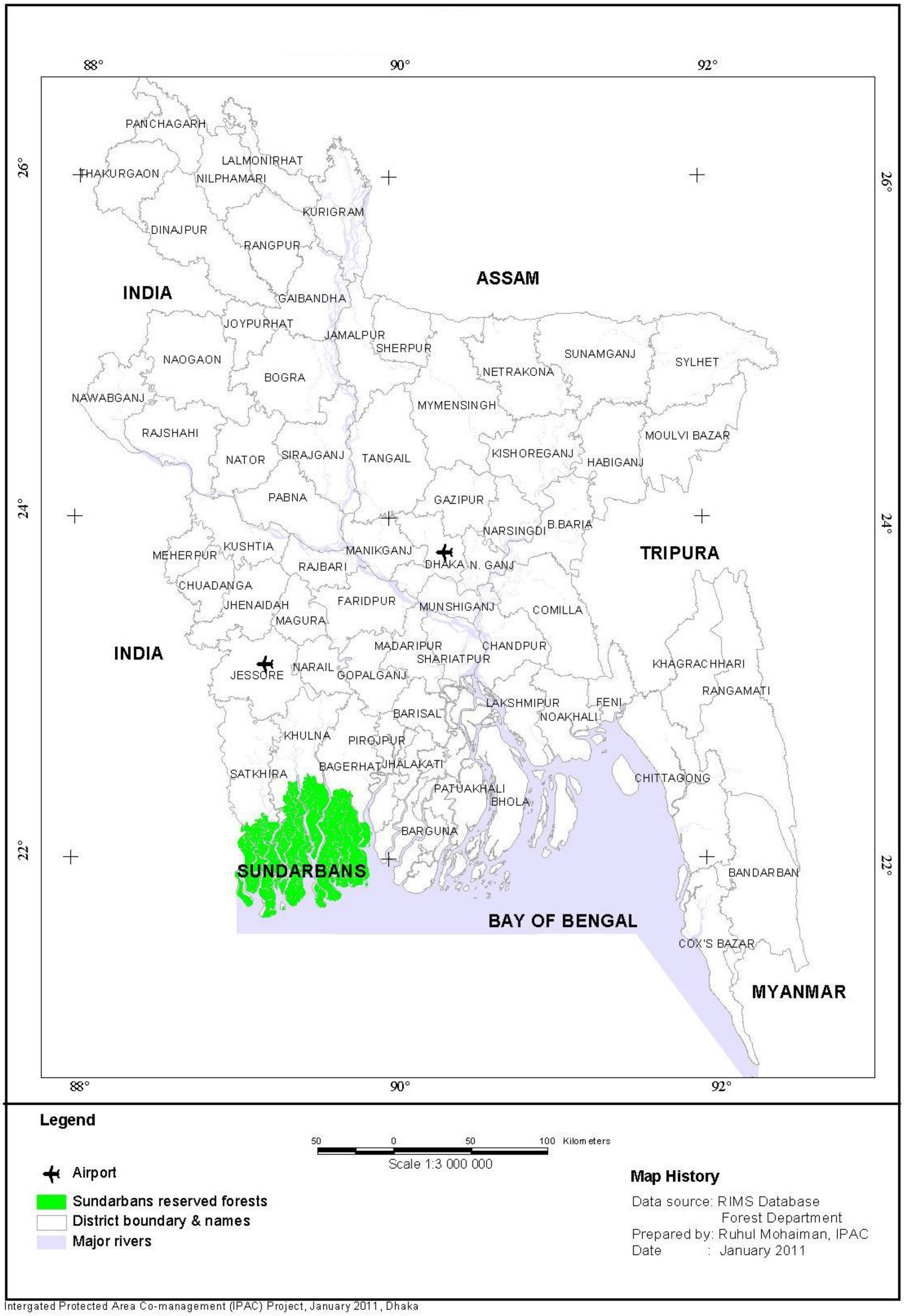
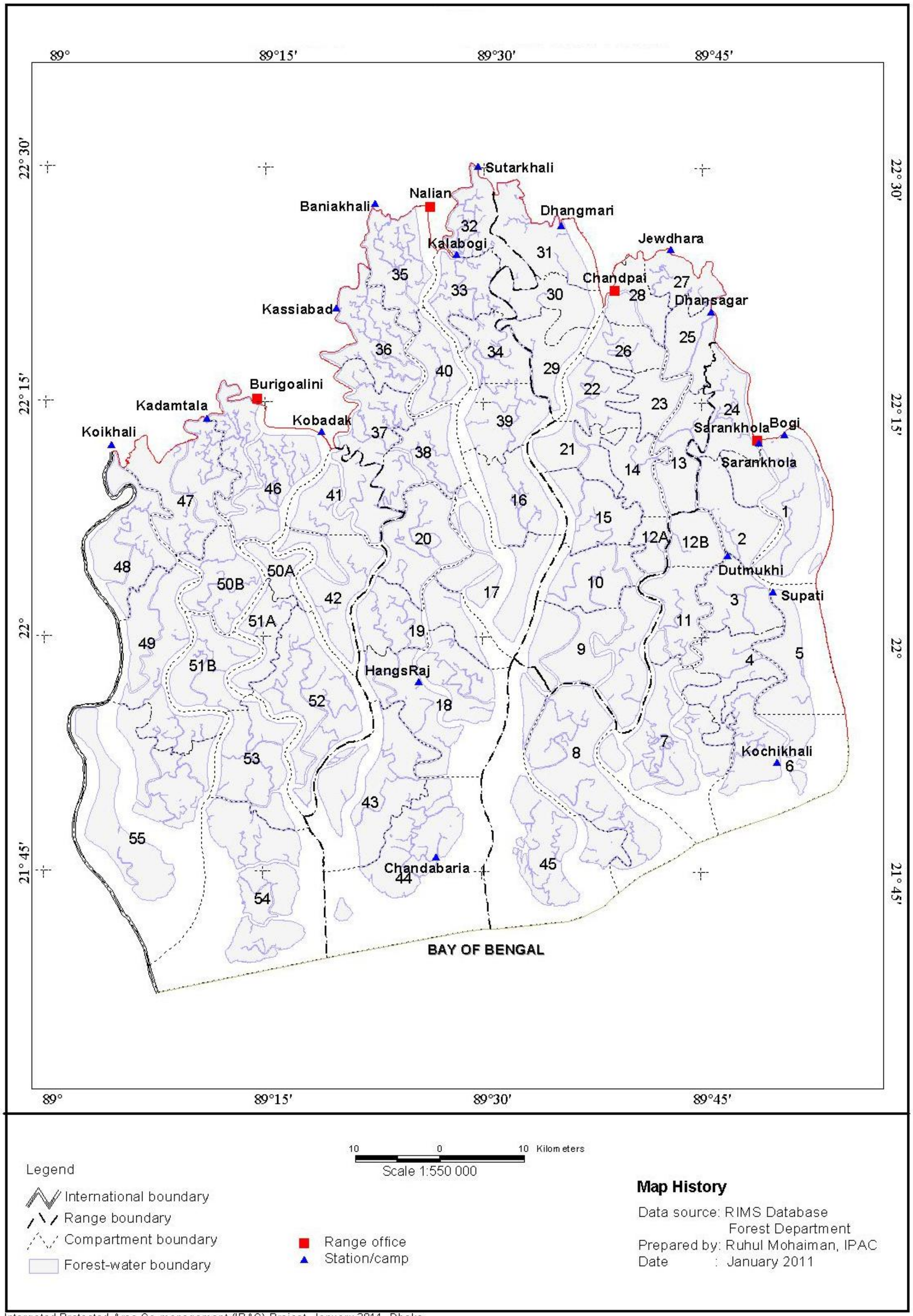


Figure 1.2: Compartments of the Sundarbans Reserved Forests



Intergated Protected Area Co-management (IPAC) Project, January 2011, Dhaka

Table1.1: Major Physiographic area of Bangladesh and the Sundarbans

Description	Area in km^2	% of total area	Cumulative total (%)
Rivers, canals, streams	8,300	5.76	5.76
Easturine, brakish water	1,828	1.27	7.03
Floodplian	112,010	77.76	84.09
Wetlands (beels and haors0	2,930	2.03	86.82
Freshwater tanks and ponds	794	0.55	87.37
Artificial lakes	906	0.63	88.0
Hill areas	17,286	12.00	100
Total (Bangladesh)	**144,054**	**100.00**	
Forest (managed by FD in Bangladesh)	14,610	10.1[1]	
Reserve Forest	11,777	80.6[2]	
The SRF land area including sandbarbs	4,142.6		
SRF Marine zone	1,603.2		
River Channels, streams, canals	1,874.1		
Total area of SRF excluding marine zone	6016.6	51.1[3]	
Total area of SRF including marine zone	7620.0	64.7[3]	

Source: IFMP (1998)
[1] of total area of Bangladesh.
[2] of total area
[3] of total reserve forest in Bangladesh

1.2.4 Legal Status of the Sundarbans Reserved Forest

There is a long and varied history of the legal status of the SRF recorded as far as back as the Mughal period (1203-1538) when the area was leased to a local king (Hossain & Achrya, 1994). Records on reclamation, forest clearing and settlement stem from the late eighteenth century and the first management legislation was the Charter of Indian Forests and the Forest Act of 1876 according to which the Sundarbans was declared as Reserved Forest by the Government of British India. Subsequently, systematic management became official and Heinig (1892) in his working plan recorded important events in the legal background to what eventually became the Forest Act of 1927 which makes provisions for RFs and their legal position. In 1915, the whole area was re-notified under the Gazette notification 1439 for Khulna and the RF area was increased to 5,950 km^2 (IFMP 1998). The properties with which the northern boundaries merge are either permanently settled estates or lands held as grants made under the rules of September 1853, or the lots leased under rules of November 1879, namely lots 216, 223, 224, 225 and 240. The boundaries of the Sundarbans are all natural, except as below:

(1) A short length of 1.2 miles separating lots 7 and 7 Kawlia-Barisal, on the eastern side of the Bagerhat forest, a line maintained by the FD clear of jungle, 15' wide, with conical mounds of earth 6' high and 4' diameter at base, 100' apart.
(2) The northern boundary of lot 164, and the north western boundary of lots 172 and 169, which are maintained in a state of repair by the lessee of adjacent lots of wasteland.

The first National Forest Policy promulgated in 1894 provided the foundation for all future acts and rules which underpinned the administration of the SRF. The principal policy directives and legislation which affect integrated management of the SRF are:

- ✓ The Forest Act of 1927 and its amendments
- ✓ The National Forest Policy of Bangladesh, 1994.
- ✓ The Wildlife Ordinance 1973 and The Wildlife (Preservation) Act, 1974
- ✓ The Brick Burning Act, 1991.
- ✓ The Protection and Conservation of Fish Act, 1950.
- ✓ The Embankment and Drainage Act, 1952
- ✓ The Protection and Conservation of Fish (Amendment) Ordinance, 1982
- ✓ The Marine Fisheries Ordinance, 1983
- ✓ The Protection and Conservation of Fish Rules, 1985.
- ✓ The National Environment Act, 1995
- ✓ The Environment Conservation Rules 1997
- ✓ The National Conservation Strategy

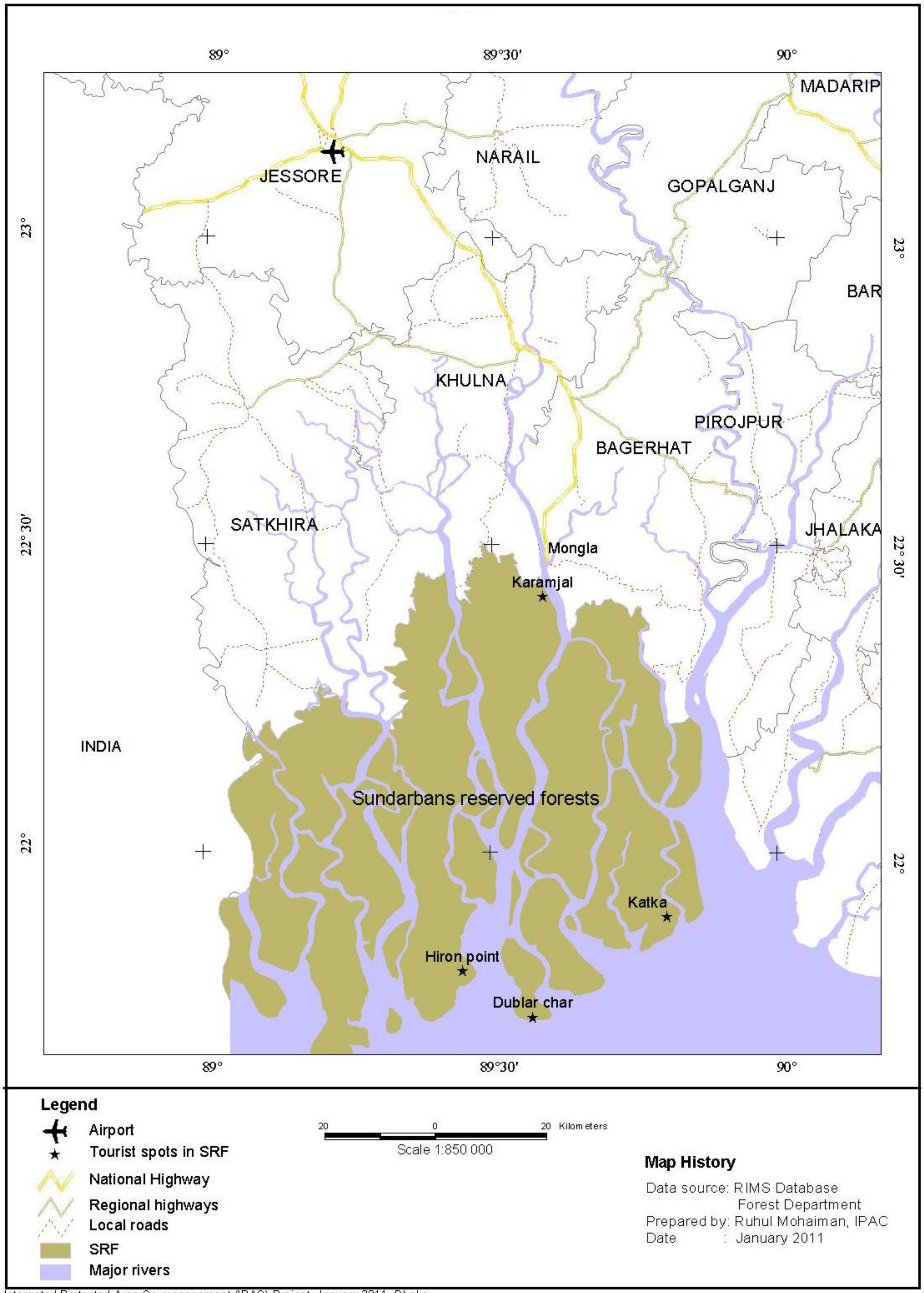
1.2.5 Approach and Access to the Sundarbans

The main access (Figure 1.3) to the Sundarbans is through the cities of Khulna and Mongla in the north and Shyamnagar to the west. Another route through Sarankhola is under planning. The main navigation into the area is through rivers and by boat and there are tour operators with luxury vessels directly from Dhaka and Khulna. Although Bangladesh is virtually surrounded by India on three sides and the Indian ocean to the south, Bangladesh's strategic situation offers immense opportunities as a hub for traders and travelers for the entire region. The Sundarbans forms the powerful natural bastion to the south. There is a very high potential of eco-tourism development in the Sundarbans, increasing the income and benefiting to local and national economy.

1.3 The Integrated Resources Management Plan Structure

This ten year IRMP is a revision of the existing Integrated Forests Management Plan (1998-2010) and the Conservation Management Plan of the three Wildlife Sanctuaries (1997-98 to 2002-03). The IRMP comprises two volumes: Volume 1 is divided into Part I and Part II, whereas Volume 2 provides support material and is so a compilation of guidelines, data analyses and lists of flora and fauna. The present situation with analysis of management situations and issues is assessed in Part I of the Plan. Based on the findings of Part I, the Part II of the Plan recommends ten interlinked strategic programs for ten-year period with suggested actions and priorities for future development and management of the Sundarbans. The IRMP may be revised mid-term in order to take on board relevant lessons learnt during its implementation.

Figure 1.3: Access Routes to the Sundarbans Reserved Forests



Intergated Protected Area Co-management (IPAC) Project, January 2011, Dhaka

2. Strategic Goals and Objectives of the Sundarbans Management

The IFMP, developed during 1997-1998, included a long term vision for the SRF. While many of the previous descriptions are still appropriate, there are important changes needed or further emphases to be added to better reflect the current management situation. This IRMP prepared for the period of 2010-2020 includes assessments of the conditions and trends of the resources within the SRF and an elaboration of appropriate spatial and resource specific management programs needed to address the desired conditions and goals as described below. The IRMP assessments and associated management programs, guidelines and best practices have integrated biodiversity conservation, climate change considerations, co-management approach, eco-tourism, and conservation oriented forests and wetlands management and addressed projected future scenarios and necessary management implications and changes, if these continue to occur.

2.1 Strategic Vision

The following vision statements are proposed by the FD as the long term vision for the sustainable management of the SRF and its interface landscape:

- The Sundarbans shall continue to provide subsistence consumption resources at a level in which the sustainability of the resource is ensured, though emphases will be on reducing community dependency and improving current management practices.
- Traditional users will acquire a greater awareness and shared responsibility and a share in the benefits as a result of co-managing the resources and will act accordingly to help conserve them.
- The FD will involve local people in the SRF protection and management.
- The Department of Fisheries and Department of Environment will be consulted and their advise will be taken in the SRF management, whenever necessary.
- The FD will develop its capacity including infrastructure, logistics and technical capacities and seek technical assistance where appropriate in the SRF management.
- Development and efficient operation of alternative income generation and value chains enterprises in the interface landscape will help depress the demand for resources currently obtained from the SRF.
- Wildlife and fish resources will prosper throughout the SRF where populations will thrive at optimum carrying capacity. The SRF landscape will be managed to ensure that essential ecological services are maintained. The wildlife sanctuaries, designated as Ramsar site, will be managed to provide secure habitat for wildlife resources with tigers as umbrella species.
- Specific sites, infrastructure and routes in designated areas of the SRF will be developed and/or maintained to provide for quality ecotourism and recreation experiences.
- In order to take advantage of the increasing eco-tourism, the FD will seek public/private partnerships consistent with the guidelines and principles established by the GOB to improve the ecotourism services and facilities.

- The effects anticipated to result from climate change will be recognized and, mitigation and adaptive management strategies developed and implemented in order to ensure the maintenance of ecosystem (forest and wetlands) goods and services.
- Restoration and maintenance of essential ecological and climate amelioration functions and services of the SRF comprising the mangrove forests and wetlands will be recognized.
- The Sundarbans, as the largest contiguous mangrove system in the world and befitting its world heritage site designation, will become the international recognized example of collaborative management of a mangrove ecosystem, with provisions for sustainable financing for more effective conservation efforts in the SRF in tandem with a broad range of programs supporting food and ecological security, poverty reduction and sustainable socio-economic development in the interface landscape.

2.2 Strategic Opportunities

The SEALS (2011-2015) project, the IPAC (2008-2013) project, the WB non-lending technical assistance, the assistance from German Development Cooperation in the livelihood interventions in the Sundarbans ECA, in combination with the full support of the GOB MoEF and FD provide an opportunity to address some of the significant issues (forest and aquatic resource and habitat management, food and ecological security, alternative income generation, resource dependency, tourism, climate change and sea level rise, land use and demographic trends in the landscape) that are currently affecting the SRF. Discussions have been held for reinforcing cooperation between Bangladesh and West Bengal with a view toward enhanced collaboration in the management of this globally important transboundary ecosystem. There is also the prospect of increased investment by the WB and others in the landscape to help address the infrastructure needs and structural challenges inherent in the threats to the conservation of the Sundarbans.

Forest protection must respond to the modern means available to timber thieves and poachers with a protection strategy and equipments to match. A protection strategy that enlists the support of fringe communities for co-management to plug the gaps in the forest's defenses will have a far greater chance of success than a confrontational approach. A change of protection strategy is required, backed with a substantial improvement in operating conditions for FD staff, particularly those who actually implement policy – those actively operating on patrol, etc. Co-management organizations must be formed and empowered in order to play a more active role in establishing adequate enforcement of protection and management provisions. Involving the communities in these decisions and giving them a stake or share of the benefits is expected to result in higher levels of ownership and compliance.

The GOB and the FD stands ready to capitalize on the continued successful co-management of the Sundarbans. Global carbon markets have the potential to assist in a sustainable financing mechanism for the management of the Sundarbans. The IRMP will be the basis for developing carbon market financing proposals (including for reduction of emissions from deforestation and forest degradation, REDD+ and improved forests management, IFM) and will help to reinforce the important role of the Sundarbans in mitigating and adapting to global climate change. It will also help in augmenting food security through improved wetlands management and conservation linked livelihood enterprises for the local stakeholders in the surrounding landscape and beyond.

The continued and increasing demand for recreation and tourism in and around the Sundarbans is an opportunity for the FD to showcase its world class management situation. Integrating communities into co-management systems, combined with international carbon financing, eco-tourism revenue, and tiger species and habitat protection and education represents an outstanding opportunity to secure sustainable financing for the long term conservation of the Sundarbans. In addition, the conservation programs recommended in the IRMP are expected to result in a more formal approach to achieving long-term conservation of wildlife including tigers and other threatened and endangered species in Bangladesh. The IRMP vision is to ensure protected tiger landscapes in the Sundarbans, where wild tigers as umbrella species thrive at optimum carrying capacities and by doing so the essential ecological products and services available in the Sundarbans are sustained.

2.3 Management Strategies

In order to achieve the desired condition, it is recommended that the following management strategies will be adopted over the Plan period of ten years:

- To FD as an agency with the capacity to plan, implement and monitor a biodiversity and wetlands conservation and resource management program that includes subsistence use of its natural resources.
- To participatory, collaborative approaches to management with increased coordination and cooperation with relevant government agencies such as DOF, DOE, Coast Guard, other agencies, local government, private sector, local communities, tour operators, etc.
- To mobilization of sustainable financing for conservation through innovative mechanisms and partnerships.
- To a management system and approach that embraces new opportunities and needs related to eco-tourism, recreation, biodiversity conservation, sustainable livelihood, food security, carbon sequestration and other ecosystem services.
- To an emphasis on co-management and facilitation of responsible stewardship by concerned stakeholders.
- To a forests and wetlands protection strategy that improves FD patrolling, monitoring, staffing, work incentives and staff living conditions.
- To a framework that reinforces participatory governance and equitable benefits sharing.
- To a system based on upgraded equipment provisions and improved human resource utilization designed to efficiently ensure more effective protection and support for community based, collaborative management and conservation.
- To a system of financial and economic incentives that support behavior change consistent with increased investment in natural resource management, habitat protection and restoration, long term increases in resources productivity and sustainable use.
- To a sustainable landscape scale management perspective that includes the entire SRF as well as considers the effects and impacts of the surrounding landscape.

2.4 Strategic Goals and Outcomes

The strategic management refinements and shifts identified above are expected to contribute to the achievement of the following goals and outcomes for the sustainable management of the SRF and its surrounding landscape:

Goal 1: Protect, restore, sustain and enhance the biodiversity of the SRF and its interface landscape.

Outcome: Forests and terrestrial resources, and wetlands and aquatic resources with the representative capacity to maintain their health, productivity, diversity, and resistance to unnaturally severe disturbance.

The SRF was established to protect the land, provide security for neighboring communities from catastrophic disturbances, and provide a sustainable supply of goods and services. Over the past century, the FD has strived to achieve a balance between providing land stewardship services and meeting public demands for various uses of the Sundarbans. In recent years, people have become more aware of catastrophic disturbances such as Sidr and Aila and the role that the Sundarbans has in mitigating the effects of these disturbances on neighboring communities. The increasing extent and frequency of uncharacteristically severe cyclones and rising salinity have been of particular concern to the affected communities, the political administration, NGOs and the FD. A much broader conservation program must be implemented in the SRF and led by FD, in order to ensure that the ecosystem structure and processes are able to adapt to unnaturally severe disturbances and the anthropogenic interferences which are continually exerting biotic pressures on the ecosystem. Appropriate planning, capacity building and organizational changes must be recognized and planned for in order for biodiversity conservation, sustainable resource management, recreation, and co-management to become institutional throughout the FD in the SRF.

Goal 2: Provide for resilience-based food security through provision of a variety of subsistent uses including fisheries, values, benefits, products, and services, while ensuring the sustainable supply of these resources for future generations.

Outcome: Resources use is managed on the basis of sustainability and co-management through the consultation of best available science and stakeholders.

This strategic goal focuses on the portion of the MoEF's mission related to sustaining the productivity of the Sundarbans to meet the needs of present and future generations. The SRF contains abundant natural resources and opportunities that help meet the demands and needs of the local people. Sustainable management of these resources ensures that the availability of goods and services continues into the future and that forest land and wetland productivity is maintained. The forest reserves that formed the base of the Sundarbans were created in 1875 for the purposes of regulating the yield of forest products. Human habituation has been prohibited in the reserve. The Bangladesh Wildlife (Preservation) Amendment Act 1974 provided for the establishment of wildlife sanctuaries where extraction of resources is not allowed. Forests and fisheries management provides a variety of use opportunities while maintaining biodiversity, supplies of wood and non-wood products, energy sources, wildlife forage, water supplies, and other goods and services. Primarily through the strategic programs outlined in the IRMP and implemented through field administration, community based co-management, and forest protection strategies, the FD provides for natural resource management and the sustainable use of resources within the SRF. Suggested research themes provide a solid scientific foundation for the sustainable management of forests and aquatic resources and improvements in the use and marketing of forests and wetlands products and services.

Goal 3: Provide for and enhance eco-tourism and visitor recreation opportunities.

Outcome: Eco-tourism revenues are augmented to provide enhanced alternative incomes as well as provide for increased emphases on biodiversity conservation and visitor management.

The FD is challenged with sustaining sufficient quality and quantity of eco-tourism and recreational experiences to meet the country's needs while maintaining the ecological integrity of the SRF and associated protected areas. As the population is projected to continue to increase, the combination of increasing populations and the continued increase in demand for its recreational and tourism experiences creates extensive pressure on FD to provide more and improved recreational opportunities. If the SRF is to provide additional recreational benefits without unacceptable resource impacts, effective management solutions should be emphasized. The condition of the land (especially the habitat for the keynote species-Royal Bengal Tiger), recreation facilities, and transportation infrastructure, must be considered if we expect to preserve and enhance recreation experiences. Coordination with partners, nongovernmental organizations, other agencies, and the private sector is essential to achieve acceptable results.

Goal 4: Support and improve community based co-management approaches for the activities taking place in the SRF and its surrounding landscape.

Outcome: The FD facilitates and engages with the landscape communities and stakeholders in determining appropriate co-management practices and benefits sharing.

The protection strategy of the FD in the SRF should be one that works in collaboration with neighboring communities and key stakeholders to achieve its conservation and custodial responsibilities. Based on the IRMP, CMCs, in collaboration with FD, will be enabled to develop and implement annual operating plans as well as ensuring forest resources are protected.

Goal 5: Provide for and implement appropriate climate change mitigation and adaptation options and opportunities.

Outcome: The FD ensures the continuation of the Sundarbans as carbon sink (both for green carbon in forests and blue carbon in wetlands), and contrtibutes in enhancing the ecosystems resilience for improved adaptation of local communities to climate change impacts including cyclones and storms.

The existence values of the Sundarbans stem from its ecosystems functions and services for the mitigation of climate change as a result of CO2 sequestration and storage but also due to climate change adaptation as a result of community protection and livelihoods through resilient ecosystems.

2.5 Strategic Management Planning Principles

The IRMP strategic goals and outcomes outlined above are guided by the understanding of the relationships of the different types of planning as outlined below:

- *Strategic planning* takes place at the highest level and eloborates strategic priorities, identified by the GOB, MOEF and the FD, which are implemented over a period of time through annual plans and budgets. These priorities reflect social, economic and ecological conditions and trends as well as lessons learned from previous management direction. The strategic priorities outlined in the IRMP are responsive to the goals outlined in the Forestry Master Plan (1993-2012).
- *IRMP planning* (e.g., an adaptive and integrated land and resource management plan for the Sundarbans) provides an inventory of resources, and specific management programs and land use zonation for particular resources and/or areas. This information, coupled with the desired future condition for the resources, is the basis for permitting sustainable resource use and protection, annual work planning and budgeting and projections over a 10 year timeframe. The IRMP planning for the SRF will integrate the various resource management plans, land use zoning, prescriptions and best management practices. The IRMP planning is considered as an adaptive or "living" document with necessary mid-term amendments to be included after the appropriate involvement of communities and other stakeholders. The IRMP planning consists of resource-specific goals, objectives, management guidelines, management area delineations and suitability determinations, and monitoring and evaluation criteria.
- *Annual development planning* identifies the projects proposed in the IRMP for funding within a fiscal year. This level of annual planning involves the CMCs and FD field staff for the final application of strategic direction into a unit's annual plans and budget to move its resources toward its desired future condition. Based on the proposed strategic programs and indicative physical and financial targets of the IRMP, annual development plans are preprared annually in consultation with key stakeholders.

3 Biodiversity Conservation Attributes

3.1 Statement of Biodiversity Significance

The forests, wetlands, wildlife and aquatic resources of the Sundarbans are very rich biologically, located as they are in one of the most dynamic bio-geographic coastal zone. Accordingly, the Sundarbans attract both national and international attention whenever the status of forests and wetlands comes under scrutiny. For instance, the inclusion of the Sundarbans as Ramsar Site and the three wildlife sanctuaries as UNESCO World Heritage Site is testimony to the global realization about the Sundarbans ecosystem comprising the world's largest mangroves and complex networks of tidal and fluvial waterways with rich terrestrial and aquatic biodiversity. The conservation of the Sundarbans and its interface landscape and coasts is critical for ensuring the country's ecological and food security. The mangroves and wetlands of the Sundarbans are significant carbon sinks, necessary for addressing climate change both globally and locally. The Sundarbans is a very popular recreation destination both for domestic and foreign tourists.

Enormous amount of sediments and nutrients brought by the freshwaters from the Ganges and Brahmaputra into the Sundarbans and its adjacent landscapes is circulated by a seasonally reversing, wind-driven, basin-scale gyre, with adjacent meso-scale eddies rotating in the opposite direction, thereby producing highly stratified and productive coastal waters. The Sundarbans is not only the last remaining habitat of the Royal Bengal Tiger but also important breeding ground of indigenous and marine fishes including hilsha, and ceteaceans such as Ganges and Irrawady dolphins. Intense forests-water interactions result in high productivity, making the ecosystem very dynamic and useful both ecologically and socio-economically. Nearly one million people from the interface landscape depend on the Sundarbans for earning their livelihoods. Transnational biodiversity values ensue from the fact that the mangrove forests in West Bengal are in contiguity with similar ecosystem values.

3.2 Biodiversity Conservation Values

Main biological values of the Sundarbans include providing suitable habitat to the biodiversity of global significance, comprising both terrestrial and aquatic flora and fauna; habitat connectivity; and sustenance of threatened and endemic species. Important ecological functions of the Sundarbans include climate change mitigation through carbon sequestration and storage, conservation of waterbodies, coastal protection and climate change adaptation, inland and coastal fisheries, amelioration of environment, food and ecological security, etc. The Sundarbans provide significant scope for outdoor recreation, nature interpretation, conservation awareness, and wildlife education and research. The Sundarbans is also a good source of eco-tourism, aesthetic values, dense mangroves, tiger habitat, historical and cultural values, and scenic beauty. The Sundarbans ecosystem is, however, fragile with a very rich biodiversity, which if not conserved timely, may be lost for future generations. Many conservation values of the Sundarbans are characterized as global and regional public good but also have significant national and local conservation values.

3.3 Biophysical Attributes

3.3.1 Topography

The Sundarbans forms the south most portion of the Ganges (Padma) and Brahmaputra (Jamuna) river deltas. Topographic variation within this low-lying physiography of the area compared to upland areas is negligible: The SRF floor rises from 0.9m to 2.11m above the mean sea level. The whole area undergoes a twice daily tidal inundation.

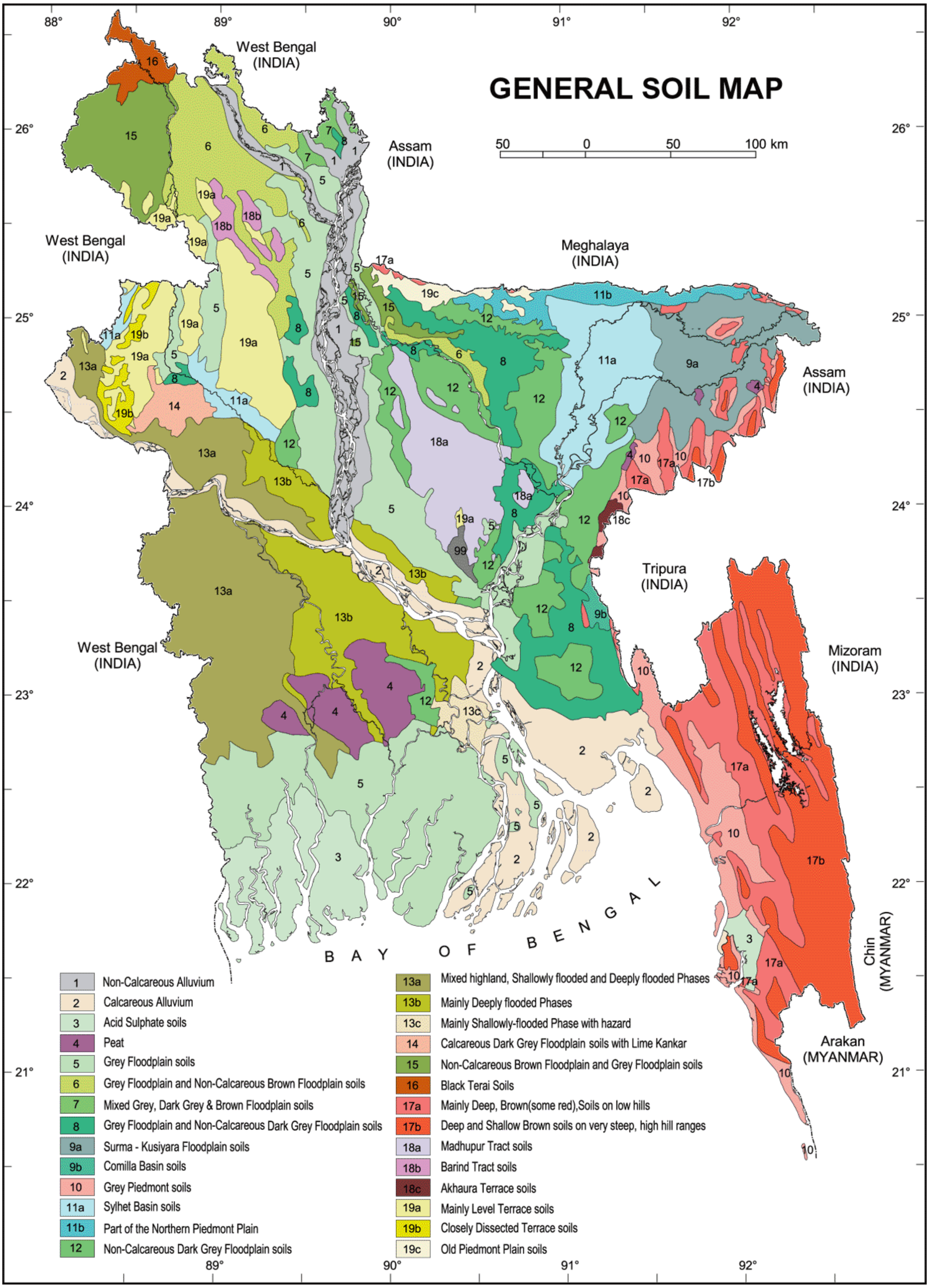
3.3.2 Geology and Soils

The geology of the Sundarbans is of recent origin, raised by the deposition of sediments formed due to soil erosion in the Himalayas. The process has been accelerated by tides from the sea face. The substratum consists mainly of Quaternary Era sediments, sand and silt, mixed with marine salt deposits and clay. Geologists have detected a southeastern slope and tilting of the Bengal basin during the Tertiary. Recent work on the detailed geology of Pleistocene and post Pleistocene soils, including radiocarbon dating has been carried out by Umitsu (1991). Based on the variation in soil strength, grain size characteristics, etc., the depositional sediments can be divided into 5 categories, namely uppermost, upper, middle, lower, and the lowest. These categories are defined by a weathered surface and a sharp change in lithology, representing a period of marine regression.

Umitsu correlated the boreholes at Khulna (Daulatpur) with those in Faridpur and Barisal. While the slope is consistence with present day ground elevations between Khulna and Barisal, the ground level is higher at Barisal, the uppermost layer is twice as thick as that at Khulna (12m compared with 6m). Thus Barisal appears to be an actively accreting area, while Khulna and Faridpur appear to be moribund. Studies from the boreholes indicate that apart from a regression at around 12000 BP before 1991, there was a rise in sea level as observed elsewhere in the world. The shell identified at Khulna borehole depths of 20m and 35m are of tidal brackish environment with a deposition estimated 7000 and 9000 BP. The evidence from these boreholes tends to confirm the impression that while the western side of the region is relatively stable, the south-eastern corner is an active sedimentary area that is subsidizing (Hossain and Acharya ,1994)

Soils of the SRF are derived from a mixture of deltaic floodplain deposits and tidal marine deposits (Figure 3.1). The surface soil is a silty clay loam, overlying alternating layers of clay and sand. In general, the soil fertility decreases from east to the west and from north to south (IFMP, 1998). In the north and east portions of the Sundarbans, relatively high fertility is maintained by annual silting. These soils are slightly saline, silty clay loam and the sub-soil consists of alternate layers of clay and sand. Silt appears to be the most common textural class and grain size is larger in the eastern forests than in the west. Pyrite may occur on the localized depressions containing higher amount of organic matter. The presence of biotic, carbonate and feldspars protects the soil from becoming acid sulphate where drainage in not impeded (IFMP, 1998). Hasan (1990) described the soil of the Sundarbans delta as unripened, slightly calcareous, tidally folded, grey, massive, alkaline, clay muds with low (<2%) organic matte content and saline, uncured or partly cured grey clayey deposits, and homogeneous in vertical and horizontal directions.

Figure 3.1: Soil Map of Bangladesh with particular reference to the Sundarbans



Organic Matter

The soils of the Sundarbans being formed entirely of fine silt and sediments carried by the Ganges and Brahmaputra, contain a high percentage of calcium carbonate and, therefore, fall essentially under the Pedocal group. The percentage of organic matter appears to be generally low: Bhuiyan (1994) found variations in the range 0.8 to 3.3% in the top layer and 0.2 to 2.9% in bottom layer. The highest percentage of organic matter was found in the top layer of the compartments 36 and 39. The lowest percentage of organic matter was found in the bottom layer of the compartment 24. The organic matter was found by Karim and Islam (1983) to vary from 4 to 10%, which is considerably higher than those determined by Bhuiyan (1984). The Bangladesh Forest Research Institutre (BFRI) has recently estimated the soil organic matter for the Sundarbans by using soil samples collected during carbon inventory (Annexure 3.1)

Soil pH

The soil pH varies from 6.8 to 8.4, but throughout the SRF most of the soils fall on the alkaline pH range between 7.0 and 8.0.

Mineral Composition

The results obtained from a mechanical analysis of different samples showed that the silt fraction varies with depth. The clay fraction varies from 24 to 44%. Sand fraction varies from 8 to 30% and silt varies from 40 to 60%. It was found from the particle size analysis that different textures were readily discernible and could be used as a basis for classification into silt loam, silty clay and clay loam.

Chloride

Chloride is said to be the most common anion in the coastal soils of Bangladesh, ranging from 57mg/100g to 232mg/100g in oven dry soils, with significant gradation in proportion to distance from the sea perennial freshwater flushing, especially to east.

Sodium and Calcium

Content of Na and Ca were found to be highly variable in all studies, ranging between 57-98mg/100g of oven-dried soil with variations along north-south and east-west gradients. Experimental results for calcium ranged from 0.50mg/100g for subsurface soil to a maximum of 12.4 for surface soil in the compartments to the north-east; and for sodium, 1.8 to a maximum of 9.3mg/100g of oven dried soil in the compartments 6 and 8 in the south-west near sea (IFMP, 1998)

Sodium Absorption Ratio

This measure of the exchangeable sodium percentage shows considerable variation as was found by Chaffey *et al* (1985) to vary between 1.3 and 31.6% in surface soils and between 6.4 and 40.7 in subsurface soil.

Cation Exchange Capacity

The highest cation exchange capacity (CEC) of 22.87mg/100g was found in the permanent sample plot (PSP) 16 of the compartment number 1 and the lowest CEC of 9.94mg/100g was found in the compartment number 54. These figures are according to Karim (1988) and

Chaffey et al (1985) who found the variation at their sites of 12-23mg/100g of soil with little difference between wet and dry season.

3.3.3 Climate

The Sundarbans is located south of the tropic of cancer and at the northern limits of the Bay of Bengal and may therefore be classified as Tropical Moist Forests. In absence of a meteorological station inside the Sundarbans, all data are collected from the nearby station in Khulna. The coolest average annual temperature (11.8^{o}C) occurs during December-January, and the warmest (34.6^{o}C) at the end of dry season, during May-June. According to Bengali calender, there are six seasons in Bangladesh, namely: summer (*Boishakh-Jayistha*), rainy (*Ashar-Sharaban*), autumn (*Bhadra-Ashwin*), late autumn (*Kartic-Agrahayan*), winter (*Pous-Magh*) and the spring (*Falgoon-Chaitra*). However, at present the identification of the six seasons is difficult and so three main seasons are felt as a long summer, rainy season and winter. Another classification could be as pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November) and the dry-winter season (December-February).

During pre-monsoon the average annual temperature at Khulna ranges from 20.4^{o}C to 35.2^{o}C, and during monsoon the temperature ranges from 23.6^{o}C to 33.5^{o}C and the monsoon winds bring high rainfall, humidity and cloud cover; sediment load and water levels of rivers also increase due to heavy rainfall in the upper catchment areas. The annual average temperature during post-monsoon at Khulna is 31.75^{o}C and the season is characterized by southerly winds, high temperatures and evapo-transpiration rates, with occasional heavy thunder storms. The area inundated by tidal water increases and the salinity of river water reaches a maximum during this season. The post-monsoon season is hot and humid, sunny, with dewfall at night, sometimes quite heavy. There are occasional thunder storms, cyclones and strong surge. The dry winter season is characterized by cool, dry and sunny weather with low precipitation. Tide levels remain low and large areas of the Sundarbans experience a dry, exposed period with no tidal inundation.

3.3.4 Temperature

The annual mean (over a period of ten years: 2000-2009) maximum and minimum temperatures of the Sundarbans were 12.75^{o}C and 28.44^{o}C respectively. The highest and lowest monthly temperatures were recorded as 36.6^{o}C in April 2009 and 11.9^{o}C in January 2010. The annual and monthly temperatures are given in Annexure 3.2.

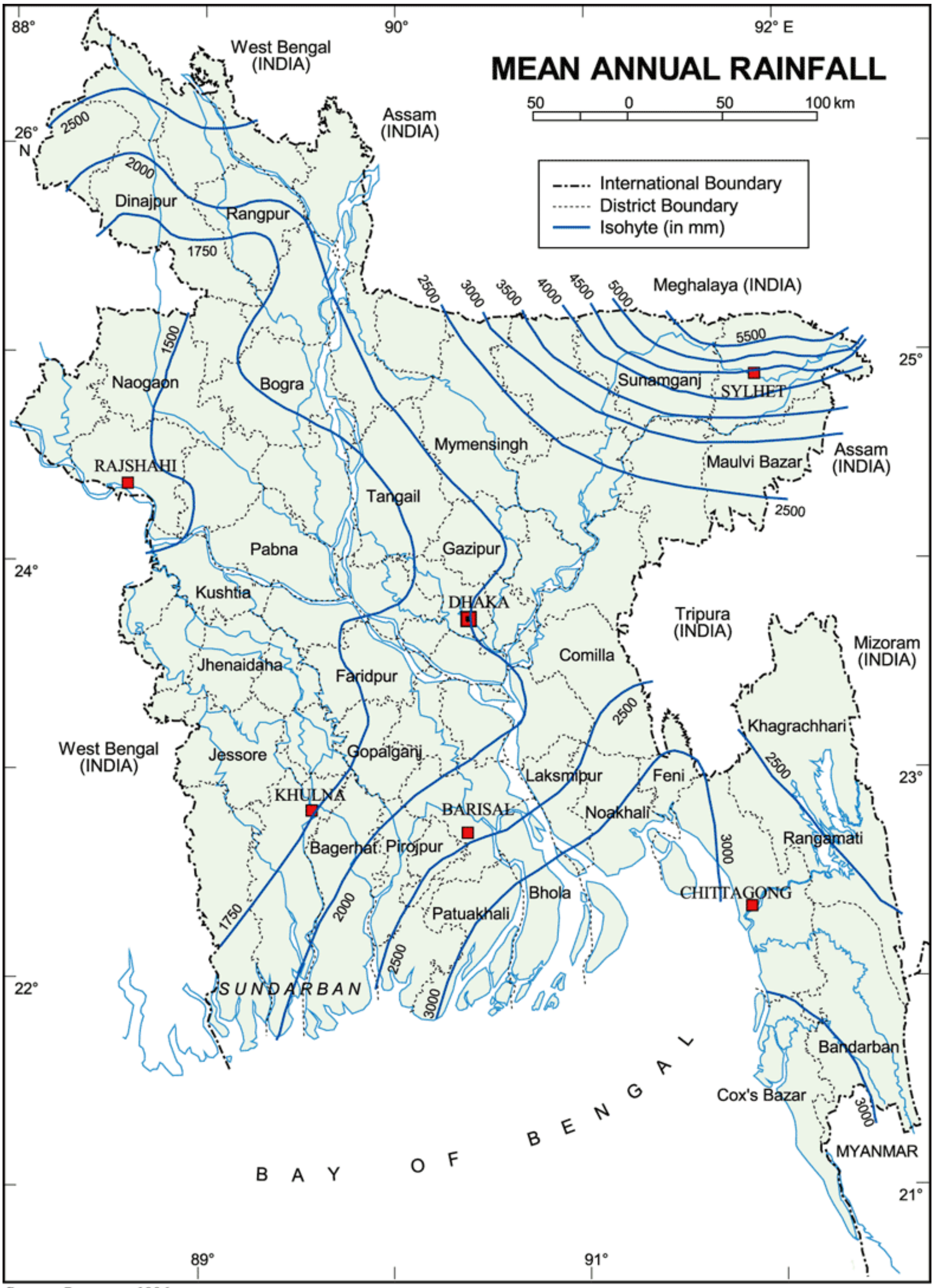
3.3.5 Rainfall

The details of rainfall at Khulna are in presented in Annexure 3.3. The annual average (over 2000-2009) rainfall at Khulna was recorded as 1614mm : maximum annual average rainfall was 2040mm in 2000, whereas the minimum was 1,080mm in 2005. Figure 3.2 presents mean rainfall variations in the SRF.

3.3.6 Humidity

The region has relatively high humidity. The 10-year (2000-2009) annual average humidity was recorded as 81%. The highest and lowest humidity were recorded as 90% in April 2000 and as 65% in January 2005 respectively (the details are in provided in Annexure 3.4).

Figure 3.2: Mean Annual Rainfall in Bangladesh with particular reference to the Sundarbans

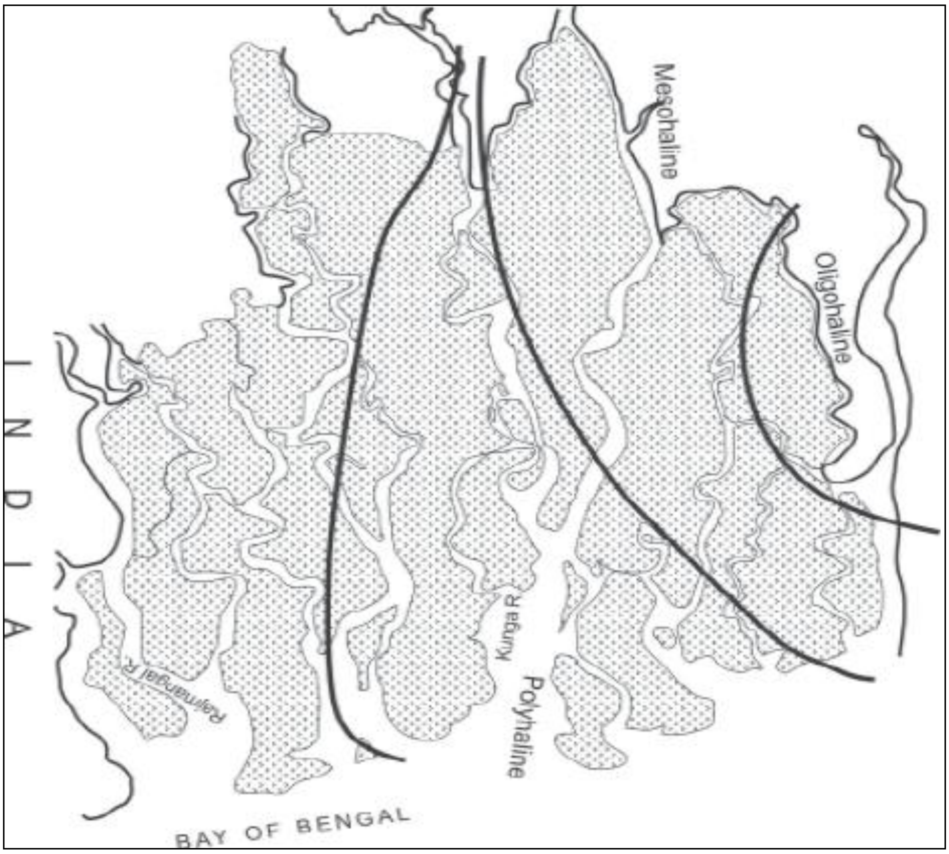


Source: *Brammer, 1996*

3.4 Hydrology and Salinity

The hydrology of the Sundarbans is quite complex and is dominated by the freshwater flows from the Ganga, Brahmaputra and Meghna rivers, which exhibit very high seasonal variation in their discharge, and the tides which range in height from 2 to 5.94 m. Tidal influence extends to more than 50 km inland from the shoreline and surges increase considerably during the cyclonic storms. The freshwater flows from the rivers and the tidal ingress result in a gradient of salinity that varies both spatially and temporally. In general, the salinity is higher nearer the coast and the water is nearly fresh on the inland side limit of the SRF. Similarly, the salinity decreases from west to east (Figure 3.3), and the eastern part of the Sundarban is oligohaline (<5% salinity). During the past few decades, however, the sources of all rivers in the western part of the Sundarban have progressively silted up, thereby disconnecting the inflow of fresh water into the mangrove delta. Freshwater flows are much larger from the Brahmaputra and Meghna rivers, particularly in the Baleshwar River on the eastern side of the Sundarbans. The reduced freshwater flows in western parts of the Sundarban have resulted in increased salinity of the river waters, and have made the rivers shallow over the years. At the same time, during ebb tides, the receding water level causes scouring of top soil and creates an innumerable number of small creeks, which normally originate from the centre of the islands. The ebb tide eroding action is stronger in some islands, and the receding water carries large volumes of silt, which is deposited along the banks of rivers and creeks during high tides, resulting in increase of the height of the banks as compared to the interiors of the islands.

Figure 3.3: Salinity zones in the Sundarbans



Source: Gopal and Chauhan, 2006

3.5 Wind and Cyclones

Wind and Storms

The winds are generally light to moderate with a slight increase in force during the summer and monsoons, but in the southern Sundarbans, particularly near the coast, winds are stronger. At Khulna, the mean annual wind speed is 4.0 knots whereas this mean at Satkhira is 5.0 knots. The mean monthly distribution at Satkhira to the west has two peaks, in April and August. Winds blow mostly from directions between the south-east and south-west during May to September but in October, winds vary in direction. During the winter, winds blow mainly from the north-west but in March and April they blow from the south and south-west. Thunderstorms are common during summer afternoons. These may be in association with severe squalls and occasional hail. These are commonly known as nor'westers (because the associated squalls usually come from the north-west) or Kalbaisakhi (the disastrous winds of Baisakh, the first month of the Bengali calendar). Storms result in heavy rain and a sharp drop in temperature. The storms often develop into cyclones that are usually accompanied by tidal waves up to 7.5 m high.

Cyclones

The SRF is located at the apex of the Bay of Bengal and its geographical position places it in the immediate path of cyclonic storms generated over the sea or down from the Himalayas. These are accompanied by heavy tropical storms, floods, and tidal bores, which after combining in this part of the continental coast result in many natural disasters that frequently strike fast and unexpectedly. Major cyclones have been reported for centuries as cause of loss to human and animal life. During the last 135 years, more than 45 cyclones have crossed the coastal belt of Bangladesh, of which 13 are trekked through the Sundarbans.

The cyclonic winds rotate anti-clock wise, producing the highest winds and surge condition on their right side. Thus most of the Sundarbans can expect moderate damage compared to more severe effects in the lower Meghna estuary. Records available at the Surface Water Modeling Centre (SWMC) show that cyclone occurrences have averaged at 1 every 5 years in the coastal area since 1882. Although there is a gap in the records from 1926 to 1941, the frequency appears to be increasing this century from 1 in 3 years in 1950 to less than 1 in 2 years at present. Studies conducted by the Cyclone Protection Project-II (Flood Action Plan, FAP-7) commented on the role of the Sundarbans in dampening tidal surges and pointed out that 100m to 200m wide strips of dense mangrove vegetation can reduce wave energies by 20-25%. In addition, FAP-7 emphasized the need for disaster preparedness, to consider cyclone resistant housing; to give careful consideration to environmental impacts; and to undertake mangrove planting on a massive scale. Apart from coastal protection, mangrove plantations create employment opportunities for the poor, generate wood for many purposes and have many benefits for the mangrove ecosystem.

In last 10 years, several cyclones have crossed through the Sundarbans; the most devastating one was the cyclone Sidr which occurred on the night of November 15, 2007. The velocity of the wind was 220 to 240 kilometers/hour. It inflicted a huge loss to the Sundarbans and the coastal districts. More than 3,000 people were dead, thousands injured. Nearly 20 lakh families and 90 lakh people were affected by the Sidr and the damage to property, houses and crop was huge. There was huge damage to the SRF in terms of biodiversity and physical infrastructure. At palces trees were uprooted and broke down and wild animals died. The freshwater ponds inside the Sundarbans were flushed with saline water, resulting in the scarcity of sweet water for the animals and local FD field staff. Table 3.1 shows physical and infrastructural damage to the Sundarban due to Sidr.

Table 3.1: Damage to the Sundarbans Reserved Forests by the Cyclone Sidr in 2007

Sl. No.	Physical Damage	Amount (lac Taka)
a.	**Damage of Forest Resources**	100,000.00
a.1	Heavily damaged forest 30,000 ha	
a.2	Partial damage of forest 80,000 ha	
	sub-total	*100,000.00*
b.	**Infrastructure (completely damaged)**	
b.1	Office and Residents - 126 nos.	900.00
b.2	Water Vessels - 50 nos.	198.84
b.3	Jetty and Poltoon - 59 nos.	146.32
b.4	Wireless tower, RT sets and Base set - 32 nos.	166.60
	sub-total	*1,411.76*
c.	**Infrastructure (partially damaged)**	
c.1	Office and Residents - 93 nos.	127.03
c.2	Water Vessels - 9 nos.	60.87
c.3	Jetty and Poltoon - 12 nos.	6.76
c.4	Others	393.58
	sub-total	*588.24*
	Grand total	**102,000.00**

Source: www.bforest.gov.bd

The other important cyclone was Aila that occurred on May 25, 2009, mainly in the western part of the Sundarbans. Nearly 200 people died, and about 10 lakh families and 40 lakh people were affected. Many embankments and dams were washed out and people were in huge distress. The saline water entered into large area, damaging crops and shrimp/fish farms.

4. Biodiversity and Habitat

Major agro-ecological zones in the Sundarbans and its interface landscape are shown in Figures 4.1 and 4.2. In line with a biogeographical zoning approach, five habitat types are identified in the SRF, namely: shore, low mangrove forests, high mangrove forests, open land/grassland, and esturine-riverine areas. The shore habitat covers the open sandy to muddy areas along the edges of the Bay of Bengal which generally serves as the main habitat of a lot of shore bird species in the SRF. Mangrove forests, based on crop height, are divided into high and low forests. Intermittent grasslands, suitable for wildlife such as deer, are found in the SRF (e.g. Jamtala). Nearly one third of the SRF is under rivers and estuaries.

4.1 Ecosystems Analyses

A system encompassing a community and the interacting environment is referred as an ecosystem. The Sundarbans and its interface landscape thus comprise both terrestrial ecosystems with mangrove forests and wildlife, and aquatic ecosystems of wetlands with important aquatic resources, on which the landscape population depends for coastal protection and also for meeting their subsistence food consumption and livelihoods needs. A variety of terrestrial and aquatic plants, animals and micro-organisms and associated ecological processes that make them function are present in the ecosystems. The influence of micro-climatic, hydrolic and edaphic factors including rainfall, freshwater flows, tidal flows, humidity, aspect, sunshine and soil is predominant on the Sunadrbans ecosystem. Conversely the Sundarbans ecosystem has created its own micro-climate that is an integrated result of meteorological processes and the conditions present within the space occupied by the forests and wetlands ecosystems.

Of the four distinct biogeographic zones in Bangladesh, Sundarbans Forest Biogeographic Zone (SFBZ) encompassing the Sundarbans ecosystem is of immense importance. It encompasses the mouths, deltas, alluvial pans and coastal tributaries of the well-known rivers such as the Baleswar river on the east, and the Sela-Gang-Bangra rivers, the Pasur-Shibsa-Kunga rivers, the Arpangasia-Manalcha rivers, and the Jamuna-Raimongal-Harinbhanga rivers on the west. As the depository pan of these rivers, which drain with immeasurable amount of silt from the vast mountainous watersheds in the Himalayas and Meghalaya, this zone keeps on expanding in land area outward onto the Bay of Bengal due to land accumulation. It is generally characterised by thick vegetation dominated by well-known mangrove tree species such as sundari, gewa and keora, mixed with other species such as goran, pasur, kankra, baen, dhundal, and palms (e.g, golpata and hantal) and patches of grassland dominated by sungrass. This zone harbors the famous Royal Bengal tiger and many other important mammal species which include the Spotted Deer, Rhesus Monkey, Jackel and Civet, Reptile species such as the Estuarine Crocodile, and Monitor Lizard, bird species such as White-breasted Water Hen and Emerald Dove, and amphibians such as Bull Frog. In this zone abound also a good number of aquatic resources like fishes and crabs, and ceteaceans such as dolphins and porpoises.

Figure 4.1: Agroecological zones in the country including the Sundarbans and its surrounding landscape.

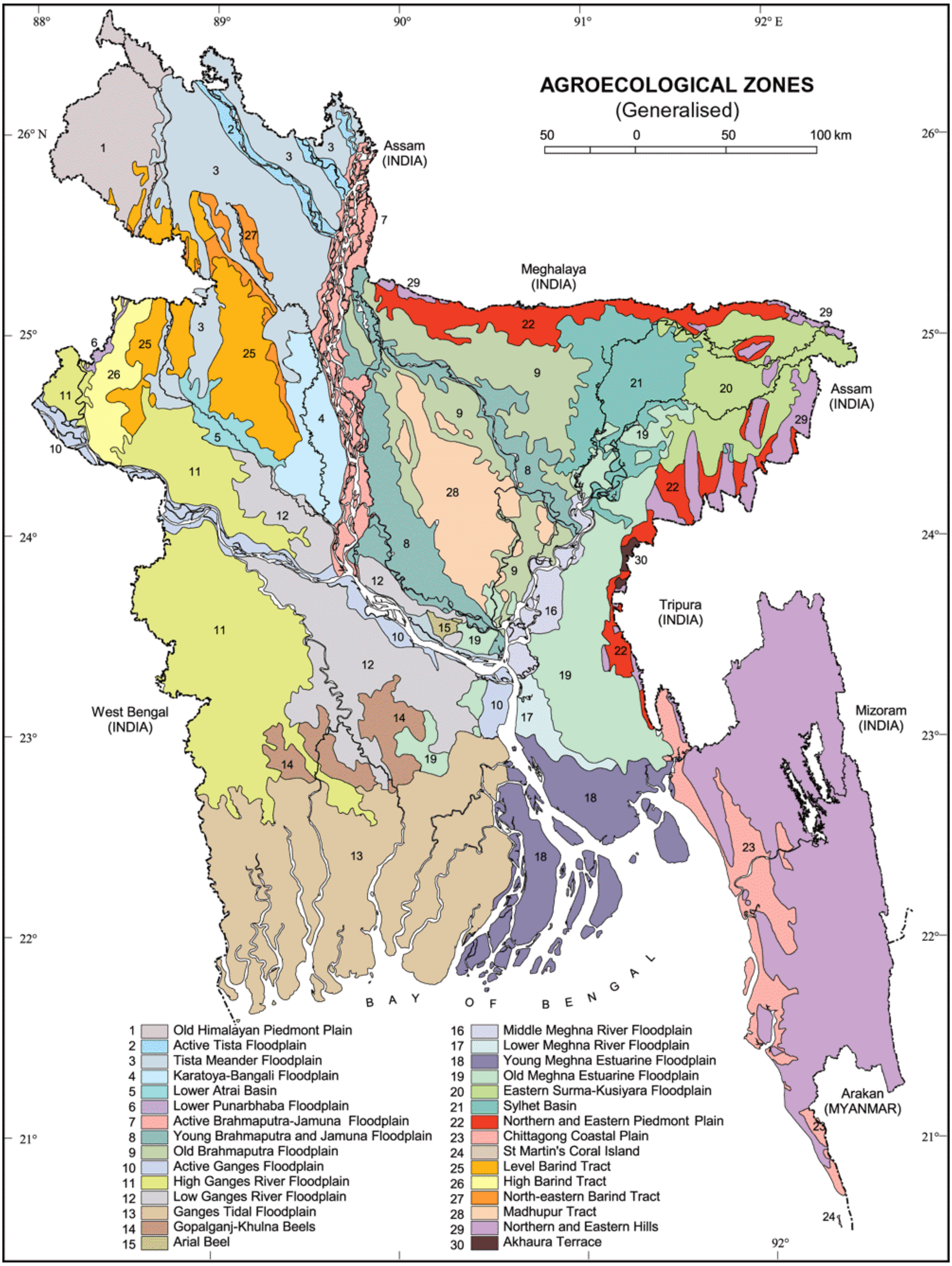
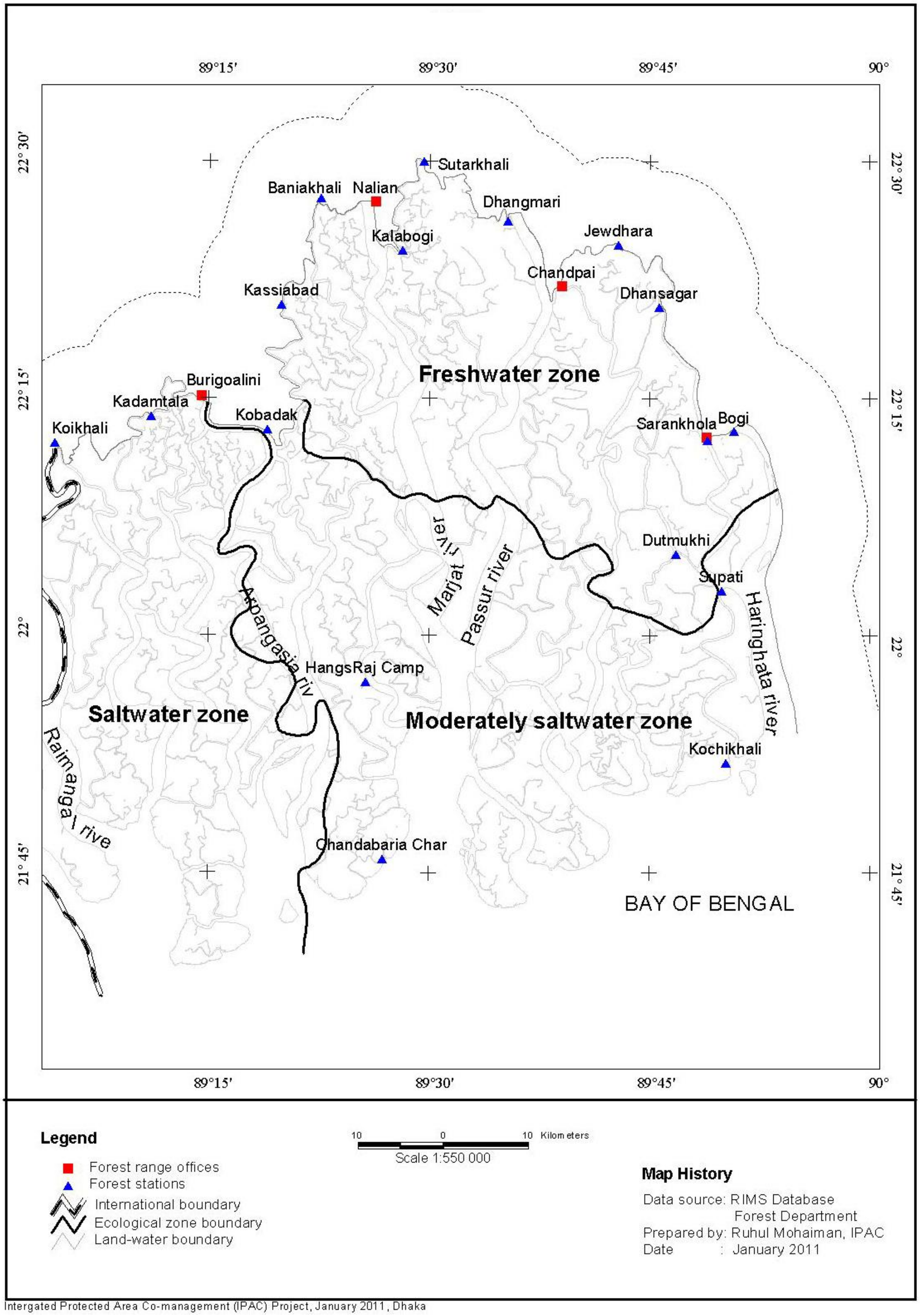


Figure 4.2: Ecological Zones in the Sundarbans Reserved Forests



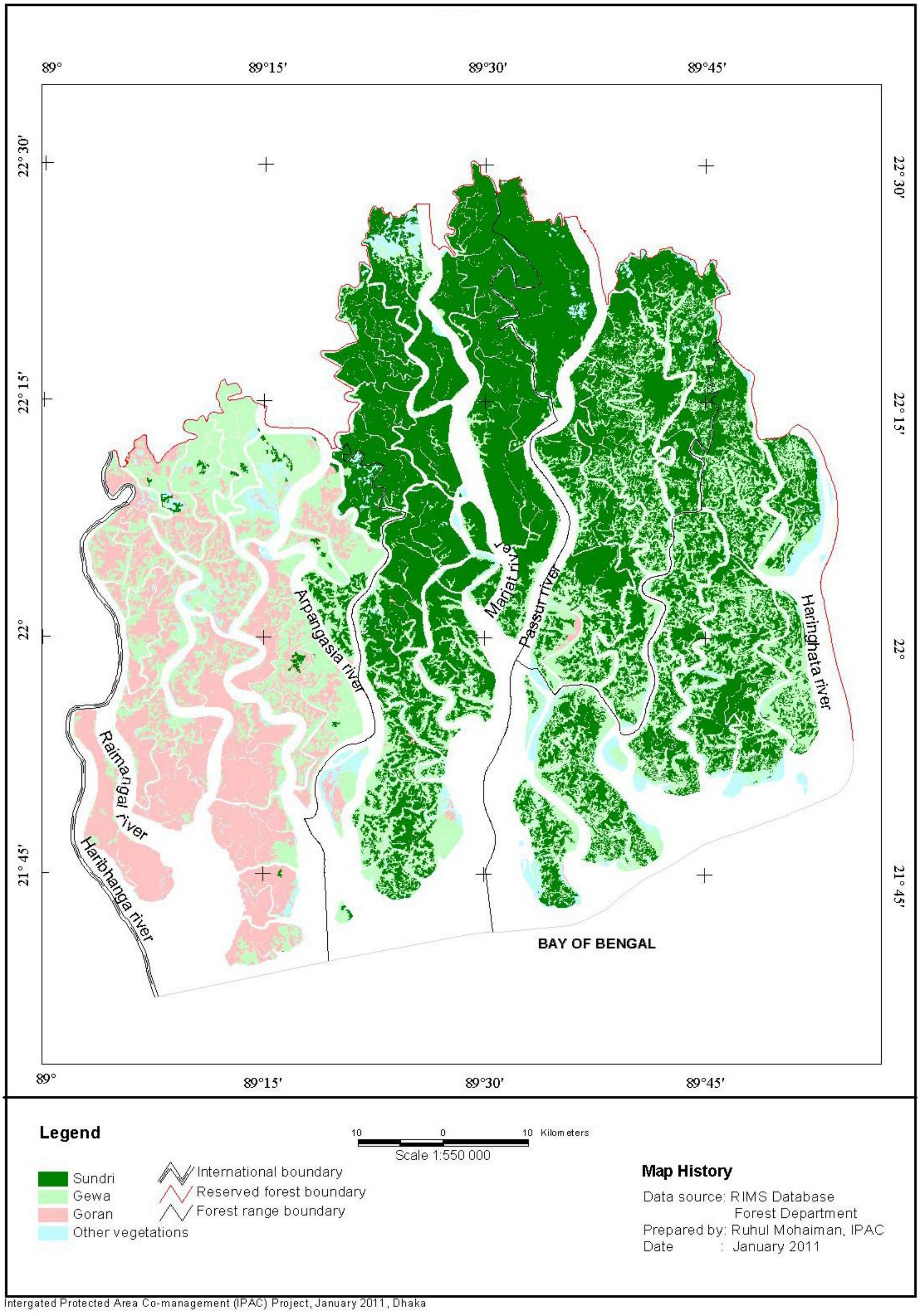
Sustainable management of both forests and wetlands of the Sundarbans for producing products and generating services while maintaining their environmental roles and functions, is feasible but ecologically complex. Success of sustainably managing both mangrove forests and wetlands would, amongst others, depend upon adequate site information, understanding of plant and animal communities, co-management with local community, nutrient availability, natural regeneration, eco-restoration and ecological succession. An important process responsible for the sustainability of the Sundarbans is the biogeochemical cycling of nutrients both in forests and wetlands. The leaves, twigs, small branches and fruits make the litter falling on the forest floor and the decomposition of humus through micro-organisms (bacteria and fungi) helps in adding nutrients to forest soils for plant growth and also in storing soil carbon through organic matter.

Appropriate forests and wetlands management should thus be part of biodiversity and land management strategy so that perennial vegetative cover can be maintained in perpetuity. Such a management system should be perceived as husbandary of renewable forest and wetland resources with attention to the protection of conservation, food and ecological security, recreational and climate change values. As in the past, the Sundarbans ecosystem is expected to tolerate some level of disturbance including climate change due mainly to its in-built resilience (the disturbance the Sundarbans can tolerate before it shifts into a different state). However, anthropogenic climate change and human interventions may result in non-renewable state that may exacerbate biodiversity (exceeding critical thresholds and triggering non-linear response) loss. Adequate cycling of nutrients through flow of freshwaters and tidal ingress of saline waters is important for the sustainability of both wetlands and forests.

4.1.1 Mangrove Forests

The mangrove vegetation of the Sundarbans differs a great deal from other non-deltaic coastal mangrove forests and upland forest associations. In the Sundarbans, mangrove plants occur in mono-dominant patches to a mix of species in various proportions. The forest patches are highly variable in size and combinations, and form a mosaic pattern of vegetation. The species that dominate the patches are not many. Unlike other mangrove areas, Rhizophoraceae species are of minor importance and dominant species are sundari, gewa, keora and goran. The forests occupy a flat deltaic swamp, extending over an area measuring more than 4,000 sq.km. Most of the area of the forest is washed by high spring tides during the rainy season. About 90% of trees are of brackish to saline tidal swamp type of littoral zone. Littoral forests, as the forests of the Sundarbans are ordinarily known, occur in the subtropical seas, especially on flat muddy shores where the water is relatively calm, as in lagoons, inlets and estuaries.

Figure 4.3 : Major Forest Types of the Sundarban Reserved Forests



The land in the Sundarbans is rarely at a height of more than five feet above the mean high tide level. A high percentage of the trees growing in the Sundarbans produce profuse pneumatophores or breathing roots which overhang from the ground like spikes. Pneumatophores help in taking oxygen from the air to the roots of trees; the breathing roots may grow up to 1.5 meters, the average being about 30cm. The natural vegetation of the Sundarbans is halophytic which can loosely be termed as mangroves. The forest canopy is seldom more than 10m above the ground level and is typically more or less open, permitting at least some direct sunlight to reach the forest floor. Much of the forest is two storey, with scattered dominant trees attaining a diameter of up to about 20cm at breast height, although one or two species attain diameters up to 1m Epiphytes are commonly found.

The Sundarbans flora is not particularly rich in species due to salinity: It is dominated by two species, sundari and gewa and there are about 25 other tree species which are common but considerably less frequent in their occurrence. A resource survey was conducted in the Sundarbans by Leech and Ali (1997) under FRMP and a comprehensive list of species of trees and other plants was prepared (see Annexure 4.1). In general, the forests in the northern and eastern parts of the Sundarbans, are better supplied with fresh water and are so floristically richer than those in the south and west. golpata palm, for example, which forms conspicuous fringes along the riversides in the north and east, becomes progressively less frequent towards the south and west. kewa kata, a prickly, succulent suffritex is similarly restricted in its distribution. Species such as jhanna, gurae and goran, which are members of the Rhizophoraceae and are frequent in the more saline areas, nonetheless occur in the north and east, though relatively less frequent. The other member of this family in the Sundrbans is kankra but the distribution of this species is widespread and does not appear to reflect salinity differences.

Apart from the family Sterculiaceae, to which belongs the dominant sundari, there are three plant families which can be regarded as key components of the mangroves, they are Avicenniaceae, Rhizophoraceae and Sonneratiaceae. The first of these is represented in the Sundarbans by baen and sadda baen, and possibly by others as yet unidentified species or varieties in the same genus. The second is represented by goran, gurae, jhanna and kankra, and the third, Sonnerratiaceae, by keora and ora. Six other families which are typically associated with dry land habitants include woody mangrove species and five of them are represented in the Sundarbans: Combretaceae, Euphobiaceae, Meliaceae, Myrsinaceae and Plumbaginaceae. Certain tree species which occur in places of lower salinity, usually on raised areas, are more commonly found as components of dry-land forest and are only marginally salt-tolerant; jir, jam and gab are examples. The trees of the Sundarbans exhibit various patterns of hydorphytic and halophytic adaptations, which facilitate survival in waterlogged and saline conditions. They have to compete not only with these factors but with their fluctuation, resulting from changes of tide and river flow.

The Sundarbans natural forests are characterised by the abundance of sundari, gewa, goran and keora. About 99% of the forest area is accounted for by 9 forest types and the areas of these are shown in Table 4.1 below:

Table 4.1: Major forest types according to the predominant species

Forest Type	Area (ha)
Sundari	74,992
Sundari-gewa	105,973
Sundari-pasur-kankra	9,556
Gewa	21,520
Gewa-sundari	75,703
Gewa-goran	34,604
Goran / Goran-gewa	64,807
Passur-kankra-baen	4,030
Keora	8,286
Total Forest	399,471

Source: IFMP, 1998

Except for two forest types, the major types listed above are all characterised by the presence of one or both of the two species of sundari and gewa.

4.1.2 Wetlands

Nearly one-third of the Sundarbans is composed of a complex network of tidal and fluvial waterways ranging from a few meters to a few kilometers wide and carries substantial sediment load with a large amount of nutrients. Salinity levels in the Sundarbans are determined by physical forcing from freshwater flows and to a lesser degree by diurnal tides. Freshwater discharge from the Ganges-Brahmaputra-Meghna rivers, which are fed by snowmelts in the Himalayas and monsoon rains, is maximum during monsoon season (June-September) which coincides with the formation of a counter-clockwise gyre in the Bay of Bengal. This gyre though responsible for the wide distribution of nutrients, their availability remains limited because coastal upwelling is suppressed by freshwater inputs along the coast, especially at the system mouth. The northeast monsoon during December-February drives a clockwise gyre which persists until May and reduced freshwater discharge during this time allows for upwelling of nutrients that were transported to the delta by counter-clockwise gyre formed during the previous months of the southwest monsoon (Babu et al, 2003). The high amount of nutrients, along with light winds, results in intensive coastal fisheries, which supply much needed protein to local community and beyond.

The process of accretion and erosion within the Sundarbans is highly complex due to the large number of interconnecting waterways. The sediments to both tidal and river water are distributed on the forest floors. The entire Sundarbans is in a dynamic state of erosion and accretion, constantly creating new environmental conditions. Tides affecting the Sundarbans originate from the Indian Ocean and travel past the deep Bay of Bengal reaching nearly 10 fathoms at Hiron Point. River flow and tidal currents play a major role in creating the environmental conditions of the estuaries around the Sundarbans (Hossain and Archarya, 1994).

4.1.3 Protected Areas

Within the SRF lie (see Figures 4.4 & 4.5) three wildlife sanctuaries (the Sundarbans, East, West and South, totaling 139,698 ha and gazette in 1996), the descriptions of which are provided in Table 4.2:

Table 4.2: Wildlife Sanctuaries in the SRF

Protected Areas	Water type	Description of the floral species
Sundarbans East H.Q. Katka Range: Sarankhola	Fresh or slightly saline	Predominant species Sundari is mixed with varying quantities of Gewa. The next important species is Passur frequently associated with kankra, beneath the Sundari stands. Singra is found on comparatively dry soils and Amur on moist soil. Goran is rare but Golpata is common.
Sundarbans West H.Q. Notabaki Range: Satkhira	Salt	Sparsely spaced, short-boled gewa is the main species over dense goran, interspersed with dense patch of Hental palm on the drier soils. Dhundal, Passur and Kankra occur sporadically throughout the area. Sundari does not thrive well and Golpata is very scarce.
Sundarbans South H.Q. Nilkamal Range: Khulna	Moderately salt	Gewa predonimates. It is also mixxed with Sundari in varying proportion, growing over a very dense jungle of Goran. Passur is associated with Kankra and baen. Golpata is abundant.

The unique array of natural mangrove forests, creeks, meandering streams, mighty rivers, estuaries and spectacular wildlife including royal Bengal tigers and dolphins make it a feast for all eyes.

Figure 4.4: Wildlife Sanctuaries and Forest Ranges in the Sundarbans Reserved Forests

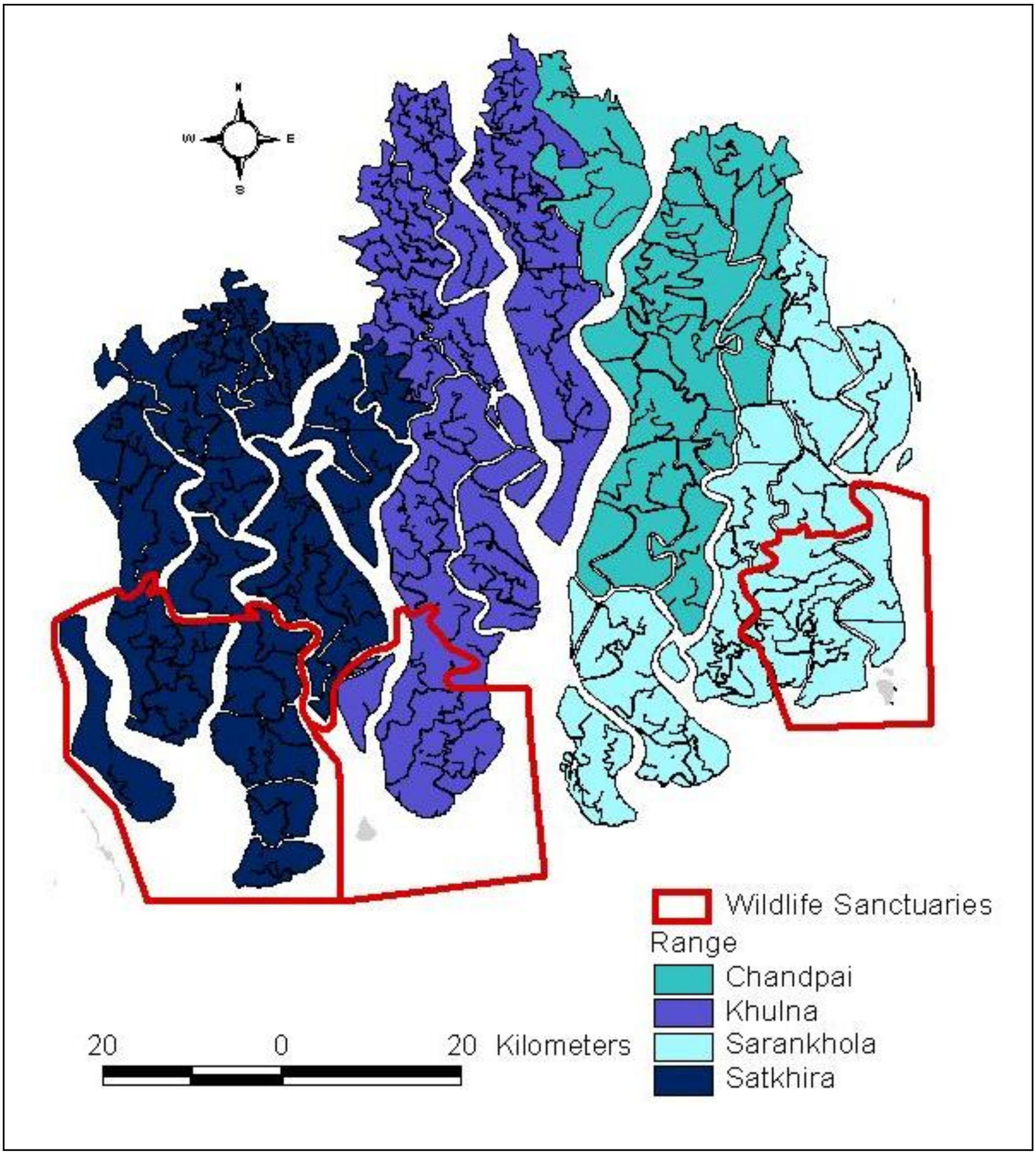
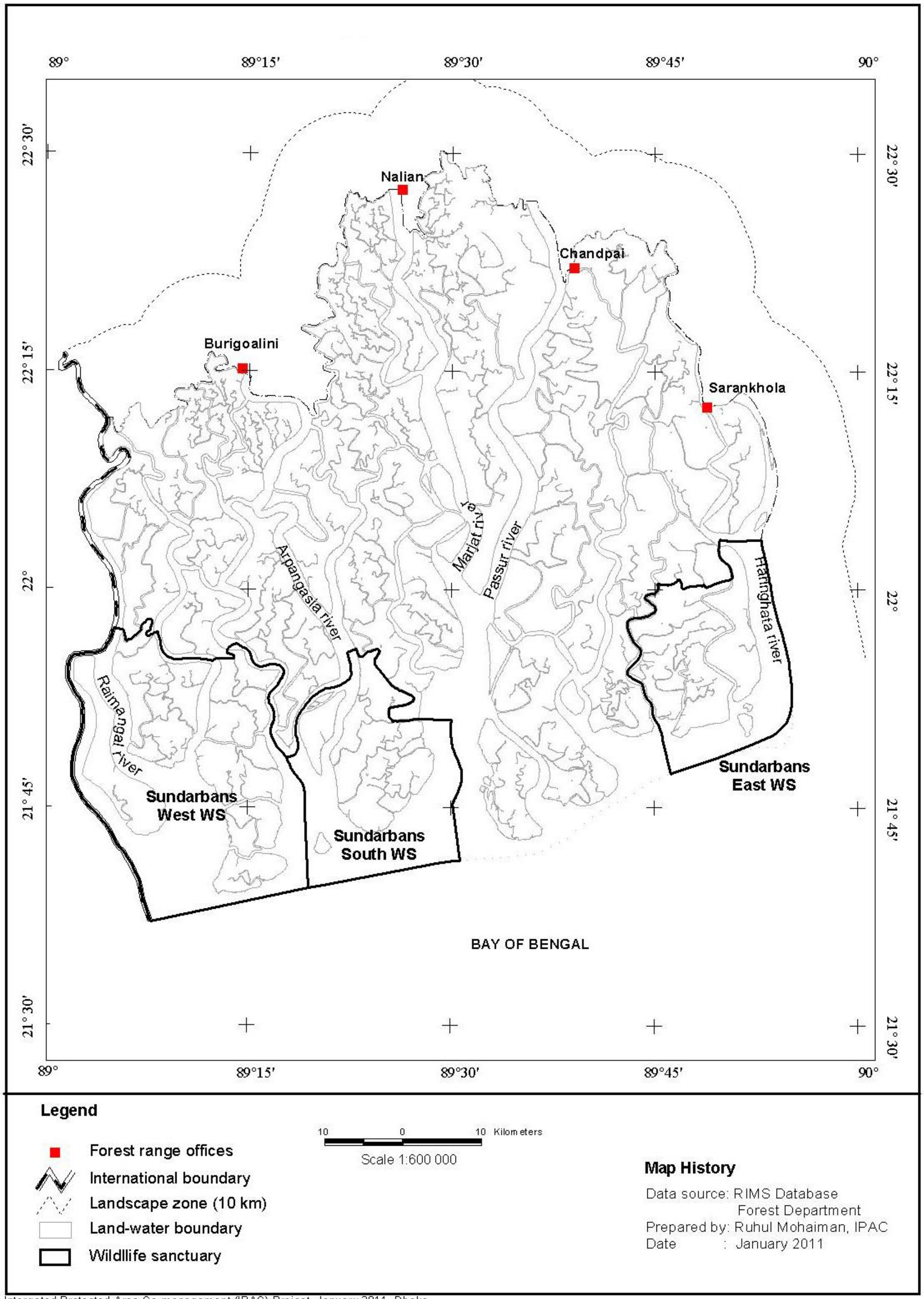


Figure 4.5 : Wildlife Sanctuaries in the Sundarbans Reserved Forests



Intergated Protected Area Co-management (IPAC) Project, January 2011, Dhaka

4.2 Biodiveristy Analyses

Biodiversity analyses for major components of the Sundarbans are presented in this section by reviewing relevant literature.

4.2.1 Floral Biodiversity

The Sundarbans contains moderate floral diversity: A total of 245 genera and 334 plant species are recorded (IFMP, 1998). The more prominent and important tree species found include sundari, gewa, keora, goran, singra, dhundal, amur, passur and kankra. Golpata palm, commonly found in the Sundarbans, is widely gathered for thatching material. Hental is another palm species which is used extensively in the construction of small huts as roof rafter and frame of walls. Sungrass or ullu is widely gathered for thatching, in addition to being the main fodder species for deer. Hogla, a bulrush is gathered and split for cheap fencing, and Nal is used expensively for making mats. Hargoza, a shrub, Hudo, another shrub, together with Ora are stream bank protection species that predominantly grow along riverbanks (see Annexure 4.1 for a detailed list of the species).

4.2.2 Faunal Biodiversity

About 289 terrestrial species of 185 and 219 aquatic faunal species of 146 genera (IFMP, 1998) have been reported as found living in the Sundarbans. Predominant and important mammal species include the Royal Bengal tiger (Dora Bagh), spotted deer (Chital Harin), macaque monkey, wild Boar, jackel, jungle and Indian fishing cats, small and large civets, small mongoose, common ottter, smooth coated otter, bats, Irrawady squirrel, crestless Malay porcupine, large bandicot rat and others. The principal reptiles species include the estuarine crocodile, python, common cobra, gecko, sea snakes, monitor lizard, turtles and others. Of the bird species, the aquatic ones include the adjutants, storks, herons, egrets, little cormorant and others. The semi aquatic ones include the Plovers, red-wattled lapwing, avocet, stint, curlew, sandpiper, common greenshank, gulls, terns and others. A number of raptorial birds are also found which include the falcons, eagles, vultures, kites, harriers and others. The other terrestrial birds include the kingfishers, doves, pigeons, flycatchers, oriental magpie robin, red jungle fouls, woodpeckers, owls, rose-winged parakeet and others. The SRF and the surrounding landscape have a rich avifauna and the most recent list of species indicates that at least 315 species representing 48% of the birds known to occur in Bangladesh, have been recorded here (IFMP, 1998). Of these, 84 species are migratory, making the SRF a valuable location of passage of migrant and seasonal birds.

The inshore island of Tinkonia and offshore island of Putney, Nilbaria, Kachikhali and Dubla are valuable habitats for waders and resting points for migrating flocks. Some of the amphibians include the rana and mycroplyla species of frogs. Commercially important species of fin fish, shrimp and crabs in a provincial species list for the Sundarbans tallied a fisheries fauna of 8 species. Chondrichthyan fish, 168 species of Osteichthyan fish and 31 species of crustacean are identified from the SRF (IFMP, 1998). There are over 120 species of fish that are commonly caught in the SRF. Shellfish and mollusks such as univalves (gastropods) and bivalves (polycypods) are generally collected for lime production. There are at least seven species of bivalves in estuarine areas and the mangrove floor of the SRF. Leech and Ali (1997) provided a list of animal species in the Sundarbans, which is shown in Annexure 4.2.

4.2.3 Cetaceans Biodiversity

Cetaceans is a scientific grouping of dolphins, whales and porpoises. The wetlands in the SRF and coastal waters are suitable habitats for a large number of Ganges River dolphins (or Shushuks), Irrawady dolphins and finless porpoises. This section is written by taking inputs from the Bangladesh Cetacean Diversity Project (BCDP, 2008) proposal for a PA Network for Cetaceans. It describes cetaceans abundance in the SRF and coastal waters. As in case of vegetation, the salinity gradient partitions Cetaceans' abundance in the SRF and the interface landscape: i) Shushuks found in mangrove channels with high freshwater inputs, ii) Irrwady dolphins in more saline mangrove and in open estuarine waters where freshwater inputs are reduced but still fairly high, and iii) Indo-Pacific humpback dolphins and finless porpoises in moderately saline, nearshore waters affected by freshwater inputs.

Shushuk (*Platanista gangetica*) has a long snout with supple and robust body that attenuates behind the dorsal fin to a narrow tailstock. The dolphins have gray color or light brown and the bellies of young animals are lighter and often have a pinkish hue, whereas the mature females have a longer rostrum. Their eyes are very small and visible as pin-hole openings, slightly above the upturned mouth. A distinct median ridge begins anterior of the blowhole and bisects a convex melon, which becomes less rounded as the dolphin approaches adulthood.

Irrawady dolphin (*Orcaella brevirostris*) has a rounded head, overlapping the mouth, which is oriented at a posterior-dorsal angle towards the eye, and a crescent-shaped blowhole, positioned to the left of midline. A shallow dorsal groove runs posterior of the neck crease to the dorsal fin that is small, triangular, slightly falcate with a blunt tip. The dolphin is uniformly dark gray on the dorsal and lateral fields with variable shading among individuals. They are adopted to relatively rare and patchily distributed ecological conditions – deep pools of large rivers and nearshore marine environments with freshwater inputs. Finless porpoises (*Neophocaena phocaenoides*) are smaller than Irrawady dolphins but have no dorsal fin. They have dark grey body that is slender and torpedo shaped with a rounded head and no beak. Their tail stocks are narrow with concave flukes, and pectoral fins are relatively large with rounded tips. They prefer deeper and more saline waters compared to Irrwady dolphins.

Indo-Pacific humpback dolphin (*Sousa chinensis*) has a robust body with well defined beak, and the dorsal fin sits on a hump in the middle of the animal's back. They are generally grey to light cream-colored but the coloration varies with age and region. Although they can be confused with bottlenose dolphins, differences in color and in the dorsal fin and head shape can be distinguishing features. A large group size with 30-40 individuals has been sighted in the Sundarbans. Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) have botlle-like snout and their maximum size can reach about 2.5 metres. They have large flippers, dorsal fin and flukes, and are robust. They are grey with a slightly darker cape that extends below the dorsal fin. Pantropical spotted dophins (*Stenella attenuate*) are slender and streamlined, and have a long narrow beak demarcated from the melon by a distinct crease. The dorsal fin is narrow, falcate and pointed at the tip, and the cap runs narrow on the head and dips down towards the dorsal fin. Spinner dolphins (*Stenella longirostris*), named due to their habit of leaping and spinning, are slender with an extremely long beak and their dorsal fins range from triangular to slightly falcate. They have a three part color pattern that includes a dark dorsal cape, light grey sides, and white belly.

Bryde's whales (*Balaenoptera edeni/brydei*) are slim and streamlined, and have three prominent body ridges running from the tip of their snout to the blowholes. They have dark grey or almost white scars caused by bites of lampreys. They have 40-50 throat grooves and their pectoral fins are relatively short and pointed at the tips. The cetaceans are threatened in the country from the adverse effects of dams, embankments, dredging, fisheries, hunting, vessel strikes and water pollution.

4.2.4 Ecosystems Biodiversity

A broad understanding of the importance of the inter-relationship of the flora, fauna, aquatic and water resources and the edaphic condition on which they occur, and that make up the mangrove ecosystem, has emerged in Bangladesh. These combinations of resources and conditions, occupying the special ecological niche where sea water meets freshwater, fertilized periodically by sediments from the land and the sea, are the foundation of its high biological productivity, uniqueness and diversity. These circumstances also provide the basis for the broad range of productive assets it contains and protective services it offers. The hydrological regimes and their characteristics are the primary determinants of the Sundarbans ecology. Nutrient rich tidal waters and sediment laden stream flow from upstream watersheds maintain the inherent productivity and build the land base. Three broadly defined ecological zones have been recognized based on the very complex correlation of varying degree of residual salinity, fresh water flushing physiography and their influence on the composition and character of species which inhibit the ecosystem. They are slightly saline zone, the moderately saline zone and the strongly saline zone, occurring in the rough bands running from the north-west to south-east (refer to Figure 3.3). The boundaries of these zones are far from static and affected by the natural temporal changes of a daily (tidal and run-off) and seasonal (rainy season versus dry season) nature and the long-term (alterations in the upstream watersheds) impacts of human interventions.

Mangroves over the world are not particularly diverse in terms of their floristic composition, specially compared with rainforest ecosystems. Only 50 to 75 species are recognised as genuine mangrove plants. The SRF is no exception and its floristic composition is made up of nearly 60 species. What makes the flora of the SRF special, however, is the predominance of nearly the families of the Sterculiaceae and Euphorbiaceae in contrast to other mangrove associations which more typically are made up of Rhizophoraceae, Avicenniaceae and Laganculariaceae families. Similarly, the SRF is also floristically unique because of the dominance of sundari (*Heritiera fomes*), a high prized timber species. In addition to sundari, two other prominent species are gewa (*Excoecaria agallocha*) and goran (*Geriops decandra*).

4.3 Threatened and Endangered Species

All the plant species found in the SRF are indigenous and there is neither endemic nor exotic species and so far none is considered as rare. But sundari is considered threatened due to its top dying and selective removals due to commercial value. The SRF is the only remaining habitat within the lower Bengal basin where wildlife still finds refuge; at present, there are 42 species of mammals within the SRF and the adjacent areas, constituting 35% of the total fauna of Bangladesh (IFMP, 1998). Historical records suggest the loss of at least six spectacular mammal species in recent times: Javanese rhinoceros (*Rhinoceros sondaicus*), one horned rhinoceros *(Rhinoceros unicornis*), wild buffalo (*Bulbulus bulbulus*), gaur (*Bos gaurus*), swamp deer (*Cervus duvaucali*) and the hog deer (*Axis porcinus*). Although the SRF in many respects has a high degree of uniformity, it has an interesting spectrum of faunal species, albeit reduced in numbers in recent times and difficult to observe in many instances. Of particular importance are the Royal Bengal tiger (*Panthera tigirs*), spotted deer (*Axix axis*), wild boar (*Sus scrofa*), monkey (*Macaca mullata*), monitor lizard (*Varanus spp.),* turtles (both fresh and marine water), snakes, dolphins especially the gangetic dolphin (*Platanista gangetica*), otter (*Lutra perspicillata*), and the saltwater crocodile (*Crocodylus porosus*), which are diverse examples of rich wildlife spectrum requiring urgent management attention and intensive conservation action. The tiger is an inseparable legend attached to the Sundarbans and the species occurs throughout the SRF. Tidal mangrove forest is a rare habitat for the species where it has been pushed due to habitat shrinkage. In many ways, mangrove has proved to be an unusually secure abode for the tiger, in spite of the fact that the species is listed in CITES as endangered species as per the IUCN red data book.

Like the tiger, the other most visible mammal species, the spotted deer (*Axis axis*) lives on the edge of its natural range in the SRF. They are found throughout the SRF but are most abundant in the south where extensive grassland and scattered forests of keora occur; this type of habitat occurs in the three existing wildlife sanctuaries. The occurrence of barking deer (*Muntiacus muntjak*) appears to be limited to the north and the north-east in the SRF. wild boar (*Sus scrofa*) occurs throughout the SRF including the off-shore islands. Monkey occurs throughout the SRF and is a common sight with greater incidence in the south. Some 35 species of reptiles have been recorded in the SRF. The marsh crocodiles (*Crocodylus porosus*), once abundant, is now quite rare. At least 30 species of snakes are reported to have found in the SRF but there has been a general decline in densities, especially over the last 15 years (IFMP, 1998). The rock python (*Python morulus*) is listed as a vulnerable by IUCN and is another valuable species which is said to have declined over recent years and is rarely encountered. A detailed list of threatened species is preseneted in Annexure 4.3.

4.4 Ecologically Critical Area

The 10-km wide area surrounding the northern and eastern boundaries of the SRF, with an approximate area of 175,000 hectares, was declared (by the Ministry of Environment and Forest, ref no. pa ba ma/ 4/7/87/99/263) as Ecologically Critical Area (ECA) on 30 August 1999, with the main objective of providing protection to the SRF and conservation of its biodiversity. The ECA has some wetland resources which have over the period become degraded thereby limiting the access of the poor people. There has been a great deal of change in the land use pattern and agricultural lands have been converted to *gher* for fish and shrimp culture. The fisheries production is going down in the ECA water bodies due to reduction of grazing ground and movement of spawn and hatchling. The area and the local people are characterized by poverty, natural calamities, poor education and health services, drinking water scarcity, and little income opportunities, all of which contribute to high biotic pressure on the natural resources of the SRF and the ECA. As the ECA area coincides with the identified interface landscape, a detailed analysis is presented in this section. A total of 5 districts, and 10 upazilas are within the ECA. Of the 47 Unions, only 27 unions are fully and the remainder are partially covered. Table 4.3 gives the list of district, upazila and unions with the coverage ratio and names. A list of ECA villages is given in Annexure 4.4.

Table 4.3: Districts, upazilas and unions in the Ecologically Critical Area

Sl	District	Sl	Upazila Name	% coverage	Sl	Union Name	% coverage
1	Borguna	1	Patharghata	40%	1	Char Laldi	100%
					2	Hatempur	100%
					3	Char Duani	100%
2	Pirojpur	2	Mothbaria	30%	4	Sapleza	40%
					5	Gulishakhali	100%
					6	Amragachia	40%
					7	Baromachua	20%
3	Bagerhat	3	Sharankhola	95%	8	Dakhin Khali	100%
					9	Rayenda	100%
					10	Rajapur	100%
					11	Dhansagar	100%
					12	Khonkata	80%
		4	Morrelgonj	30%	13	Jeodhara	100%
					14	Nishanbaria	80%
					15	Khaolia	50%
					16	Baraikhali	50%
					17	Hoglabunia	20%
					18	Baharbunia	20%
		5 6	Mongla Sadar	80%	19	Chila	100%
					20	Sundarban	80%
					21	Chandpai	100%
					22	Mithakhali	80%
					23	Pourasava	100%
					24	Burirdanga	20%
4	Khulna	7	Dacope	60%	25	Laudobi	100%
					26	Banishanta	100%
					27	Bajua	100%
					28	Kailasgonj	100%
					29	Sutarkhali	100%
					30	Kamarkhola	50%
		8	Koyra	80%	31	Dakhin bedkashi	100%
					32	Uttar Bedkashi	100%
					33	Moharajpur	100%
					34	Baghali	80%
					35	Maheshwaripur	100%
					36	Amadi	90%
5	Satkhira	9	Paikgacha	5%	37	Goruikhali	50%
					38	Soldana	20%
		10	Shamnagar	70%	39	Kaikhali	100%
					40	Ramjan Nagar	100%
					41	Munshigonj	100%
					42	Burigoalini	100%
					43	Gabura	100%
					44	Nurnagar	20%
					45	Ishwaripur	10%
					46	Atulia	80%
					47	Padma Pukur	20%

Main wetlands in the ECA, distributed all over the area, cover canals and rivers which are connected with the rivers of the Sundarbans. Out of 16 unions, 4 unions have information on the wetland natural resources and it shows that are 29 water bodies of which 25 are canals and 4 are rivers. The length of 8 water bodies located in the eastern part is 52 km with perennial water retention and they are owned by the Government and so have open access as no fee is required for resource collection. On the other hand, in the west the canals (13 canals of this type under Shyamnagar Upazila) are closed as they are either leased out or illigeally occupied for fish culture, with no access to general people. Due to embankments, many of the canals have been closed and it has affected the fisheries, reducing the income of the poor.

Many canals are dead with no/little connection with the rivers. The canals are also getting silted up, making them seasonal with low water retention. The salinity is increasing in the area due to the reduction of sweet water flow as the rivers and canals in the upstream have become dead, silted up and blocked. The wetland resources list is given in Annexure 4.5. The unemployment rate is high (20% to 90%) due to lack of income opportunities. As a result, a large number of local people depend on the SRF for livelihoods. The PRA/RRA information from 13 unions shows that the households' dependency for livelihoods on the SRF is minimum 10% and maximum 80%, whereas the forest resource dependency ranges between 2% and 60%, and the dependency on wetland (fisheries) resources is 5% and 70%. But as the ECA is endowed with low natural resources, the stakeholders' livelihood dependency on it is comparatively low as evident from the Table 4.4:

Table 4.4: Stakeholders of the Sundarbans ECA

SL #	Stakeholder Name	Description of Stakeholders	Type of Stake	Level of Stake
A. Primary Stakeholders				
01	Occasional Fisher	Poor people: Mainly male; sometimes female and child	Fish and fisheries item	Moderate
02	PL collector	Poor people: Male, female, children	PL of Golda and Bagda	Major
03	Subsistence fisher	Poor people: Male & female	Fishes	Major
04	Fish culturist	Rich and influential people	Fish culture in closed canals	Moderate
B. Secondary Stakeholders				
05	Small Mohajons (money lenders)	Local people, influential persons	Small funding, purchase product	Moderate
06	Gher Owners	Influential and powerful persons	Purchase shrimp PL, small investment to from PL collectors	Moderate
C. Other /Institutional				
07	Department of Environment	Govt. body	In charge of resource management	Major
08	Department of Fisheries	Govt. body	In charge of fisheries management	Moderate
09	Upazila Administration	Govt. body	Management of Khas jalmohal and leasing	Moderate
10	Union Parishad	Local Govt.	Management of Khas jalmohal (small size) and leasing	Moderate
11	Forest Department	GOB Project	Biodiversity conservation, livelihood	Major

In the 14 unions there are 83,314 households (HH) with a population of 425,685, of which male population is 221,436 and female as 204,249. This information, if extrapolated, results in the information for 40 unions as; Households 238,040, total population 1216,242 with male 632,675, female 583,568. Average HH size is 5.12 and male female ratio is 1.08: 1.0. It should be mentioned that all the 40 Unions are not within the ECA. Thus the actual number of households and population of ECA would be somewhat less than the calculated figure. Available data from 14 unions showed that the minimum and maximum literacy rates are 30% and 80% respectively; the percentage of educated people (SSC and above) is 5% as minimum and 60% as maximum. Most of the villages are in poor category and so the entire ECA area is poverty-prone with limited income opportunities, disaster prone, and conversion of agricultural land into ghers results in the benefits flowing to handful people who are already rich. The vulnerability to climate change is high in the entire ECA area.

There are huge number of landless people and average rate is 29%. There are about 898 widows per union and 565 separated/divorced women per union. The disable and beggar number per union are 335 and 217 per union respectively. The higher rate of widow is due to the death of males during SRF resource collection by the attack of tiger, pirates and cyclones. The Muslim community is dominated all over the ECA with particular domination in Sarankhola, Morelgonj and Munshigonj Upazilas. The Hindu community prominent areas are Dacope, Koyra and Mongla Upazila, whereas the Christian community is mainly in Mongla Upazila.

Natural disasters such as cyclones, storms, water surge are very common and affect most the resource poor people who are most vulnerable. Main disaster coping mechanisms available to local people include the embankment/dyke along the riverside, good houses, cyclone centers, etc. There are embankments around the periphery of the ECA in most of the areas except Mongla Upazila. However, the embankments in south and west regions are fragile and have been damaged due to cyclones such as Aila and Sidr. The present status of many cyclone centers is not very encouraging; the information collected from 14 unions shows that there is minimum 1 cyclone center in one Union Parishad (UP) with a maximum of 18, and with an average of 5 per UP. As most of the houses are non-bricked and unable to bear a cyclone, the whole area of ECA is under the threat of disasters and so subject to high level of vulnerability.

Although there are some health care service facilities in each union (in the form of “Family Health Care Center” and “Community Clinic”), there is no hospital in any of the unions. As a result, the local people rely on quacks and doctors with traditional practices. Drinking water is one of the major problems in the whole ECA due to salinity. Most of the ECA is with poor road and transport communication. Many outsiders have settled in the area permanently due mainly to easy access to natural resources of the SRF. They are competing with the local community over resources, thereby hastening resources depletion in some cases. In 11 unions there is 131,000 hectares of total land, of which only 48% is arable. Some land is used for fish and shrimp culture in ghers and ponds; in 10 union there are about 12,300 ghers, covering about 9,000 hectares area, and there are 30,663 fish ponds in 7 unions. The gher farming is done by the rich people, limiting the scope of income for the poor. It increases the salinity in the area, making land less fertile. The gher farming is believed to change the soil and water quality, causing degradation of the environment. The agriculture that produce many by-products such as fodder and cow-dung help in fire wood and livestock rearing. The gher farming has created several social problems as it is capital intensive and requires less labour.

4.5 Environmental Pollution

Within the south-west region, industrial activities are concentrated along the roads between Kushtia-Jessore-Khulna and along the rivers. In recent past there were about 165 industries in Khulna, located in Rupsha, Khalispur and Shiromony industrial zones. Some of them have closed in recent years, but approximately 150 exist presently. These industries discharge untreated waste into the Bhairab-Rupsha river system. In addition, several match factories, fish processing units in the Rupsha industrial area discharge effluent into the Rupsha river. Goalpara power station, some jute mills, match factories in the Khalispur industrial belt also discharge their untreated waste into Bhairab river. The pollutants find their way to the SRF wetlands through the Pasur-Sibsa river system to well below Mongla port which is the center of the country's maritime activities and also a significant source of water pollution. Presently in Bangladesh, the use of chemicals has an increasing trend and about 20 insecticides, 18 fungicides and 2 rodenticides are being used in the country. These chemicals eventually drains into the adjacent water bodies and are carried downstream in the SRF through the river waters. Their subsequent incorporation into the food chain, with biological magnifications at higher tropic level, risks the stability of the biota itself and result in the disruption of the biochemical cycles of the ecosystem.

Oil pollution is also affecting the environment of the SRF. Bilgewater and crude oil slicks derived from mechanized boats, fishing trawlers, goods carrying vessels and passenger launches travel along the Pasur river at a distance of about 100 km via the SRF to Mongla port. The number of sea going vessels handled by the Mongla port is less in recent years as the port activities have reduced substantially. However, there is potential of activating the port and the ship number will increase, if this happens. The number of other vessels (mechanized, passenger, fishing, etc.) has been reported to be on the increase in last 10 years. Oil from the fuel tanks spreads about 15 km downstream from the ship and affects a considerable part of the Sundarbans. There are reports about mortality of seedling, fishes, shrimp and other aquatic animals from the oil spill. At present, the oil pollution is not a big threat for the SRF but there are increased potential risks in future.

Monitoring and surveillance facilities are not available to quantify the extent of the pollution. However, it is known that the fine grained anaerobic sediments, characteristic of mangrove forests, severely reduce the rate of microbial breakdown of oil. Burrowing activities of crustaceans, a characteristic of mangrove forest, can lead to persistence, high levels of oil contamination, not only on the soil surface but also deep in the sediments in the mangrove root zone. The light fraction of the oil, considered to be the most toxic, generally evaporates or degrades rapidly. Hence, the heavier fraction is the cause of most of the chronic impacts. Chronic exposure to oil residues results in damage to aerial roots, reduction in litter fall, and reduced survival and deformation of seeding. Coastal and marine fisheries are affected quantitatively and qualitatively with a reduction in the nutritional value of fish. The thin layer of oil on the water affects the multiplication of planktonic organisms and interferes with the growth and reproduction. Fish can also absorb oil directly with their feeding, resulting in the tainting of fish tissue. Also, the aromatic hydrocarbons present in the crude oil are persistent and carcinogenic. Since they have tendency to be biologically accumulated in fish tissue, they can pass it on into organisms of higher tropic levels in the food chain.

4.6 Polders

More than 125 polders have been constructed in the south-west region along the upper catchment area of the Sundarbans rivers. These polders were constructed mainly to control the saline intrusion into the agricultural fields. The impact of polderization has also been felt in the rivers of the Sundarbans. A large number of rivers have been silted up. It is feared that the Bhadra river, which passes through the Sundarbans to meet the Pasur, is undergoing rapid siltation and may cease to connect this part of the SRF with upstream catchment area of the river in near future. Another boundary river, the Kharma Khal, which used to connect eastern fresh water carrying rivers with Pasur system, no longer connects these rivers and has silted up completely. Major interventions including excavation are needed to re-connect some of these streams and rivers. Some of these embankments can be brought under co-management through benefit sharing by involving local community in raising embankments plantations that will stabilize the polders and also provide benefits to local community.

5. Assessment of Biodiversity Management Practices

A detailed review of various management systems and practices employed for scientifically managing the Sundarbans is necessary for drawing relevant lessons that can be taken on board while designing and implementing future management plans.

5.1 Early Forests Management and Mapping

The management of the Sundarbans is several hundreds year old. For example, during the Mughal period (1203-1538), the local kings leased out the forests of the Sundarbans (Rahman, 2000). The history of changes in legal status boasts a number of unique features including the distinction of being the first mangrove forest in the world to be brought under scientific management. The area was mapped by the Surveyor General as early as 1764, following soon after proprietary rights were obtained from the Mughal Emperor, Alamgir II, by the East India Company in 1757. The early management of the Sundarbans was confined to revenue generation from the export of timbers. In the middle of the 16th century, the local king imposed levy on exporting wood from the forests. During the early British rule, the forests were leased out to settlers, which resulted in the conversion of large track of forests into farm-lands and human settlement areas. At the beginning of the British rule, the Sundarbans was twice from its current size and the local landlords, whose properties extended up to the boundary of the forests, cleared and reclaimed forestland regularly.

Systematic management of the Sundarbans forest tract started in the 1860s after the establishment of a Forest Department in Bengal. The Sundarbans was declared a Reserved Forest in 1875-76, under the Forest Act, 1865 and was transferred from the civil district administration to the newly created Forest Management Division in 1879 with the headquarters at Khulna. The first survey of the Sundarbans was carried out by Messrs Ritchie, Richards and Martin during 1769-1773. The results of the work were compiled into a chart of the Sundarbans rivers by Rennel and this was followed by a number of surveys of the waterways in the region.

In 1821-23, Lt. Prinsep surveyed the boundaries between the forests and cultivated areas from the Hoogly to Jamuna rivers. This boundary survey was continued as far as Baleswar river by Lt. Hodges in 1829, and two years later a map (scale: 0.5 inch = 1 mile) was published depicting the result of his own survey as well as Lt. Princep's survey. Captain Smyth preserved Princep's and Hodges's boundary line in 1850. Revenue surveys were made in the 24-Parganas district in 1851-1855 and in the greater Khulna district in 1855-59. The data from the various surveys were collated by Ellison who published a complete map of the Sundarbans in 1873 (scale: 0.25 inch = 1 mile).

A number of inspections of the Sundarbans by prominent British Foresters between 1863 and 1874 raised the awareness about its value as forest resource base. The recommendations of these foresters resulted in the formulation of the first set of guidelines for harvesting regulations, thereby promoting the conservation of the forests. The export of timber from the forests was regulated through the establishment of Forest Stations on the main routes of timber export from the forests.

Between 1905 and 1908, the Sundarbans was again surveyed in detail by the Survey Department of the province of Bengal and map sheets (Scale: 1 inch = 1 mile) were published in 1909. Subsequently, local surveys have been undertaken to incorporate accretion as well as loss of areas through erosion. The latest sheet of these maps was published in 1924, which was updated during working plan preparations. During the field work for the preparation of the working plan by Curtis, a stock map for the entire forest was prepared on a scale 1:31,380. A set of maps based on both aerial photographs and field surveys was prepared during the 1959 inventory by Forestal, which was published in 1960. A new set of maps became available in 1985 after the ODA inventoried the forests.

The Forest Resource Management Project conducted forest inventory in 1996/97, and prepared maps based on the base-map derived from 1:50,000 SPOT satellite imagery of 1989 and amended by using 1:15,000 aerial photographs taken by QUASCO Ltd., in 1995. The latest version of the Sundarbans maps was produced by the RIMS-GIS Unit of the Forest Department in 2002 by modifying the maps produced under the Forest Resource Management Project. The maps are at a scale 1: 20,000 and show the area and boundaries of the ranges and compartments, wildlife sanctuaries, the locations of all station and camp offices and a distinct classification of each forest type. These updated maps have been used in the IRMP.

5.2 Management Plans Preparation

The first 10-year management plan, written by R.L. Heibig, came into operation in 1893-94 wherein the forests of Khulna and Bagerhat subdivisions were divided into two felling series and 10 annual coupes. The felling of sundari was limited to these coupes and minimum felling girth of 91 cm was prescribed. In the plan, sundari and to a limited extent *Sonnetatia apetala*, *Xylocarpus mekonggensis*, *Bruguiera gymnorhiza* and *Amoora cucullata* were dealt for conservation. Felling of other species remained practically unregulated. A revised working scheme was prepared by W. F. Loyd for the period of 1903-08. The same felling series were maintained but the annual coupes were reduced to one-fourth of the former size, thus increasing the felling cycle to 40 years. Simple silvicultural rules were prescribed for the felling of sundari. During this period the introduction of transit permits and felling hammer marks helped reduced the incidence of timber theft. Sir Henry Farrington prepared working scheme for the period 1906-07 to 1909-10. The felling series and the cutting cycle for sundari were the same as in the former scheme but the exploitable girth was raised to 106.6 cm. All mature trees were hammar-marked before felling and thinning was prescribed in overcrowded younger stands. The application of Farrington's plan was extended until 1930.

The first regular working plan for the SRF was prepared by S.J. Curtis for the period of 1931-1951. The Curtis' plan focused on scientific harvesting and this plan was in effect when the subcontinent’s partition divided the administration of the Sundarbans between Bangladesh and India. Both countries continued to protect the area after independence, though some revisions and improvement took place. S. Chowdhury revised the Curtis plan for the period 1937 to 1947 to enable the execution of certain prescriptions which were found to be too elaborate. Several interim plans were prepared based on the Curtis' prescriptions until the Forestal Inventory was completed in 1959. Based on this inventory, A. M. Choudhury prepared the fist truly comprehensive management plan for the period 1960-1980. This plan included a harvest plan for Khulna Newspaper Mill (KNM) which was then newly established. The A.M. Choudhury plan continued beyond 1980 and was still in effect when the ODA inventory was conducted in 1983. From the results of ODA inventory, Balmforth prepared his interim prescriptions which were followed until the government declared a moratorium on the felling of timber from the natural forests in 1989. The felling of gewa and fuel wood, however, were exempted from this ban.

After this period, there were at least two major attempts to prepare a new management plan for the Sundarbans. In 1990, Zillur Rahman who was then Divisional Forest Officer (Working Plans Division, Dhaka) prepared a draft management plan for the Sundarbans for the period 1990-2000 based on the Management Plan manual developed by Balmforth in 1985. The proposed plan was not implemented, however. The Integrated Resource Management Project funded by FAO and UNDP, tried to develop a 10-year Integrated Resource Management Plan for the Sundarbans in 1994. But as the proposed plan only featured an elaborate and unusually lengthy description of the Sundarbans without providing any plans, it was not accepted by the government. After 1990, the felling of sundari was restricted to salvage felling of top-dying sundari trees. Meanwhile, gewa continued to be felled to serve the raw materials needs for KNM. Goran harvesting for fuel wood also continued during this period. The KNM has been closed on November 30, 2002 due to shortage of raw material and growing losses, and thus there is no use of gewa since then.

In 1998, a comprehensive IFMP for the SRF was prepared for 12 years period (1998-2010) by J. A. Canonizado and Md. Akbar Hossain under the WB supported FRMP. The plan has the 3-stages : an interim period of 2 years (1998-2000), and another two periods, each with 5 years (2000-2005, and 2005-2010). The management plan has three parts: The 1st part (Book-I) explained the existing situation and the 2nd part with the management plan (Book-II) whereas the 3rd part (Book-III) contained the annexures with the details of inventory, fauna and flora. The management plan was quite elaborate and holistic, and gave insights of the management needs, management prescription and a future prediction of the SRF resources. However, as discussed in the next section many prespcriptions of the IFMP could not be implemented mainly due to ban on commercial felling and lack of resources. In 1997, the first conservation management plan for the three wildlife sanctuaries was prepared for 5 years by Rosario (1997) under the WB funded FRMP. But main recommendations of this plan were not implemented due to lack resources and since then no revisions of this plan have been taken up.

5.3 Management Plans Implementation

The IFMP was accepted by the Government but the Forest Department could achieve very limited implementation of the management prescriptions over the 12-year period up to 2010. Although the plan was for 12-years, the second ten-year period (2010-20) provided an insight into a longer planning horizon, completing the prescribed cutting cycles for the major wood products (sundari, gewa, keora, goran and other timber species). It also featured the various programs covering regulatory, conservation, and development areas and a 12-year revenue forecast. In the IFMP, for sundari the cutting cycle was for 20 years, minimum felling diameter 27.6 cm for sundari production areas and 22.6 (for compartments of 7,18,19,20, 38 and 40), annual allowable cut (AAC) prescribed 21,500 cu. m. for interim period and around 54,000 cu. m. in regular period. The keora harvest plan was 28,200 cu. m. for 2000-2005 and 26,700 cu. m for 2005-2010. The felling suggestions for other timber species were 14,124 cu. m. for 2000-2005 and 15,067 cu. m for 2005-2010.

The previous management plans had the regulation of timber resources as an overriding objective, implemented through the determination of sustainable harvest levels and careful planning of the field operations. Prior to IFMP, the last set of management prescriptions for the Sundarbans was from the Balmforth Interim Felling Prescription prepared in 1985. It was intended to bridge the interim period between the ODA inventory and until such time as a comprehensive management plan could be prepared. Unfortunately, the ODA inventory results were not accepted by the government. Before the Balmforth prescription (and the ODA inventory) could be accepted, the moratorium on felling in natural forests went into effect in 1990 when the felling of sundari and other timber species, except gewa and fuelwood, was stopped. An exception was made for the salvage harvesting of top-dying sundari as sanitation measure. Balmforths recommended an AAC of 91,000 cum for gewa but an inter-ministerial meeting in 1986 increased this to 127,000 cum in order to ensure the validity of the government-owned KNM operations. Another inter-ministerial agreement further increased this AAC to 130,000 cu.m. at the onset of the ten-year moratorium in 1990.

The moratorium, which was applied to all natural forests in Bangladesh, was intended to give enough time to natural forests to regenerate, as well as to stop further loss of natural forests through conversion (to plantations). For the Sundarbans, the moratorium was justified as timely to avert depletion of the growing stock, the trend which was already manifested in the results of the Forestall and ODA inventories in 1959 and 1983 respectively. The FRMP inventory showed that the depletion of sundari resources persisted in spite of the moratorium. The number of sundari trees per hectare of the 15 cm and above diameter classes was found to go down to 102 by the FRMP inventory, from 125 of the ODA inventory, and from 211 during the Forestall Inventory. In the FRMP estimation in 1988, over a past period of 37 years, the number of trees per hectare in the growing stock was found to reduce by 52%. Between the ODA and FRMP inventories, the reduction was 18%. However, the number of stems per hectare in the 10 cm and above diameter classes has remained stable in the last 13 years prior to FRMP inventory, and this indicated that the large diameters were running down rapidly.

There were several possible causes of such unexpected depletion. Fishermen used sundari poles as anchor post for their boats, liberally obtained from the forests. With more than 25,000 registered boats in the Sundarbans, and probably an equal number of unregistered ones, the use of sundari for boat alone was substantial, considering that fishermen operated year round. Top-dying of sundari also had a profound effect with almost 3% of the growing stock infected. Erosion of river embankments added to the causes of depletion. Since the ODA inventory, it appeared that there was a net loss of land area of 3026 hectare, representing 1% of the growing stock. For the most part, timber theft was the cause of the greatest damage. The moratorium created an artificial shortage of the valued sundari and in all likelihood that might have induced some pilferage and smuggling. While regular confiscation and apprehensions were made, the FD, with its limited forest protection force, was ill-equipped of fully guarding the vast Sundarbans.

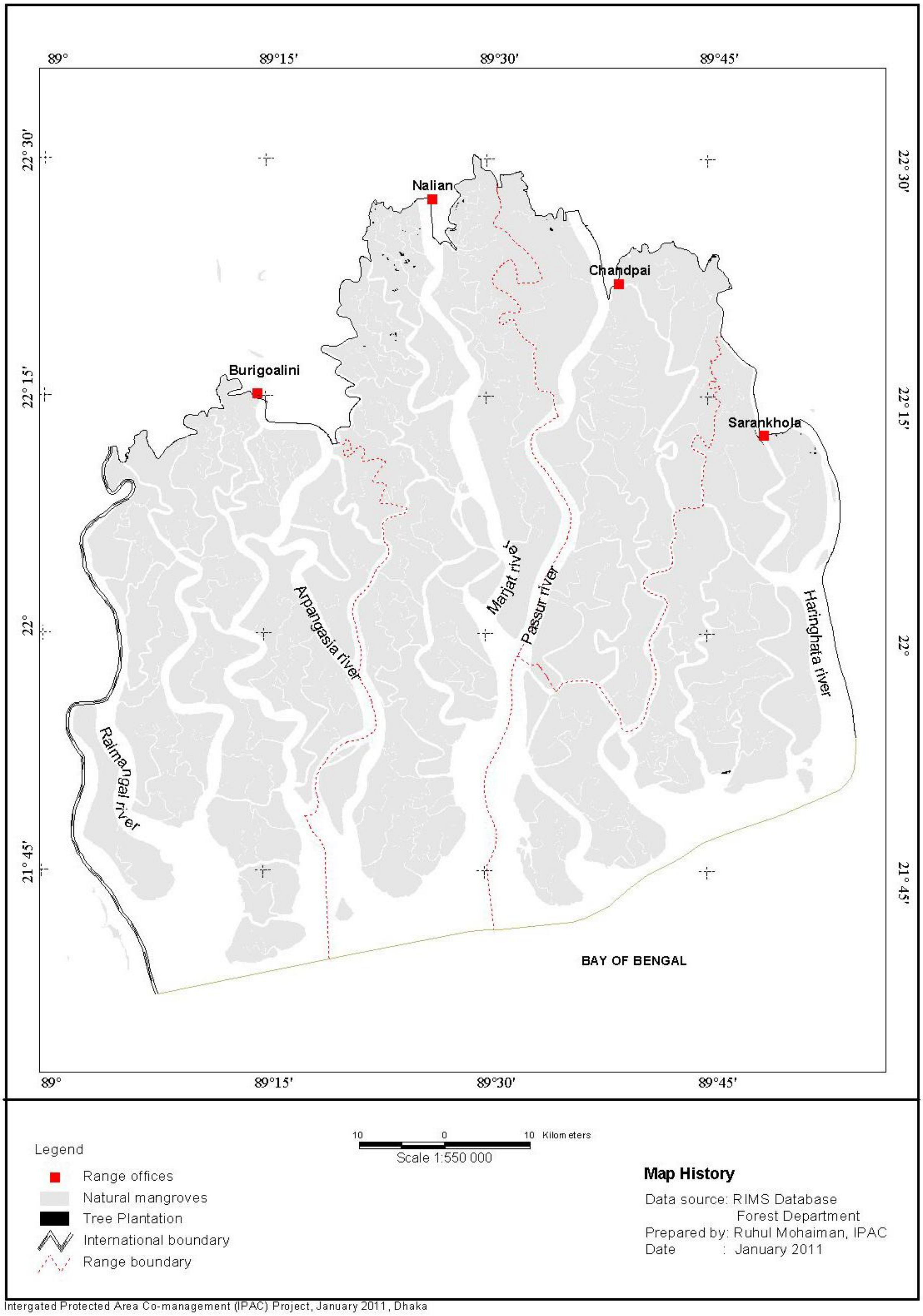
The FRMP inventory of 1996/97 and the analysis carried out by the FRMP showed that the increased AAC by the Balmforth Interim Felling Prescription for gewa was way above the sustainable capacity for the forest, resulting in further degradation of the growing stock. The KNM's harvest level dropped considerably at the time of FRMP (and later KNP was closed in 1992) as its effective manufacturing capacity dropped. For a long time, the gewa resources of the Sundarbans were compromised to maintain commercial operations of KNM. If the KNM would rehabilitate to be able to resume normal operations, it must face the reality that the previous level of gewa extraction was no longer possible. In fact, the KNM was closed in 1992 due mainly to the shortage of gewa and other reasons.

The IFMP covering a 12 year period (1998 to 2010) reviewed the prescriptions of all the past management plans and traced out the limitations and main causes of limited success in the implementation. The plan was elaborative and explanative, and also had a forecast on the harvest plan for another 10-year (2011-2020). Though it gave the details of harvest plans for all major timber species, the prescriptions could not be carried out due to ban on commercial timber felling. While the IFMP was in operation by the Forest Department, there were couple of natural incidences that damaged the Sundarbans to great deal; the most devastating one was the cyclone Sidr of November 2007. To compensate the loss and early recovery of the Sundarbans, the IFMP prescriptions were put on hold; all the forest products harvest were banned except few minor products like fish, honey and bee wax, and only in 2009, when the forests came back to a reasonable situation, the golpata harvest was permitted. The commercial ban on felling has resulted in increase in growing stock including sundari as discussed in Chapter 3 of Part II.

For the aquatic resources, the traditional approach, which was carried out through the previous plans did not set any limit to the levels of extraction. These resources together with fuel wood and golpata extraction, gathering of honey bee's wax, and collection of other minor forest products, were a major source of revenue to make up for the lost timber revenues during the moratorium period. Minimal harvests of sundari from top-dying salvage operations were made available to the market through departmental extraction and public auctions. However, the fishermen continued using of tender sundari poles, and the sundari top-dying continued. The erosion of river embankments and siltation continued and the reduction in water depth and freshwater inflow from the upstream had negative impacts. The impact of climate changes (temperature increase, salinity increase, reduction in fresh water flow, cyclones, etc.) is believed to have some changes in the overall environment of the Sundarbans. Some plantations also were raised (Figure 5.1) inside the SRF.

In case of the aquatic resources, the main constraints in proper management planning were the lack of authentic information on the resources status. Two destructive fishing methods have been particularly detrimental to the fisheries resources; the poison fishing and Post Larvae (PL) of prawn and shrimp collection. Due to the low catch rate and greed, many fishers used poisons for fishing in the canals and rivers. The IFMP prescribed some measures for aquatic resources management in the form of resource development initiative and regulatory measures for resource harvest. However, the plan was more on do's and don't. It proposed fishing ban in less-wide canals situated around FD office and in sanctuaries, a harvest limit and punishing measures to fishers for non-compliance of the rules. The management prescriptions were based on assumptions rather than any authentic information base on the current status of the resources. No attempt was made to assess the Maximum Sustained Yield (MSY) for hilsa, catfish and mud crab. In the absence of rigorous monitoring in the ground as well as lack of resources, many prescriptions of the plan for sustainable fisheries management could not be implemented. As in case of the IFMP, main prescriptions of the CMP also remained unimplemented in the three wildlife sanctuaries.

Figure 5.1: Location of Tree Plantaions in the Sundarbans Reserved Forests



6. Interface Landscape

As integrated management of the Sundarbans can not be achieved in isolation from the surrounding socio-economic realities and development priorities, it calls for a sustainable landscape approach. The Plan has, therefore, adopted a sustainable landscape approach and an interface landscape and its relevant socio-economic characteristics are identified in this chapter.

6.1 Sustainable Landscape Approach

Sustainable landscape approach of the Sundarbans management focuses on a broader spatial scale in order to integrate relevant forests/wetlands and ecosystems with socio-economic and institutional systems. It is a holistic approach that takes into account relevant factors that impinge on the sustainable management of the Sundarbans in the context of a mosaic of different land-use patterns and socio-economic attributes. The identified landscape will be taken as a plannaing and development unit for an integrated management of the Sundarbans in order to address co-management issues in the context of a broader socio-economic, natural resource governance, institutional and environmental perspective. It provides a suitable framework to manage the Sundarbans for multiple uses by addressing interactions between local economy, key stakeholders and natural resource base. It entails biodiversity conservation by establishing suitable linkages between the surrounding ecosystems with the interacting human systems. It will help restore socio-ecological processes both within the SRF but also in the identified landscape by accounting the presence and needs of local community and encompassing both terrestrial and aquatic ecosystems. It promotes gainfull partnerships with key stakeholders, which will help integrate the management of the SRF with community development.

6.2 Interface Landscape of the Sundarbans Reserved Forests

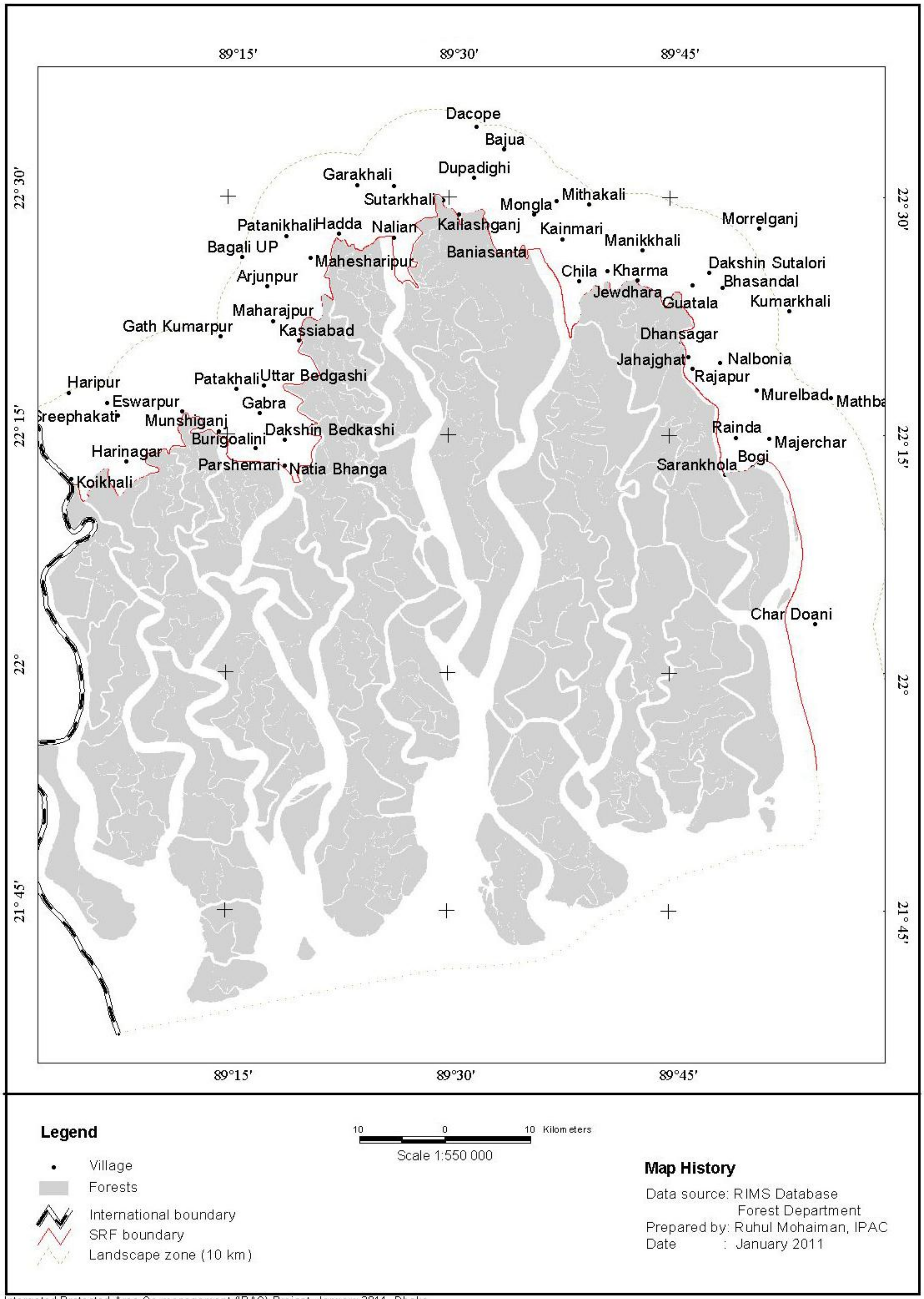
The Sundarbans comprising the SRF and its interface landscape covers full or partial areas of five administrative districts (Khulna, Bagerhat, Satkhira, Pirojpur and Borguna), of which the first three are of great importance. The Ministry of Environment and Forests have declared a 10 km band as ECA as per the provisions of Environmental Conservation Act, 1995. The periphery of the SRF thus includes the legally declared ECA within a 10-km wide band, surrounding the SRF in north and east. This is what is designated as interface landscape zone in the context of the modalities of the livelihood interventions and support for environmental and biodiversity consideration. This zone comprises 5 districts, 10 Upazilas, 151 unions and 1302 villages (Table 6.1). The location of select villages in the interface landscape zone is shown in Figure 6.1.

Table 6.1: Details of Interface Landscape Zone

District	Upazila	No. of Union Councils	No. of villages
Bagerhat	Sadar, Mongla, Morrengonj, Sarankhola	65	486
Khulna	Dacope, Koira, Paikgacha	37	440
Satkhira	Shymnagar	13	216
Pirojpur	Mathbaria	20	94
Barguna	Patharghata	16	66
Total	**10**	**151**	**1,302**

Source: BIDS, 2010

Figure 6.1: Location of Select Villages in the Sundarbans Reserved Forests Landscape



Intergated Protected Area Co-management (IPAC) Project, January 2011, Dhaka

6.3 Socio-economic Assessment

As human settlement inside the SRF is restricted due to its enhanced protection status as per the Forest Act and Wildlife Act, neither villages nor cultivated fields are found inside it. Only FD personnel and some floating dwellers engaged in harvesting SRF resources reside inside the SRF temporarily. But the total population living in the identified landscape around the SRF is estimated to be as high as 8.55 lac (about 6.0% of the country's total population) living in about 15,352 sq. km. (10.4% of the country's area); the density of population is 557 which is below the national average of 966.

Approximately half of the total area of five districts lie in the landscape zone. : Khulna has the highest area as 72%, followed by Satkhira as 51%, Bagerhat as 41%, Pirojpur as 27% and the lowest in Borguna as 21%. In terms of population more than a quarter (28%) of the total population of the five districts live in the interface landscape zone : The highest percentage of population live in Bagerhat (56.4%), followed by Khulna (24.1%), Pirojpur (23.6%), Borguna (20.7%) and the lowest in Satkhira (17.0%). Almost similar is the distribution of the 1,302 villages across the landscape districts. Important demographic and area details are presented in Tables 6.2 and 6.3 as below:

Table 6.2: Population and demographic status in the landscape districts

District	Area (km^2)	Population ('000)			# HH ('000)	Size of HH	Sex ratio (M/F)	Population (2009) density (per sq.km)
		Total	Male	Female				
Bagerhat	3,959	1,646	854	791	343	4.8	108	416
Khulna	4,395	2,728	1427	1301	568	4.8	110	621
Satkhira	3,858	2,115	1083	1031	441	4.8	105	548
Pirojpur	1,308	1,151	582	569	240	4.8	102	880
Barguna	1,832	912	463	450	194	4.7	103	498
Total	**15352**	**8551**	**4408**	**4144**	**1781**	**4.8**	**106**	**557**

Source: (BIDS, 2010)

Table 6.3: Proportion of area and population in the landscape districts

District	% lanscape area in respective district	% of landscape population (2009) in respective district	% landscape villages in respective district
Bagerhat	41.4	56.4	47.1
Khulna	72.3	24.1	40.0
Satkhira	51.0	17.0	15.1
Pirojpur	27.0	23.6	14.6
Barguna	21.1	20.7	11.8
Average landscape district	49.0	28.1	27.2

Source: (BIDS, 2010)

Nearly one-quarter of the total household in the landscape zone enjoys the electricity connection which is below that in coastal zone (31%) or the country as a whole (31%) (Table 6.4). Similarly, the number of active tube wells per Km^2 in the landscape is 5 compared to 7 in both coastal and as national average. The percentage of households enjoying sanitation in the landscape is 44.5, which compares favorably with national average (36.9%). In terms of literacy or child mortality rates, the landscape enjoys a slighty better position than that of coastal zone or the nation as a whole. Child mortality for every thousand is estimated at 93, compared to 103 for coastal district and 90 for Bangladesh as a whole.

Table 6.4: Selected socio-economic indicators by the Landscape districts

Districts	Agricultural HH as % total rural HH	Literacy Rate (7+ years)	Child Mortality (less than 5 years)	Sanitation (%)	# active tube wells (km^2)	Electricity Connection (%)
Bagerhat	76	58.7	87	33.2	4	27
Khulna	69	57.8	90	37.0	6	26
Satkhira	60	45.5	96	59.2	4	42
Pirojpur	18	64.3	94	47.6	10	10
Barguna	79	55.3	94	36.7	4	9
landscape districts	58	55.7	93	44.5	5	25
Coastal Zone	N/A	51.0	103	45.6	7	31
Bangladesh	N/A	46.2	90	36.9	7	31

Source: (BIDS, 2010)

Both the landscape zone and the coastal region of the Sundarbans contribute significantly to the economy of Bangladesh. However, agriculture still remains the mainstay of the economy of the landscape. In FY 1999-2000, the share of agriculture to GDP in the landscape was 29% against the national average of 26%. The contribution of industries sector was 22%, which was the same as that of coastal zone but less than that of national average (25%). The landscape shares nearly 50% to service sector on par with the national average in general and the coastal area in particular. Most of the landscape districts have miserably low level of GDP per unit area, indicating a low level of regional development (Table 6.5). An average landscape district has GDP per sq. km of only Tk. 8.5 million, compared to Tk. 14.4 million in coastal zone and Tk. 21.8 million in an average district in Bangladesh (see Table 6.6). The district Bagerhat has the highest level of GDP (Tk. 10.4 m), which is nearly 2 times higher than that of Satkhira (Tk. 5.6m).

Table 6.5: Per capita and per sq. km GDP

Districts	GDP (2000 constant price)		Per sq. km. GDP (Million Tk.)
	District GDP (million Tk.0	Per Capita	
Bagerhat	27,717	16839	10.39
Khulna	63,112	23135	10.20
Satkhira	27,360	12936	5.61
Pirojpur	16040	13936	7.01
Barguna	15414	16901	6.16
landscape districts	27642	15929	8.5
Coastal Zone	35726	18198	14.38
Bangladesh	40706	18269	21.8

Source: (BIDS, 2010)

The main characteristics of the landscape zone, which differentiates it from the other areas, is its complexity as manifested in the diversity and dynamic nature of the livelihoods of the local people, especially the poor. Although agriculture is still the mainstay of the economy in the zone, the landscape provides varied sources of livelihood, which are not commonly available in other parts of Bangladesh. More than half a million people live on the collection of fuelwood and NTFPs such as fish, honey, wax, and leaves of trees from the Sundarbans. In the landscape, nearly 30% of the people or nearly four times that of the share of national figure earns their living by fishing (Table 6.6). The people of the area, in general, are just surviving at subsistence level. Since soil condition varies considerably because of various hydrological conditions, the cropping intensity also varies accordingly. Generally, the zone is with low cropping intensity, 134% as a whole, but non-saline tidal water flood plain has a good agricultural land than that of saline tidal flood plain. Pirojpur has the highest cropping intensity (171%) and the lowest in Bagerhat (107%) (Table 6.6)

Table 6.6: Selected indicators for livelihoods in the Landscape zone

Districts	landless	Agri-labor (%)	Per capita land (ha)	Per capita agri-land (ha)	Fisher men (%)	One crop land	Two crop land	Three crop land	Cropping intensity (%)
Bagerhat	49.3	36	0.24	0.09	12	95	3	2	107
Khulna	49.0	40	0.16	0.05	40	NA	NA	NA	-
Satkhira	47.3	31	0.18	0.07	31	50	28	-	156
Pirojpur	53.2	32	0.11	0.09	32	36	57	7	171
Barguna	49.0	32	0.20	0.11	38	56	37	7	151
landscape districts	49.1	33	0.18	0.08	30	59	30	5	134
Coastal Zone	53.5	33	0.06	0.06	14	NA	NA	NA	-
Bangladesh	52.6	36	0.10	0.07	8	31	42	13	154

Source: (BIDS, 2010)

The local populations in the landscape are suffering from marginalization and inequality in income. Poverty status can be considered as a proxy to the extent of marginalization. BIDS (2010) conducted Head Count Ration (HCR) between the landscape and non-landscape districts, which shows a dismal picture (Table 6.7). The extreme poverty levels of the landscape districts and upazilas are at considerably higher level in almost of all the districts and upazilas, compared to respective non-landscape areas. Although the coast as a whole and the landscape in particular, is endowed with natural resources and environment resources, the landscape upazilas have much higher extreme poverty compared to non-landscape upazilas in Bangladesh. Thus the poverty situations in the landscape zone appear to be extremely severe.

Table 6.7: Poverty mapping in the landscap and non-landscape Upazilas

Landscape Districts	landscape Upazila	Head Count Ration (%) (HCR)
Bagerhat	Bagerhat Sadar	0.306
	Mongla	0.415
	Morrelgonj	0.503
	Sarankhola	0.487
	landscape Bagerhat	0.430
	Non-landscape Bagerhat	0.238
Khulna	Dacope	0.604
	Koyra	0.348
	Paikgacha	0.344
	landscape Khulna	0.414
	Non-landscape Khulna	0.318
Satkhira	landscape Satkhira (Shyamnagar)	0.652
	Non-landscape Satkhira	0.451
Pirojpur	landscape Pirojour (Mathbaria)	0.179
	Non-landscape Pirojpur	0.185
Barguna	landscape Borguna (Patharghata)	0.361
	Non-landscape Borguna	0.432
Bangladesh	landscape Upazilas	0.423
	Non-landscape Upazilas (Bangladesh)	0.262

Source: (BIDS, 2010)

6.4 Landscape Community's dependence on the Sundarbans

The Sundarbans plays an important role in the economy of the southwestern region of Bangladesh as well as in the national economy. It is the single largest source of forest and provides raw material for wood based industries. In addition to traditional forest produce like timber, fuel wood, pulpwood etc., large scale harvest of non-wood forest products such as thatching materials, honey, bees-wax, fish, crustacean and mollusk resources of the forest takes place regularly. The vegetated tidal lands of the Sundarbans also function as an essential habitat, nutrient producer, water purifier, nutrient and sediment trap, storm barrier, shore stabilizer, energy storage unit and aesthetic attraction.

The direct dependency on the Sundarbans of surrounding living people is quite high: BIDS (2010) reported that more than 28% of the landscape population are dependent on the SRF. More than one million people are involved in various resources collection from the Sundarbans, a large majority of which are fishers including about 2 lacs of shrimp fry fishers. If it is assumed that on an average, a collector harvests 1.8 products over the year, the number of SRF collectors are estimated as about 0.59 million. As indirect values to local populations, the forests have immense protective and productive functions, which enhance the resilience of local community for facing adverse impacts of climate change. Various non-timber forest products help generate considerable employment and income generation opportunities for at least half a million poor coastal population. Besides production functions of the forest, it provides natural protection to life and properties of the coastal population in cyclone prone Bangladesh.

6.5 Landscape Industrial Demands

Constituting 51% of the total RF estate of Bangladesh, the SRF contributed about 41% of total forest revenue and accounted for about 45% of all timber and fuel wood output of the country. A number of industries (e.g. newsprint mill, match factory, hardboard, boat building, furniture making) were based on the raw material obtained from the Sundarbans ecosystem. Around Khulna city, a number of industries depend on the Sundarbans for their raw material needs. The most prominent among those had been the Khulna Newsprint Mill, Khulna Hardboard Mill, match factories, furniture makers and saw mills. The Khulna Newsprint Milll Ltd., the only producer of newsprint in the country, was established in 1959 for producing newsprints using the gewa as softwood from the Sundarbans. The mill used huge quantity of gewa and many workers were involved with high economic activities in the area. Unfortunately, the mill has been closed down in December 2002 due to shortage of raw material.

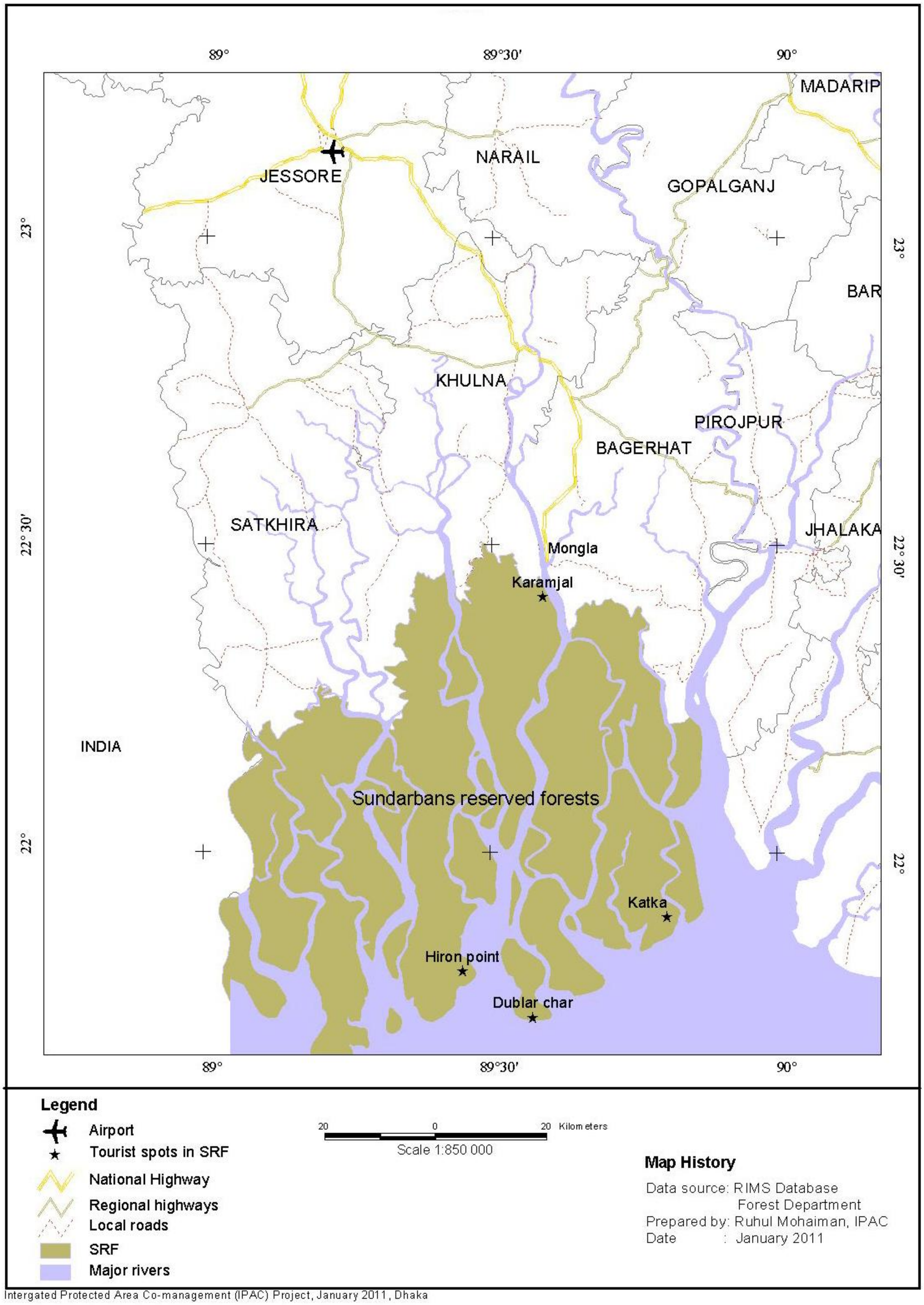
The Khulna Hardboard Mill, situated in Town Khalispur, was established in 1964 for producing hardboard from sundari harvested from the Sundarbans. Two match factories in Khulna depended on the Sundarbans for the raw material. The Dada Match Factory has been shut down in 2010 due to non-availability of raw materials. There are more than 50 saw mills with pitsaws operating around the Sundarbans, employing more than 5000 people and churning out some 250,00 cu. m. of saw timber annually. Earlier the saw mills used to run on the trees harvested from the Sundarbans. This has reduced a great deal after the moratorium, especially after the Sidr 2007 when the Government even banned the harvesting of goran. The saw mills are now dependent on the timber harvested from homestead trees.

6.6 Outdoor Recreation

The outdoor recreational facility in the south-west region of Bangladesh is very limited. There is no national park, city park, botanical garden and zoological garden where people can go for recreation. The Sundarbans has been a favorite eco-tourism destination for quite some time for both national and international tourists. There are tourists visiting the Sundarbans year round, especially during the winter and spring seasons; quite good numbers tourist visit in the Sundarbans every year. The "Karamjal Breeding and Research center" has been an important visiting place for short time visitor. People enjoy the beauty of the Sundarbans and see some animals there. In addition to outdoor recreation, the Sundarbans has been for a long time serving as the main subject area of local and international botany and wildlife ecology students, researchers and scientists. Apart from Karamjal, there are several places and spots of tourist attraction: Kotka, Jamtala, Kochikhali, Badamtala, Harbaria, Mrigamari, Kalagachi, Neelkamal, etc.

The outdoor facilities for tourists in the Sundarbans include the various guest houses established by the Forest Department over the area, the dormitory of the Bangladesh Port Harbor Authority at Hiran Point, the quarters of Bangladesh Naval Base also at Hiron Point, the dormitory of Bangladesh Port Authority at Mongla, and Hotel Pasur of Bangladesh Parjatan Corporation at Mongla. Quite good numbers of cruiser boats are operated by the tourism company from Dhaka and Khulna. During the peak seasons (winter & spring), cruise boats are operated from Mongla. Apart from the cruise boats, there are hundreds of engine boats for local and day trip from Mongla, Munshigonj and Satkhira. At Khulna city, there are good hotels where tourist can reside, rest and prepare before proceeding to the Sundarbans. They also reasonably cater to the needs and tastes of foreign tourists. The Sundarbans forests and sanctuaries have several unique and interesting attributes for domestic and international eco-tourism. There is scope and need to promote large scale sustainable tourism for the well-being of the country and the people of Bangladesh.

Figure 6.2: Route and destinations of Tourist in the Sundarbans Reserve Forests



In general, the number of domestic visitors has an increasing trend, though the rate of increase varies among years and there is decrease also (Table 6.8.). The growing affluence of the average family has increased the demand for leisure and consequently more domestic visitors go to the Sundarbans in search of new experience. The change in attitude and lifestyle has probably also contributes to such increase. Dhangmari in Mongla and Munshigonj in Satkhira are the main points of entry. Entry permits sold at these points have a constant increase over the years. The number of foreign tourists (Table 6.8) visiting the Sundarbans has an obvious increasing trend. It indicates that the Sundarbans is a favorite destination to many foreigners. It is expected that these numbers will grow as the Sundarbans becomes known to tourist circles around the world. The "New 7 Wonders of Nature" competition has given the Sundarbans a global identity to a wider number of people over the glove and it is believed that attraction to the Sundarbans will grow among international community which will result in more foreign and local visitors in near future. There are now half a dozen Tour Operators serving the Sundarbans under a working arrangement with the Forest Department.

Table 6.8: Number of Tourist Visiting SRF and Annual Revenue from Tourism

Year	Number of Tourist			Revenue (Tk.)	Annual Change (%)			
	Local	Foreign	Total		Local	Foreign	Total	Revenue
2004-05	69,078	2,124	71,202	2,186,055	-	-	-	-
2005-06	92,632	1,582	94,214	3,287,388	34.1	-25.5	32.3	50.4
2006-07	94,745	1,257	96,002	2,965,868	2.3	-20.5	1.9	-9.8
2007-08	83,709	1,479	85,188	2,745,730	-11.6	17.7	-11.3	-7.4
2008-09	97,721	1,703	99,424	4,419,960	16.7	15.1	16.7	61.0
2009-10	55,455	2,033	57,488	N/A	-	-	-	-
Average annual increase in total tourist number = 9.9%								
Average annual increase in revenue = 23.6%								

Source: Forest Department, 2010

Volume I

Integrated Resources Management Plans

for

The Sundarbans

Part II

Recommending Ten Strategic Programs for the Sustainable Sundarbans

1. Habitat Protection Programs

Heavy biotic pressure brought by manifold increase in human population and consequent demand for agriculture and settlements have in past resulted in the loss and degradation of the country's forests in general and the SRF in particular. Effective protection of the SRF is necessary for ensuring the country's ecological and food security, conserving biological diversity and controlling adverse impacts of climate change. The ecological security of the Sundarbans needs to be ensured as habitat degradation and loss of wildlife have in the past taken place in the Sundarbans as elsewhere in Bangladesh. Various habitat protection interventions recommended in this chapter are applicable in the entire SRF comprising both the core zone and the buffer zone.

1.1 Program Objectives

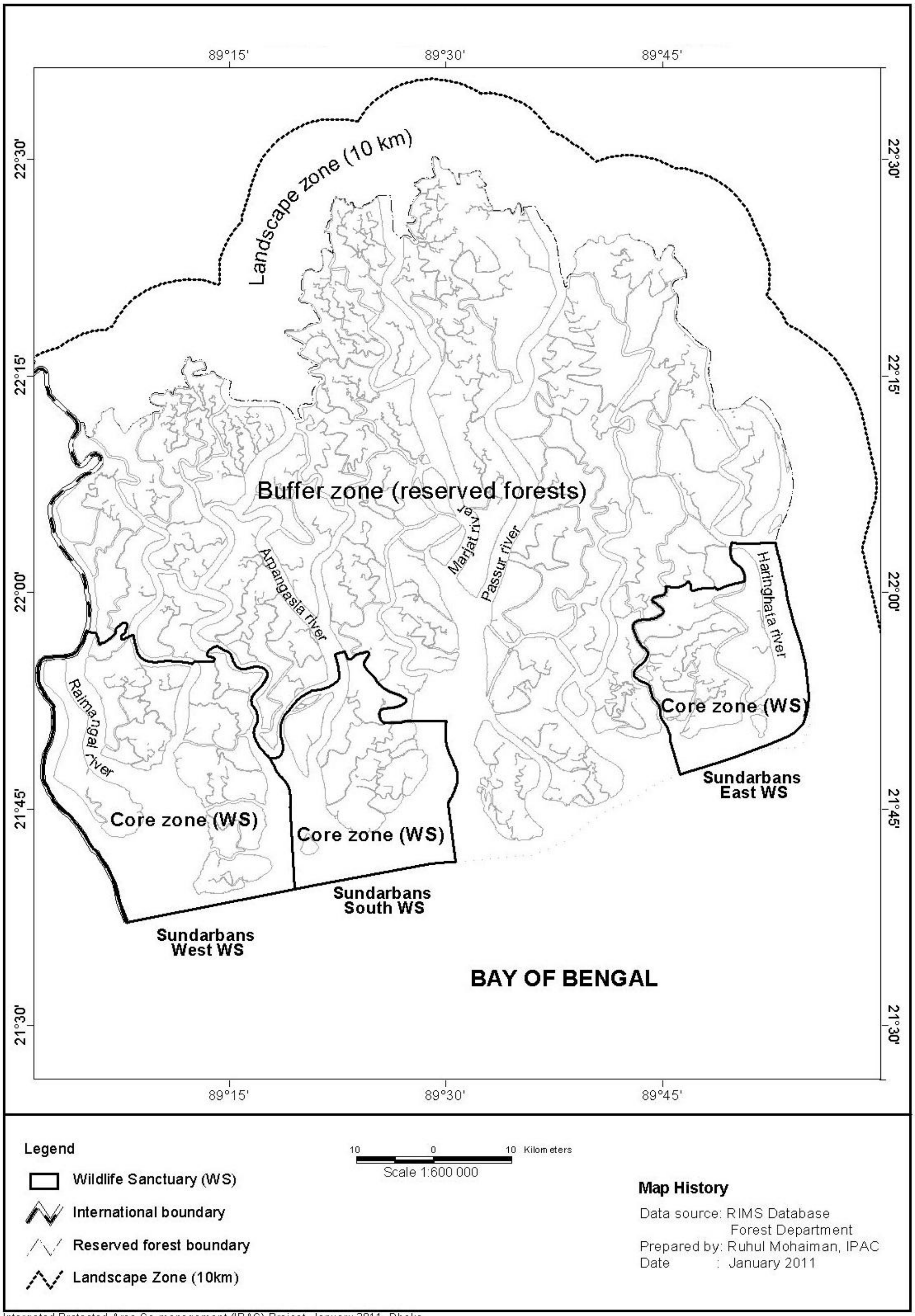
Main objective of the habitat protection programs is to provide effective protection to the SRF including forests and wetlands and their constituent flora and fauna by following a co-management approach that will focus on establishing gainful partnerships with key stakeholders but also simultaneously strengthening FD protection and communication mechanisms and facilities.

1.2 Management Zoning

A management zone is an area of specific management category, distinguishable on account of its management objectives. Zonation helps achieve different management objectives by applying appropriate management strategies and operations in each identified zone. The forests and wetlands within the SRF and its surrounding landscape will be managed based on sound co-management practices that will conserve biodiversity and benefit local community. The existing levels of land-use will be managed by means of suitable zoning in ways that do not result in major adverse environmental or irreversible ecological impacts. Sustainable management zoning is done to implement relevant management practices in identified areas of the SRF based on the above-stated management objectives to be achieved spatially. In order to provide a basic spatial framework for protecting the areas of highest conservation value and maintaining the maximum possible area under natural forest cover, the SRF is categorized into two main zones, core zone and buffer zone (Figure 1.1), based on existing biodiversity and management objectives. Additionally, the identification of an interface landscape zone influencing the designated core and buffer zones is necessary for sustainable development of both neighboring forests/wetlands and local community. The core zone will have the highest conservation value followed by buffer zone, which would adjoin the identified interface landscape zone comprising local stakeholders and impacting land-uses.

All the notified area of the three wildlife sanctuaries is the core zone, which has the highest conservation value. The entire SRF, except the three Sanctuaries, is the buffer zone to the designated core zone (Figure 1.1). The 10-km wide ECA spread along the northern and eastern boundaries of the SRF will function as an interface landscape zone. However, in near future it can be expanded to include another 10-km wide extended landscape zone to the north and east of the interface landscape zone.

Figure 1.1: Management Zoning in the Sundarbans



Intergated Protected Area Co-management (IPAC) Project, January 2011, Dhaka

1.3 Boundaries Delineation

Natural features demarcate the Sundarbans particularly in southern and eastern borders whereas the international boundary on western borders is delineated by the common international rivers. The northern and eastern boundaries of the SRF, not covered by the natural features, will be surveyed, delineated and marked on the ground with concrete pillars (see NSP and FSP Guidelines) at all important and/or turning points and will be labeled. The boundaries of the core and buffer zones will be defined, mapped and marked on the ground by associating local stakeholders, preferably with wooden posts having legible inscriptions in Bangla for easy differentiation. While carrying out the demarcation, advantage of natural features (i.e. rivers, streams/creeks/khals, ridge, roads, etc.) will be taken, wherever possible. All the locations where primary access routes cross the three sanctuaries' outer boundaries will be clearly marked with signs indicating the name and summarizing key regulations in written text and symbols. Two types of signboards will be used, i) a well designed, large wooden signboard at Range and Sanctuary HQs, and ii) concrete signboard at other identified locations. A regular maintenance program will be necessary for boundary and pillar renovation as the area is vulnerable to natural calamities such as storms and cyclones.

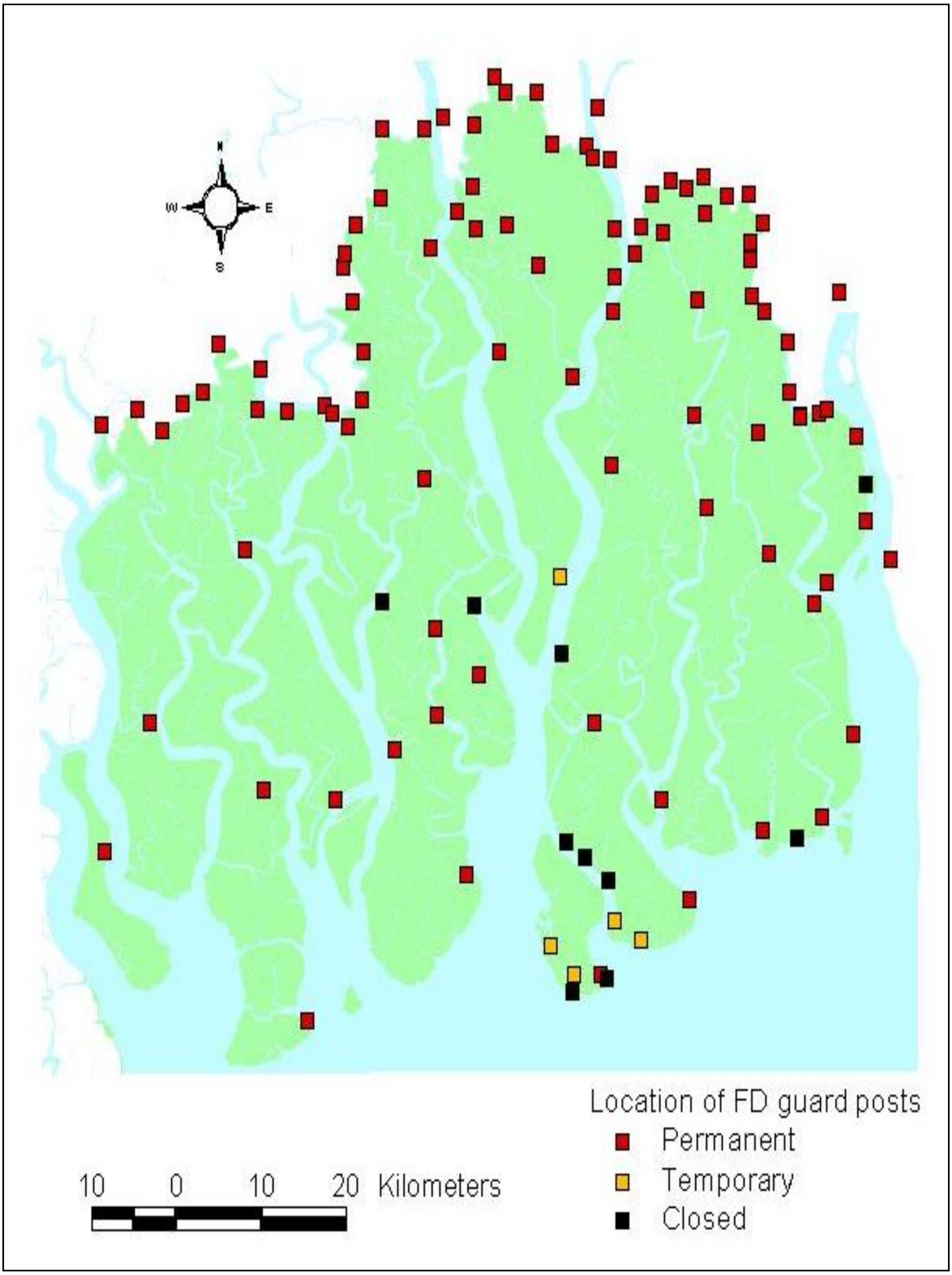
1.4 Strengthening the Sundarbans Protection

Effective conservation of the Sundarbans requires protection of forests and wetlands of the entire SRF against illegal removal of trees and other biodiversity including fisheries resources by employing local community and adequate FD field staff, who are sufficiently equipped to deal with increasingly sophisticated and armed smugglers. Based on a detailed field survey of the the Sundarbans and in wide consultation with the FD field staff, an assessment report on the current state of the SRF protection was prepared by WTB (2009) and submitted to FD for its use in developing a DPP for the EU environment program, SEALS project. Main findings of this report and the draft DPP are summarized as below for their implemention.

1.4.1 Protection Status

The FD posts responsible for protection are categorized as Range Offices, Forest Stations and Forest Camps. Forest Camps are exclusively tasked with patrolling whereas Range Offices and Forest Stations (Figure 1.2), in addition to patrolling and patrol monitoring, collect revenue and carry out general administration. A total of 104 posts, including permanent, temporary and mobile (special boats), were recorded and it was concluded that due to more post locations, northern forest areas came under high patrolling coverage when compared to southern forests. But some of the existing posts could not provide effective protection to the three sanctuaries. Only 58 boats including 44 motorized boats are in operation in 69 posts and the remainder 159 boats need repairing. Similarly of the total 95 jetties, mostly wooden, only 57 jetties are in operation. Only 61 posts have arms (total 397 guns with 53,354 bullets) and other navigation equipments including telecommunication system are largely lacking. A total of 582 FD field staff (Chandpai-158, Sarankhola-120, Khulna-196 and Satkhira-108) and 56 non-governmental personnel were found on field duty. The posts are, therefore, understaffed and not adequately equipped with required equipments and tools for efficient protection. Patrolling frequency is limited by the availability of diesel, which in most cases is not adequately provided in the formal FD budget. For instance, a total of 24,451 patrols (22,693 by boat and 1,758 by foot) were (April 2008 to May 2009) recorded in the Sundarbans.

Figure 1.2: Existing Locations of Forest Posts



1.4.2 Improving Protection Facilities

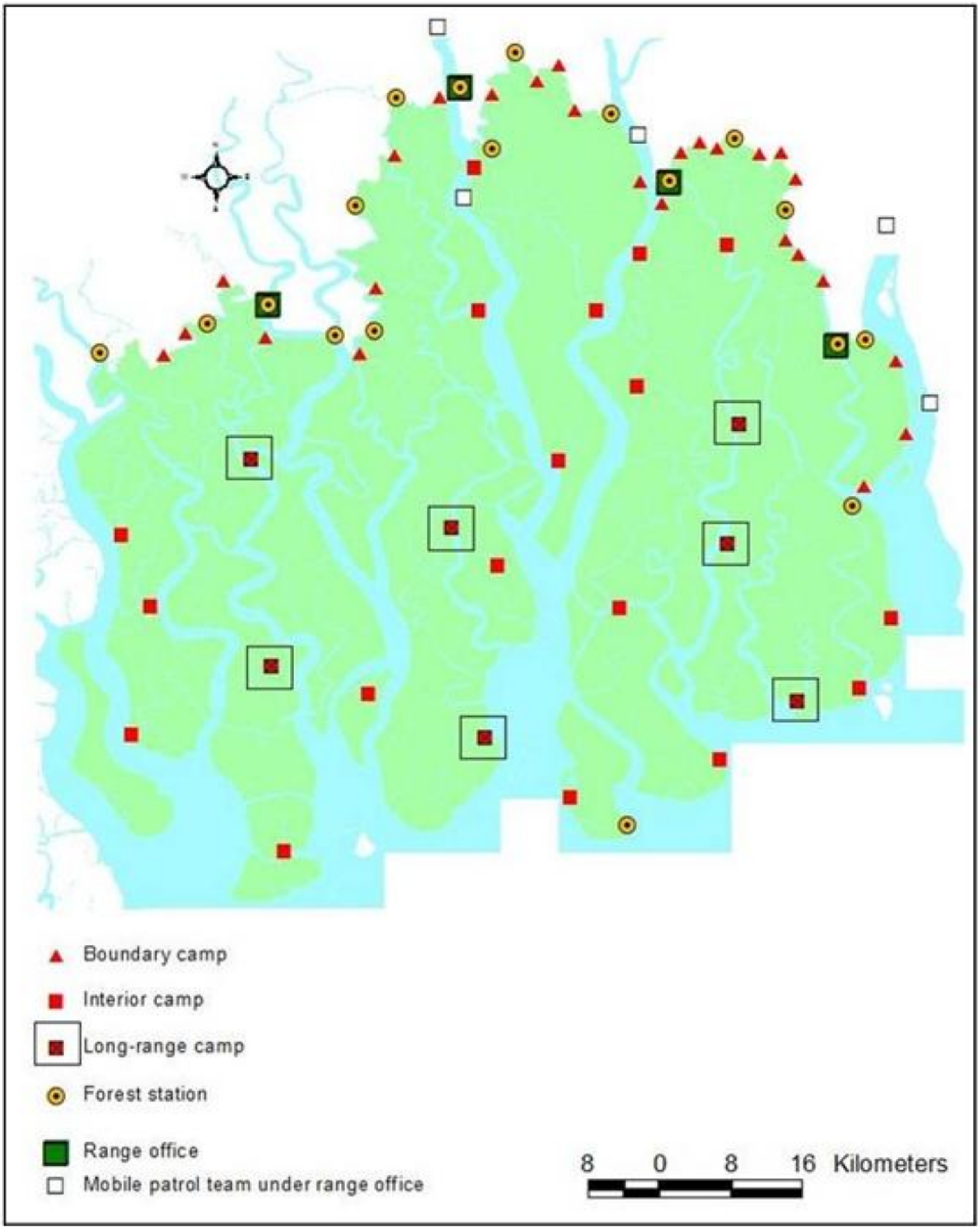
Main recommendations for strengthening the protection of forests and wetlands of the Sundarbans are summarized in this section based on the DPP of SEALS (FD, 2010) and the Sundarbans reserved forests protection report as prepared by WTB (2009) in close agreement with the FD. The readers interested in the details are recommended to refer to this report wherein detailed recommendations are made under 5 main components including patrolling, monitoring, staffing, physical work conditions, and telecommunications. A summary of main recommendations is provided as below for ready reference and implementation.

Under patrolling component main recommendations focus on, i) updating roles of teams and posts, and ii) updating numbers and locations of FD posts and their patrolling jurisdictions. Three types of patrolling posts as recommended are boundary patrol camps, interior patrol camps and long-range patrol camps. Range Offices will continue to be operational forests/wetlands/wildlife management/administration units but will be better equipped (improved communication and a striking force with arms) to deal with organized smuggling of timber and poaching of tigers. Forest Stations will continue to be responsible with revenue collection but will increasingly shoulder patrolling duties with better equipments and manpower. Boundary camps will be established near designated stretches of forest boundaries neighboring villages with responsibility of checking boats at entry and exit levels. Interior and long-range camps will continue to be responsible for normal and mobile patrol by employing FD boats and improved communication equipments. As per the report 32 Forest Camps are to be closed down but 8 new Camps are to be set up at strategic locations and 2 Camps are to be upgraded as Forest Stations. Overall there will be existing 4 field Range Offices (two additional Ranges are at Divisional HQs), 18 Station Offices, 26 Boundary Camps, 18 Interior Camps and 7 Long-range Camps (Figure 1.3).

Field monitoring will be employed as a tool for effective protection by employing selected indicators and taking corrective actions. Under monitoring component main interventions could focus on, i) improving monitoring of field staff patrolling activities for controlling illicit felling and fishing, poaching of predators (tiger) and prey (deers), and ii) establishing monitoring units in the identified canals in selected compartments. Monitoring by senior FD staff such as DFO and ACF will be strengthened by providing adequate motorized boats and equipments including GPS, life saving devices and arms. Suitable monitoring indicators would include patrolling frequency, patrolling coverage and distance from the posts, and the details offence cases booked and offenders prosecuted.

A number of existing posts are lying vacant due to frozen recruitment. Under staffing component main recommendations focus on, i) updating the existing SRF organogram by reposting existing staff in line with redistributed posts, ii) recruiting field staff to fill all the existing vacancies, iii) providing free accommodation in barracks and food subsidy, and iv) promoting all the Boatman and keeping leave reserve staff. Under physical work component main recommendations would focus on, i) to establish adequate number of FD boat fleet and jetties, and provide for their regular maintenance and running costs in annual budget, and ii) to improve infrastructure including drinking water facilities, and patrolling equipments such as GPS, flashlight, uniform, footwear, map and stationary, first aid box, and arms for defense. Under telecommunication component main recommendations could focus on, i) strengthening existing walkie-talkie system, and ii) providing GPS and laptops for internet access wherever feasible.

Figure 1.3: Proposed Locations of Forest Stations and Camps



1.5 Protection through Co-management

The GOB has agreed to implement a co-management approach for managing the Sundarbans by involving key stakeholders. The gazette notification for establishing co-management councils and committees stipulates their constitution along with their roles and responsibilities Accordingly, two CMCs have been functioning to manage the Sundarbans comprising Chandpai and Sarankhola Forest Ranges of the Sundarbans East Division. Two more CMCs are being formed for Khulna and Burigualoni Forest Ranges of the Sundarbans West Division. Colloborative management – or co-management – is defined as a situation in which two or more social actors negotiate, define and gauarantee amongst themselves as fair sharing of the management functions, entitlements and responsibilities for a given territory, area or set of natural resources. An equitable sharing of benefits and responsibilities of the Sundarbans protection and management among the stakeholders is, therefore, an important part of a co-management approach. Establishing effective linkages of socio-economic and ecological incentives and biodiversity conservation is instrumental in eliciting stakeholders' participation in protecting, rehabilitating, conserving and sustainably managing the Sundarbans by building gainful partnerships based on shared rights and responsibilities.

Enhanced protection by FD is needed particularly for combating organized smuggling by outsiders and dacoits. The strengthening of existing protection infrastructure and redistribution of posts with enhanced presence of field staff as described above will help control organized smuggling. However, the protection of the Sundarbans cannot be ensured without gainfully involving key stakeholders including local community in the interface landscape and floating forests/fisheries dependent community. Community Patrolling Groups (CPGs) will be formed particularly on the northern and eastern side of the SRF by following the approved joint patrolling guidelines (IPAC, 2010). Conservation-oriented management of the Sundarbans with restrictions on the informal harvesting of forests and fisheries through enhanced protection will result in high opportunity costs to local poor in terms of foregone benefits, which they were deriving from the forests and wetlands before the implementation of strict protection/enforcements practices. Sustainable use of identified NTFPs including grasses, golpata, honey, wax and fish will, therefore, be allowed for bonafide consumption *in lieu* of their protection efforts and increased opportunity costs. The protection efforts will be augmented through communication and outreach activities, public awareness, stakeholders' access to livelihood and value chain activities in the interface landscape zone.

1.6 Summary of Main Prescriptions

Main prescriptions outlined under the above-developed habitat protection programs are summarized (Table 1.1) with respect to indicative timing of each proposed activity and responsibility assigned.

Table 1.1: Summary of Main Prescriptions: Habitat Protection Programs

Year	Main Activities	Main Outputs/Success Criteria	Responsibility
1 & 2	-Procuring protection & communication equipments and tools, imageries, etc.	Equipments & remote sensing products procured	FD
	-Reviewing the existing forest cover and land-use maps and updating them by using latest imageries/aerial photos and ground truthing	Updated maps prepared by RIMS	RIMS/FD
	-Strengthening the existing 2 CMCs (in East Division) and establishing co-management organizations (2 CMCs in West Division) and forming community patrolling groups	Co-management committees and patrol groups are in place	IPAC/FD/Stakeholders
	-Orientation and motivation of CMCs and CPGs	Motivated CMCs and CPGs are operational	FD/IPAC/ Stakholders
	- Controlling poaching & over-fishing, and illicit removals by associating CMOs	Reduced level of biotic interference as evident from less offence cases & protected forests	FD/CMOs
	-Providing incentives for good protection efforts to FD staff & CMOs, and disincentives for offenders	Good FD field staff and stakeholders rewarded	FD/CMOs/IPAC/SEALS
	-Establish conflict resolution mechanisms through co-management committees	Conflict resolution mechanism in place and operating	Stakeholders/ FD/IPAC/SEALS
	-Identifying the three management zones in the field by using maps and GPS	Clear markers on field boundaries	RIMS/FD/IPAC/SEALS
	-Protection monitoring by the FD field staff and the CMOs	Monitoring mechanism and protocols in place and operational	FD/CMOs
	-Converting existing Boatman as FG and redeployment	Forest Stations and Camps have FGs	FD/MOEF

3 and 4	-Delineating the boundaries of the 3 management zones and putting markers by associating CMCs and patrol groups -Developing a register of the boundaries and markers, and conducting annual inspections by supervisory FD field staff & CMCs -Conducting regular meetings of co-management committees and patrol groups for providing effective protection against illicit felling & fishing and poaching -Reviewing existing camps and stations and re-locating in phases, and formalizing the FD staff roles and responsibilities -Providing incentives for good protection efforts and disincentives for poor protection -Resolving forest and wildlife conflicts -Filling vacant posts as per the approved organogram - Continue protection monitoring by the FD field staff and the CMOs	Boundaries delineated in field and mapped Register updated and inspections done Regular meetings and reduced level of biotic interference Relocated camps and stations Good FD field staff and stakeholders rewarded Certain no. of conflicts resolved Field staff in place at all the camps and stations Increased natural regeneration	FD/CMCs/SEALS/ IPAC FD/CMC FD/CMOs FD/SEALS FD/CMCs FD/CMCs FD/MOEF FD/CMOs
5 and 6	-Maintaining the register of the boundaries and markers, and conducting annual inspections by supervisory FD field staff -Conducting regular meetings of co-management committees and patrol groups for providing effective protection against illicit felling and fishing and poaching -Controlling poaching of tigers and deers by forming FD managed special squads and associating local stakeholders -Providing incentives for good protection efforts and disincentives for poor protection -Resolving forest and wildlife including tigers conflicts - Continue protection monitoring by the FD field staff the CMOs	Register updated and inspections done Reduced level of biotic interference Nos. of tigers and deers stablised or increased as assessed by surveys Good FD field staff and stakeholders rewarded Certain no. of conflicts resolved Reduced offence cases and more saplings and trees	FD FD/CMOs FD/CMCs FD/CMCs Stakeholders/ FD/CMCs FD/CMOs

7 and 8	-Maintaining the register of the boundaries and markers, and conducting annual inspections by supervisory FD field staff	Register updated and inspections done	FD
	-Conducting regular meetings of co-management committees and user groups for providing effective protection against illicit felling and fishing	Reduced level of biotic interference	Stakeholders/ FD/CMCs
	- Controlling poaching, illicit removals from the SRF and tiger & deer killings by associating local stakeholders	Reduced level of biotic interference	Stakeholders/ FD/CMCs
	-Providing incentives for good protection efforts and disincentives for poor protection	Good FD field staff and stakeholders rewarded	FD/CMCs
	- Resolving wildlife and forest conflicts	Certain no. of conflicts resolved	Stakeholders/ FD/CMCs
	- Continue protection monitoring by the FD field staff and the CMOs	More saplings and trees	FD/CMOs
9 and 10	-Continue maintaining the register of the boundaries and pillars, and conducting annual inspections by supervisory FD field staff	Register updated and inspections done	FD
	-Conducting regular meetings of co-management committees and user groups for providing effective protection against illicit felling and poaching	Reduced level of biotic interference	Stakeholders/ FD/CMCs
	- Controlling poaching, illicit removals and poaching by associating local stakeholders	Reduced level of biotic interference	Stakeholders/ FD/CMCs
	-Providing incentives for good protection efforts and disincentives for poor protection	Good FD field staff and stakeholders rewarded	FD/CMCs
	- Resolving tiger-man conflicts	Certain no. of conflicts resolved	Stakeholders/ FD/CMCs
	-Continue protection monitoring by the FD field staff and the CMOs	More trees and canopy	FD/CMOs

2. Wildlife Sanctuaries Management Programs

Wildlife includes all plants and animals, normally wild by nature and so not domesticated. Special protection measures were contemplated quite early for wildlife, mainly the elephants under the Bengal Elephant Preservation Act, 1879. The Wildlife Birds and Animal Protection Act, 1912, provided for the preservation of wildlife in Bengal. The promulgation of Bangladesh Wildlife Preservation Order in 1973 was a very significant development that strengthened wildlife conservation with provisions for declaration of wildlife sanctuaries and national parks. With the promulgation of the Wildlife (Preservation) Act, 1974, the Forest Policy of 1994 and the amendment of Forest Act in 2000 and the resulting Social Forestry Rules of 2004 and 2010, the emphasis of forests management has shifted from timber production to ecological requirements, conservation of biological diversity, meeting bonafide consumption needs of local people and other services accuring from forests.

The management of the three wildlife sanctuaries as core zone is described in this Chapter; the proposed 4th wildlife sanctuary when gazetted will also be covered under this core zone. The Chapter covers the wildlife sanctuaries management programs that will be implemented in the three wildlife sanctuaries; the management of the remainder SRF as buffer zone to the three sanctuaries is described in detail in the next Chapter 3, whereas the management of the indentified interface landscape zone is provided in Chapter 8. In addition to the forests, the wetlands and wildlife including tiger are integral parts of the Sundarbans core zone. Although the production of wood, mainly timber was the main objective of the SRF management in earlier stages, the value of forests functions and services such as biodiversity conservation, regulation of stream flow, carbon sequestration, protection against climate change, conserving breeding grounds for fish, etc. were increasingly recognized when the three wildlife sanctuaries (East, West and South) were established inside the SRF in 1996, which were in 1997 declared as a UNESCO World Heritage Site and categorized as natural heritage under the category (ii) and (iv) of the Convention.

2.1 Program Objectives

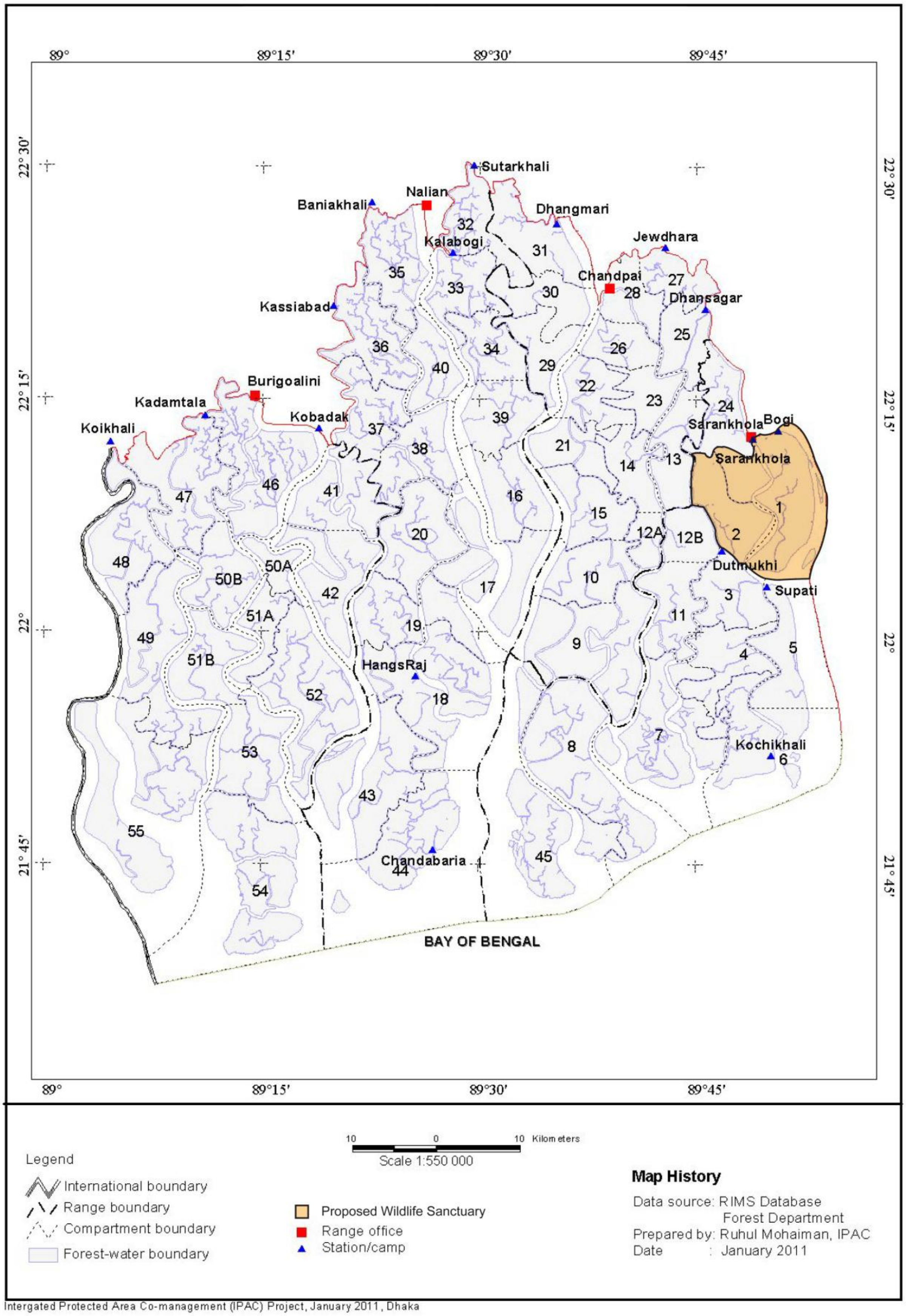
Main objectives of the wildlife sanctuaries management programs are to, i) manage the three sanctuaries in as natural ecosystem and undisturbed condition as possible as source of important genetic and biological resources, ii) provide effective protection to the constituent biodiversity including wildlife and aquatic resources against all forms of biotic interference, required for maintaining natural course of ecological succession, iii) rehabilitate and maintain good quality forest cover with natural structure and composition, iv) shift subsistence consumption use of forests, wildlife and aquatic resources to the buffer zone and the interface landscape zone, v) ensure protected habitat and prey base for tiger as a flagship species, vi) regulate high impact visitor use for outdoor recreation, research and educational purposes by mounting an awareness and motivation program, and vii) sequester and store carbon.

2.2 Management of the Wildlife Sanctuaries as Core Zone

The notified areas of the East, West and South wildlife sanctuaries constituting the respective core zones of the three gazetted PAs comprise the areas of high biodiversity values : The proposed fourth wildlife sanctuary, comprising compartments 1 and 2 (Figure 2.1), when gazetted will also form part of the core zone. The management in the core zone will focus on conserving natural forests and wetlands by providing long-term protection (as described in Chapter 1) against all forms of biotic pressure. This will be achieved by providing protection against illicit removals of forest and aquatic resources, and controlling poaching and poisoning of fish in partnerships with the co-management organizations. Effective protection against biotic pressure will allow natural processes of regeneration of wetlands and forests required for creating a favorable habitat for wildlife including tiger and its prey base. A special use sub-zone will be designated to include the areas containing existing infrastructures and fenced compounds.

Although the tiger is included in the IUCN Red Data Book of seriously endangered species, it has adapted and survived rather well in the Sundarbans ecosystem, which is not its natural home. However, the behavioural ecology and physiology of tiger in the Sundarbans should be studied for better understanding. The requirements of tiger as a flagship and umbrella species will guide management decisions and monitoring of habitat. Predator (tiger)-prey (deer, boar) ratio will be maintained through selective management interventions while preserving and increasing the diversity of interspersion of habitat. The prey base (including deer population) will be maintained by providing protection. Existing grasslands will be maintained and degraded grasslands will be restored through protection, and by arresting ingress of mangrove vegetation as a part of ecological succession. In wildlife rich areas dead and hallow trees will help provide shelter/nest to wildlife. Breeding sites of animals and fish and other important sites (e.g. burrow) harboured by nocturnal animals will be specially protected and maintained. One animal clinic with rehabilitation pen will be established at Mongla for rehabilitation and treatment of wounded animals.

Figure 2.1: Location of the Proposed Wildlife Sanctuary



Intergated Protected Area Co-management (IPAC) Project, January 2011, Dhaka

Co-management practices, implemented through co-management councils and committees, will be tailored to strengthen protection efforts against illicit felling and fishing, and poaching of wildlife including tigers and deers. The SRF dependent communities will be motivated to considerably reduce their removals and *in lieu* they will be provided conservation-linked livelihood opportunities through value chain and income generation activities (see Chapter 6) to be implemented for the local community through the CMCs. In order to reduce human interventions inside the sanctuaries, the harvesting of non-timber forest products including honey, wax, hantal and bark will not be allowed in the core zone. Chapter 7 describes eco-tourism in the SRF including the core zone comprising the wildlife sanctuaries. The visitor use of the core zone will be regulated and only low impact activities such as hiking, sightseeing, jungle boating, cruising and wildlife watching will be allowed; high impact visitor activities such as motorized vessels and group picnics will be allowed only in identified routes. The development of eco-tourism facilities is discussed in Chapter 8 where the establishment of wildlife museums, eco-cottages, trails and walkways, nature interpretation centres, watch towers, etc have been discussed in detail.

A number of natural waterbodies including rivers, streams/chara/khals, creeks and ponds are present in the core zone areas and their management will be taken up as provided in Chapter 4. A total ban on fishing in the waters inside the wildlife sanctuaries will be enforced by FD by involving CMCs to ensure the sanctuaries as protected breeding/spawning areas for aquatic fauna including marine fish. Throughout the year, all types of fishing including fin fishes, crustaceans (shrimps, prawns, crabs) and sea snakes, catching fries of fin fishes and prawns, and collecting mollusk shall be banned. Special efforts will be taken for the protection of Olive Ridley turtles on Putney Iseland (about 4 km from the South sanctuary forest boundry) and Dimer *Char* (about 1 km from the East Sanctuary forest boundary). Unauthorized fishing, poaching, hunting and poisoning will be checked by FD by associating CMCs as part of co-management activities. No temporary or permanent settlements of fishers will be allowed inside the three sanctuaries. River banks will be stabilized by protecting natural regeneration that generally comes up below the convex sections of the curves on meandering rivers.

2.3 Tiger Conservation

This section, although applicable to the entire SRF, is included in this Chapter in view of the conservation importance of tiger as flagship species for the overall management of core zone forests and wetlands in general and wildlife in particular. As per different reports and estimates there are 300-500 tigers in Sundarbans, the only significant tiger habitat left in Bangladesh (there are reports of some tigers in Chittagong Hill Tract on the border of India and Myanmar). A recent assessment by FD estimates 440 tigers in the SRF. Being an umbrella species, effective conservation and management of tigers would automatically result in securing the management of its habitat and other lower pyramid wildlife including its prey, the deers and wild boars. The tigers are threatened due to a number of factors that in the Sundarbans include poaching, habitat degradation and loss, prey (deer and wild boar) depletion, tiger-human conflicts, disease, increase in salinity and consequent vegetation patterns due to reduced amount of fresh water, and adverse impacts of climate change including sea rise. The following Table 2.1, developed based on the approved Tiger Action Plan (FD, 2010) for Bangladesh, describes main management objectives and strategic actions for tiger management.

Table 2.1: Tiger Management Objectives and Strategic Actions

Sl. No.	Tiger management objective	Strategic action
1.	Assess the present and desired state of predator (tiger) and prey (deer, boar) occupancy, connectivity and population size	Develop suitable methods for assessing predator and prey occupancy, connectivity and population size Project and monitor target state predator and prey occupancy, connectivity and population size with respect to optimum carrying capacity and management scenarios
2.	Assess potential threats and minimize man-tiger conflict and control of poaching	Investigate potential threats to prey and predator by holding PRA/RRA with key stakeholders incldung FD field staff and CMCs Evaluate causes and scale of man-tiger conflicts, and tiger & deer poaching by involving CPGs Awareness rasing and motivation of FD field staff and CMOs as recommended in Chapter 10 of Part II Reduce man-tiger conflicts, and tiger & deer poaching by mitigating causes and threats by involving CMCs Strengthen wildlife law enforcement and control illegal trade both at local and national/internation levels
3.	Assess current and desired state of the habitat for predator (tiger) and prey (deer)	Evaluate tiger and deer habitat requirements Develop suitable tiger & deer habitat indicators Monitor tiger and deer habitat requirements
4.	Ensure tiger habitat protection	Implement habitat protection measures by associating CMCs and CPGs as recommended in Chapter 1 of Part II
5.	Mitigate climate change effects on tiger habitat	Implement climate change mitigation and adaptation measures as recommended in Chapters 5 and 6
6.	Build management capacity of FD field staff and CMCs	Implement capacity building programs as recommended in Chapter 9
7.	Strengthen conservation awareness, reaserach and legal enforcement for tiger and habitat protection	Implement conservation and outreach programs as recommended in Chapter 9
8.	Colloborate with relevant national and international agencies	Undertake joint initiatives such as the ongoing collaboration with the Government of India Form relationships with other relevant government and non-goevrenment organizations

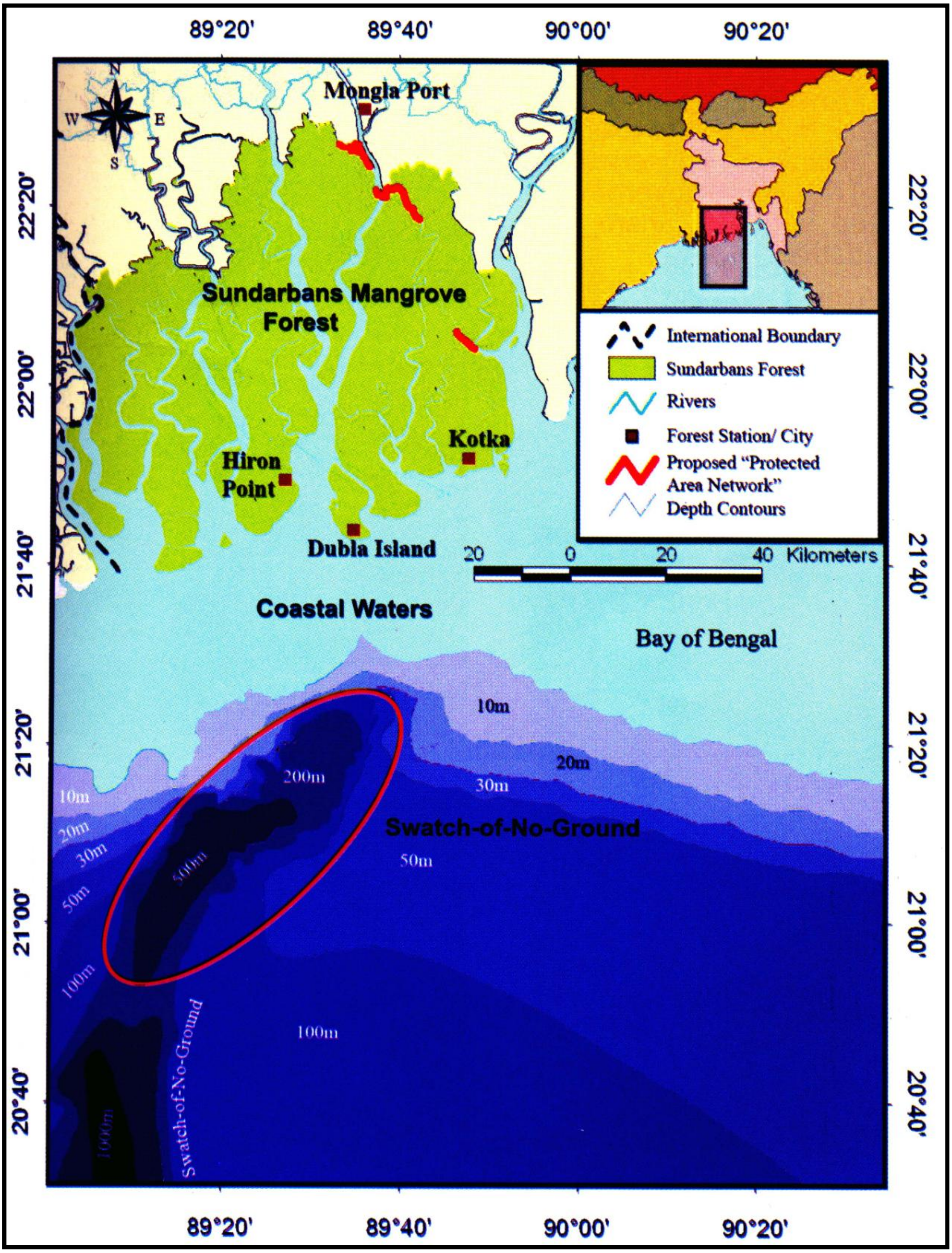
2.4 Cetacean Diversity Management

This section is based on the proposal for a PA network for cetacean diversity in Bangladesh as developed in 2008 under Bangladesh Cetacean Diversity Project (BCDP, 2008) in association with Wildlife Conservation Society, New York. Cetacean diversity is a scientific grouping of dolphins, whales and porpoises, and its abundance and habitat in Bangladesh are found in a 120-km wide belt of estuarine, coastal and deep-sea waters across the SRF and offshore to a 900+ meter deep under-sea canyon known as the Swatch-of-No-Ground (SoNG). The SoNG is a submarine canyon located less than 40km from the rim of the western Sundarbans mangrove forests and incising approximately 130km inside the continental shelf in a northeast direction. Cetaceans in the SoNG are concentrated at the head of the submarine canyon with Indo-Pacific bottlenose dolphins and Bryde's whales occurring close to the rim and spinner and spotted dolphins occurring farther offshore. A large number of Ganges River dolphins (or *Shushuks*), Irrawaddy dolphins and finless porpoises are found in this habitat.

Ganges River dolphin (*Platanista gangetica*) is distributed farthest downstream in the northern waterways of this belt whereas Irrawaddy dolphin (*Orcaella brevirostris*) is distributed farthest upstream in a generally narrow geographic band occurring within the same habitat. Indo-Pacific humpback dolphin (*Sousa chinensis*) and finless porpoise (*Neophocaena phocaenoides*) is distributed farther offshore but still occurring in habitat influenced by freshwater inputs. An high diversity abundance is found in wide channels with more than two small confluences or at least one large confluence, resulting in the hydraulic refuge and increased biological productivity provided by counter-currents induced by confluences. The SoNG, at a relatively short distance from the fluvial habitats of Shushuks, is a hotspot of biological productivity due to upwelling currents that support large groups of Indo-Pacific bottlenose dolphins (*Tursiops aduncas*), Pantropical spotted dolphins (*Stenella attenuate*), Spinner dolphins (Stenella longrirostris) and Bryde's whales (*Balaenoptera edeni/brydei*). The SoNG plays an important role in sediment transport carrying nearly 30% of the total load supplied by the Ganges-Brahmaputra-Meghna rivers system from the continental shelf to the world's largest deep-sea fan.

The sustainable existence of cetaceans is threatened by incidental killing in gillnet fisheries, depletion of prey due to loss of fish and crustacean spawning habitat, trawl fisheries, sea-level rise due to climate change, and massive non-selective catch of fish fingerlings and crustacean larvae in small mesh mosquito nets and toxic contamination from large, upstream human population centers. Addressing these threats by implementing proposed habitat protection measures (as described in Chapters 1 & 2) will help protect the habitat and conserve cetacean biodiversity. Additional protection measures focused on wetlands and deep-sea waters having cetacean abundance would include identifying and protecting their regular routes, controlling illegal fishing activities and use of damaging fish nets, reducing toxic contamination and water pollution, addressing climate change, and community awareness through CMCs. In addition to the three sanctuaries including southern waters, further southward sea-waters including SoNG may be designated as no-fishing zones and protected by involving the CMCs. The FD may review the BCDP (2008) proposal and recommend to the MoEF for declaring a marine protected area after proper study.

Figure 2.2: Map showing proposed Marine Protected Area and the Swatch-of-No-Ground



2.5 Summary of Main Prescriptions

Main prescriptions outlined under the above-developed wildlife sanctuaries management programs are summarized in Table 2.2 with respect to timing of each proposed activity and responsibility assigned.

Table 2.2: Summary of Main Prescriptions: Wildlife Sanctuaries Management Programs

Yr	Main Activities	Main Outputs/ Success Criteria	Responsibility
1 & 2	-Protecting forests & wetlands and comprising biodiversity against biotic interference as listed in Chapter 1	Reduced level of biotic interference	Stakeholders/ FD/CMCs
	-Assessing the current and desired state of tiger (and its prey base) occupancy, connectivity and population size	List & status of existing tiger occupancy & size	FD
	-Improving forests & wetlands as habitat for wildlife including tiger and its prey base	Improved tiger habitat	FD/CMCs
	-Encouraging natural regeneration of terrestrial and aquatic vegetation	Improved habitat	FD
	-Implementing habitat improvement works including conservation of grasslands and open patches as special habitats for deers as prey for tigers	Rehabilitated habitat	FD/CMCs
	-Implementing habitat restoration works (identification of eco-restoration activities including water conservation and excavation, khal connectivity, and other low input land husbandry practices)	Restored habitat	FD/SEALS/ CMCs
	-Conduct a participatory enquiry into man-tiger conflicts for assessing causes and possible resolution through awareness and motivation	Enhanced awareness among the local stakeholders	FD/CMCs
	-Strengthen wildlife enforcement for control of illegal trade	Reduced poaching	FD/CMCs
	-Develop proposal for the declaration of 4th wildlife sanctuary comprising compartments 1 and 2	Proposal	FD
	-Develop indicators and monitor tiger and its habitat	Monitoring mechanism developed and operationalized	FD
	-Review the BCDP proposal for establishing a marine protected area	Study report	FD
	-Establish collaboration with relevant national and international agencies for tiger conservation including lobal toger initiative	Regional and global limkages	FD
3 & 4	-Continue protecting forests & wetlands and comprising biodiversity against biotic interference	Reduced level of biotic interference	Stakeholders/ FD/CMCs
	-Plan and implement activities for achieving desired state of tiger (and its prey base) habitat connectivity and monitoring	Improved tiger habitat	FD/CMCs

	-Continue measures for improving forests & wetlands as habitat for wildlife including tiger and its prey base	Improved tiger habitat	FD
	-Continue encouraging natural regeneration of terrestrial and aquatic vegetation	Improved habitat	FD
	-Implementing habitat improvement works including conservation of grasslands and open patches as special habitats	Rehabilitated habitat	FD/CMCs
	-Implementing habitat restoration works (identification of eco-restoration activities including water conservation and excavation, khal connectivity, and other low input land husbandry practices)	Restored habitat	FD/CMCs
	-Reduce man-tiger conflicts by addressing causes and resolution through awareness and motivation	Enhanced awareness among the local stakeholders	FD/CMCs
	-Strengthen wildlife enforcement and control illegal trade	Reduced poaching	FD/CMCs
	-Operationalize the management of the 4th wildlife sanctuary	Adequate management facilities and manpower	FD
	-Continue monitoring tiger and its habitat and take corrective measures for its conservation	Monitoring mechanism in operation	FD/CMCs
	-Develop minimum infrastructure and facilities for the newly established marine protected area	Facilities in operation	FD/SEALS
	-Continue collaboration with relevant national and international agencies for tiger conservation including lobal toger initiative	Regional and global limkages	FD
5 to 10	Continue the above-listed activities and take mid-term corrective actions in the year 6 onwards	As above	As above

3. Sustainable Forests Management Programs

This Chapter covers sustainable forests management programs that will be implemented in the buffer zone of the SRF (i.e the entire SRF, except the three wildlife sanctuaries, the management of which is already described in detail in Chapter 2). In effect, this chapter covers the revision of the IFMP, which prescribed mainly harvesting of timber and NTFPs from the SRF, excluding the three wildlife sanctuaries. Recommendations for the wetlands management in the entire SRF are presented in the next Chapter 4.

3.1 Program Objectives

Main objectives of the sustainable forests management program are to, i) maintain ecological succession in the constituent forests in order to ensure long-term existence of the Sundarbans ecosystem, ii) develop and maintain mangrove forests as carbon sinks and good habitat favoring the conservation of flora and fauna including tiger, iii) improve regenerative capacity of the Sundarbans by conserving forests and constituent biodiversity through co-management approach that benefits local community, iv) maintain mangroves and wetlands as breeding grounds of aquatic resources including fisheries, and v) manage the Sundarbans for their protective functions and services against natural calamities including cyclones and storms.

3.2 Management of the SRF as Buffer Zone to the Wildlife Sanctuaries

In view of the felling moratorium currently in place (effective until 2015) it is not expected that in near future (at least during the plan period of ten years) any commercial tree felling will take place. Moreover, the present emphasis on the Sundarbans forests functions and services including the mangroves as carbon sinks under the reduction of emissions from deforestation and forest degradation (REDD+) mechanism means that the present ban on tree felling is expected to continue in future as well. Keeping in view of conservation-oriented management of the SRF, most of the management prescriptions detailed in the previous Chapter 2 for managing the three wildlife sanctuaries as core zone will as well be applicable for managing the buffer zone comprising the remainder SRF. However, limited harvesting of non-timber forest products including fisheries resources and golpata will continue as per the prescriptions detailed in the Plan.

All the forests/wetlands protection recommendations including control of illicit harvesting of forests and wetlands resources, as enumerated in Chapter 1 of Part II, will be applicable for the entire buffer zone as well. The FD has designated 18 *khals* in the buffer zone as fish sanctuaries which will continue to be protected. In addition, more such fish sanctuaries will be designated as suggested in Chapter 4. The wetlands in buffer and core zones will be managed as per the recommendations made in the next Chapter 4, which also contains regulatory prescriptions for sustainably harvesting aquatic resources including fish and crabs.

Appropriate regulatory prescriptions are provided in this chapter in case the Government of Bangladesh decides to lift the felling moratorium and as a result of which the FD takes recourse to timber harvesting in the identified felling series of the buffer zone. For this a forests inventory has been completed in 2010 and is described in this chapter.

3.3 Forests Inventory Design

The forest resources of the SRF were inventoried in 1959-61 (Canadian Forestry, Forestal), in 1981-85 (ODA), in 1995-1997 (FRMP) and in 2009-2010 (IPAC). The latest re-measurements, with the assistance of US Forest Service and USAID supported IPAC project, focused on the systematic randomly sampled 150 sample plots (each cluster plot designed with 5 circular subplots to be compatible with the previous inventory design) that were inventoried by FD field staff. These 150 plots were sampled from the 1204 sample plots laid out as a systematic sampling grid (at 1-minute intervals of latitude/longitude), with historical data available from those ground points established during FRMP (see Revilla, 1996 for full inventory details).

The original plot grid was sub-sampled by selecting every second plot in both the x and y directions and these yielded 295 plots. But to attain a lower plot density, every second row of this new grid was sampled to yield 155 plots, of which 5 plots were found to be in waters of the Sundarbans rivers/streams. Thus 150 plots were inventoried by two FD field inventory groups by following the detailed inventory methods given in the Protocols for "Measuring & Reporting Carbon Stocks in Mangrove Forests" by Donato *et al* (2009). Each group, with an engine boat and a boatman, was led by an ACF and comprised one Forest Ranger/Deputy Forest Ranger, two Foresters, two armed Forest Gaurds, two students and two laborers.

The plots are situated in a systematic grid across the SRF, at regular intervals of latitude and longitude (Figure 3.1). But there were some gaps in the sampling grid, which were carry-over from the previous inventory and reflect where large water channels preclude forests measurements. If a grid point was not measured in previous inventory (gap in the grid), it should not be measured now. A plot consisted of 5 circular subplots, oriented as a centre subplot with 4 more subplots oriented in cardinal directions from the centre (east, west, south, north). Different forest components were measured in different size circles (nests), co-located at the centre of each subplot (Figure 3.2).

A detailed forest inventory, by following the forest/carbon inventory guidelines as contained in USFS (2009), covering all the 1204 plots inventoried during FRMP will be repeated in the core and buffer zones in the year 2018 so that a revised plan could be ready by the end of this plan in 2020.

Figure 3.1: Sundarbans Carbon and Forestry Inventory Grid

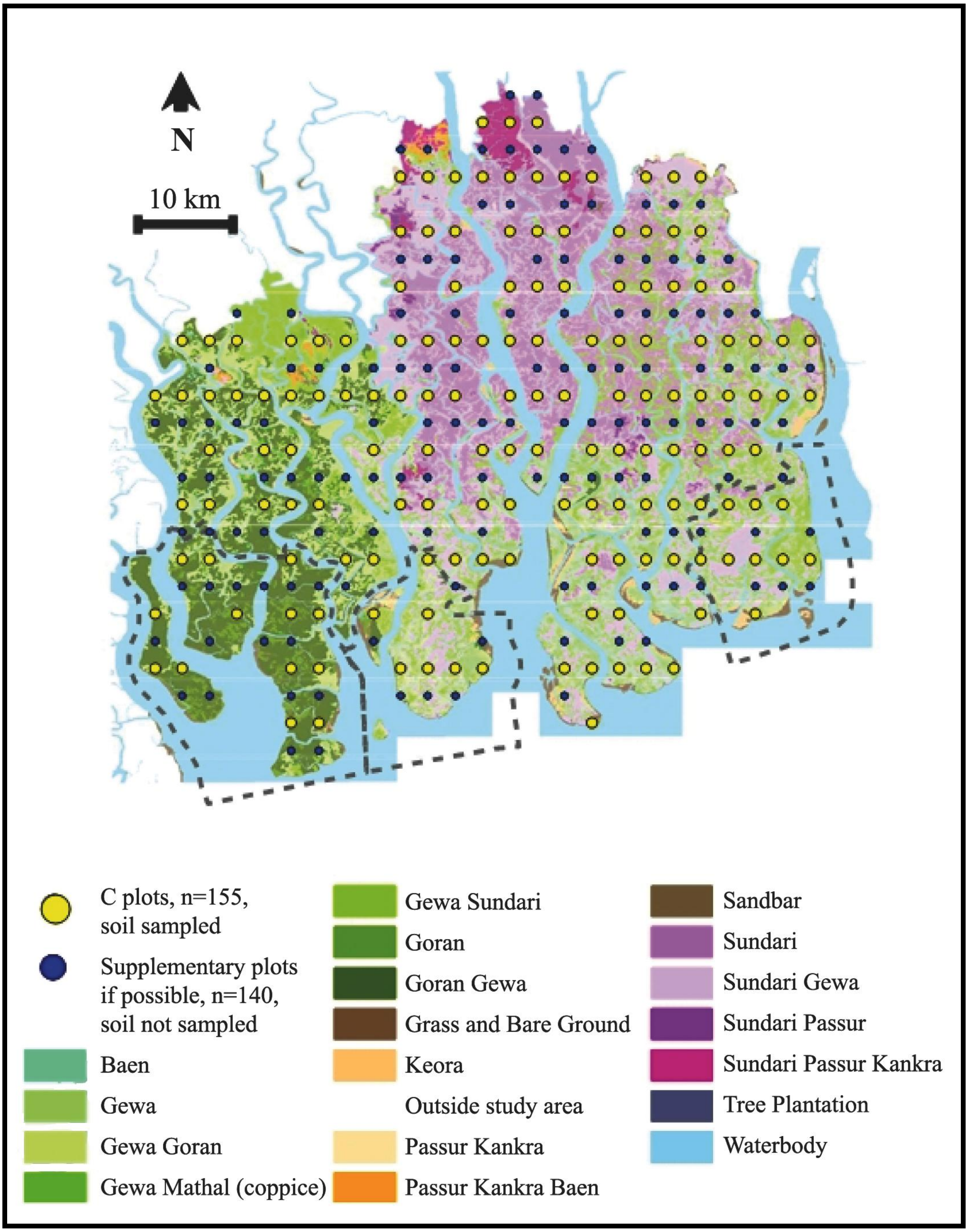
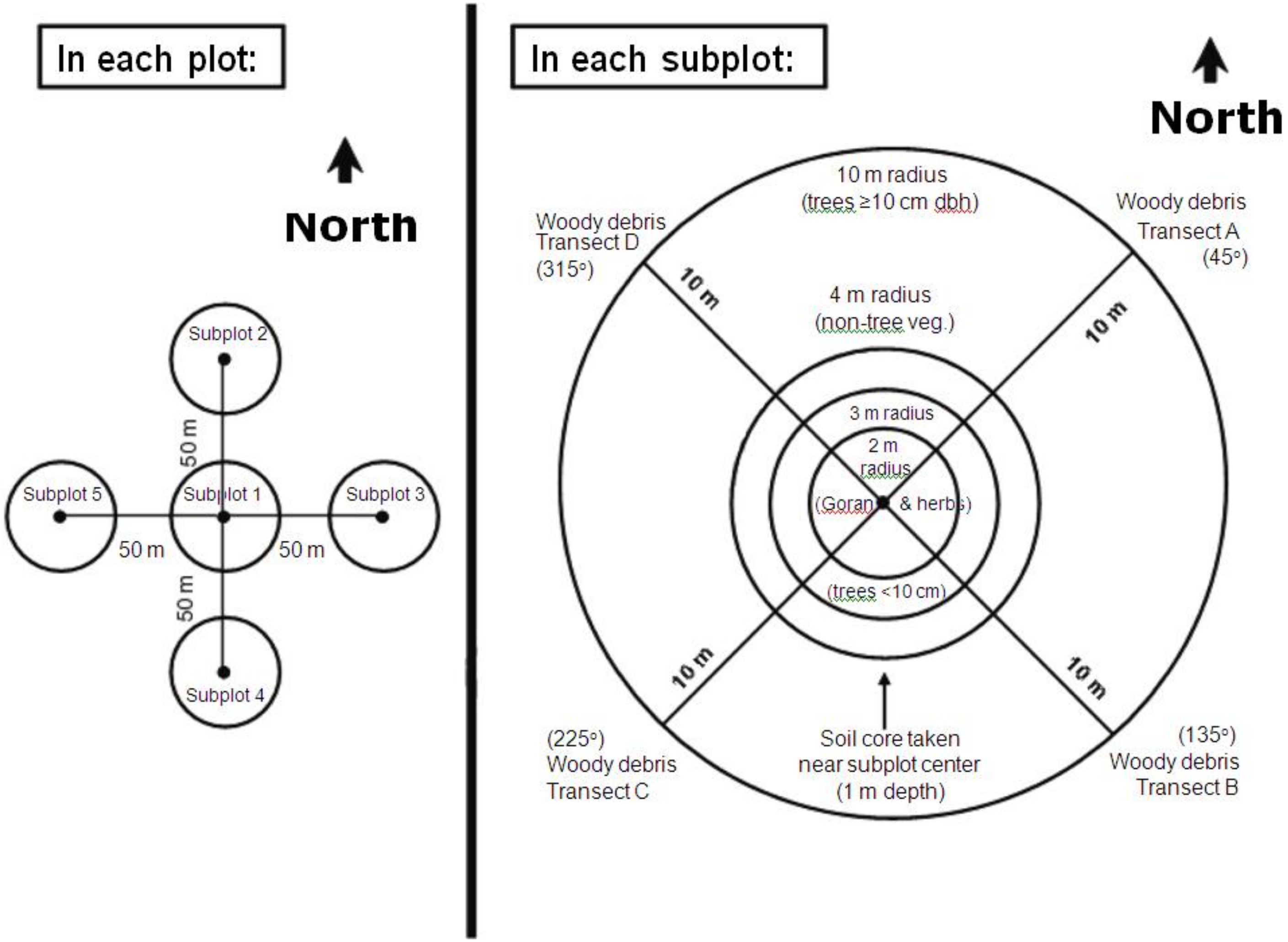


Figure 3.2: Schematic Plot Layout



3.4 Vegetation Analyses

Inventory data collected from 1204 sample plots under the FRMP, 1996-1997 and the inventory data of 150 sample plots under IPAC, 2009-2010 were employed for the temporal vegetation analyses. These two sets of data were used to estimate the growing stock details based on which a number of important conclusions are drawn as discussed below. Data from the common 150 sample plots of the 1997 inventory and 2009 inventory (Table 3.1-3.3) were compiled and the inferences compared with the report prepared from 1204 sample plots (Tables at pages 27-30 and 92-95, Revilla 1996). It was inferred from the analyses that the results are approximately similar and are so comparable. The field data collected during the current inventory were compiled in line with the procedures adopted during the previous inventory and management planning. The data were organized as per the parameters as given Tables 3.1A, 3.1B, and 3.1C.

Table 3.1A : Plant category, plant size and plot radius used for the inventory data collection

Plant category	Size (DBH in cm)	Plot radius (meters)	
Seedlings	Height< 1.5 m	1.0	
Saplings	0-2.4	2.o	
Small Poles	2.5-9.9	5.0	
Big Poles	10.0-15.0	5.0	
Trees	DBH≥15.0	11.0	
Goran		2.0	
Size Class	**Stem Size at Base**	**Mean biomass of stems (kg/stem)**	
Small	0 - 0.6 cm	Small	0.00
Medium	0.6 - 2.5 cm	Medium	0.336
Large	2.5 - 7.6 cm	Large	3.637
Extra-Large	> 7.6 cm	X-large	10.551

Table 3.1B : Statistics estimated for different plot sizes

Plant category	Estimated
Seedlings	Number of stems per hectare (N/ha) for sundari, gewa, keora and baen, and other species grouped together as "Others".
Saplings	N/ha for sundari, gewa, keora, baen and other species grouped together as "Others".
Small Poles	N/ha for 2.5-4.9 cm and 5.0-9.99 cm DBH classes for sundari, gewa, keora, baen and other species grouped together as "Others".
Big Poles	N/ha, Basal area per hectare in m^2 (BA/ha) and Volume up to 10.0 cm top end diameter in cubic meters (m^3) per hectare (V10/ha) for sundari, gewa, keora and baen, and other species grouped together as "Others".
Trees	N/ha, BA/ha and V10/ha for different DBH classes and total for sundari, gewa, keora and baen, and other species grouped together as "Others".

Table 3.1C: Estimation procedures for different parameters

Statistics	Estimation procedures	Remarks
N/ha	Total number of stems recorded in the samples/sampled area	
BA/ha, m^2	∑Pi*(DBH/2)^2/sampled area	
V10/ha, m^3	Different volume equations developed by FRMP inventory as given below (Revilla, 1996) were used to estimate the volume of each big pole and tree:	
Species	Volume Equations:	
Sundari	V10= - 0.00006083*D^1.9631*h^0.8270	V10=0 if D<10
Gewa	V10= 0.0004218*D^2-0.002032-0.2506/D	V10=0 if D<10
Keora	Ln(V10ub)= -15.9104+5.1158*ln(D)-0.0707/D	If D>+72, Otherwise V10ub = 2.407
Passur	Ln(V10ub)= 10.3302+3.0802*ln(D)-0.03026*d	If H>+10.7, D<12
Dundul	V10ub= 0.040	if 10<=D<12
	V10ub= 0.070	if 12<=D<17.5
	V10ub= 0.153	if 17.6<=D<22.5
	V10ub= 0.289	if 22.6<=D<27.5
	V10ub= 0.436	if D>27.5
Kankra	Ln(V10ub)= -6.6346+1.4818*ln(D)+0.02088*D	if H>+ 10.7
	Ln(V10ub)=-7.4828+1.7169*ln(D)+0.01095*D	if h<10.7
Baen	Ln(V10ub)=-9.4214+2.610*ln(D)-0.01155*D	
Goran	Vt=0.001429-0.001111*D+ 0.0004294*D^2	
	Wt(KG)= 1.337-0.8816*D+0.3876*D^2	
Misc. tree	Ln(V10ub)=-10.8153+3.2840*ln(D)-0.05561*D	if D<+59, Other wise V10ub=0.494
Where:	D is Diameter at Breast Height in centimeter	
	H is Height in meters	

The basal areas (BA) of each big pole and tree were estimated with the formula pi*(DBH/2) ^2. The basal area for each big pole and tree was added to get the total for each species as required and then these totals were divided by the sampled area to covert to per hectare basis. It was observed that of the 750 sub-plots (of 150 plots), in about 700 sub-plots seedlings/saplings/poles/trees were available. Similarly, the volume of each big pole and tree were estimated first by using the desired volume equation, followed by conversion on per hectare basis. The number of seedlings, saplings, poles and trees for whole of the SRF on per hectare basis for sundari, gewa, keora, baen, other species and total for all the species were estimated and are presented in Table 3.2. Similarly, the basal area in square meters (BA/ha, M^2) and volumes (V10/ha, M^3) of poles (DBH 10-15 cm size) and trees of different DBH classes for sundari, gewa, keora, baen, other species and total for all the species for the whole of SRF on per hectare basis (ha) also were estimated and are presented in Tables 3.4 & 3.5. To estimate the change of different statistics, the differences of these statistics were also estimated and are presented in Tables 3.4 & 3.5. The changes expressed in percents are given in Table 3.6.

From the results it is evident that 53,806/ha number of seedlings were grown in 2009 compared to 34,723/ha seedlings in 1996. Main reason for this increase is due to the fact that the seedlings grow during rainy seasons and gradually a number of them dye out during the following dry season. Only a small portion of seedlings thus survive : Siddiqi (1988) reported from his seven years study that the average number of seedlings regeneration is about 35, 625/ha. So the number of seedlings in 1996 is very close to the average and 2009 results are very high. Additionally, seedlings regeneration during the period is high due to non-harvesting of timber species including sundari and gewa, due to the ongoing ban on commercial felling. The total number of saplings for all the species survived (5,545/ha) from the previous years' seedlings in 2009 is less compared to 8,088/ha in 1996.

The total number of poles for all the species of sizes 2.5-5.0 cm and 5.0-10.0 cm DBH classes increased from 1,008 to 5,003 and 1,133 to 4,364 per hectare, which amounts to 31 and 21 percent increase respectively. The detailed estimates for the species sundari, gewa, keora, baen and all the remaining species grouped together as "others" are given in Tables 3.3 to 3.7. The number of poles of size 10-15 cm DBH classes and number of trees for all the species have also increased from 384 to 507 and 142 to 297 respectively, which are about 396% and 109% increase respectively. Similarly, the BA/ha and V10/ha for poles of DBH class 10-15 cm and trees increased about 285, 32, 113 and 135 percent respectively. The tree N/ha, BA/ha and V10/ha have increased for all the DBH classes. The volume increment for the species sundari was 29.188 m^3/ha (from 19.016 m^3/ha in 1996 to 48.204 m^3/ha in 2009) (Tables 3.5 to 3.6). Similarly, the volume increment for the species gewa was 5.572 m^3/ha (from 2.268 m^3/ha in 1996 to 7.84 m^3/ha in 2009).

Table 3.2: Number of seedlings, saplings and poles for the years 2009 and 1996 in the Sundarbans

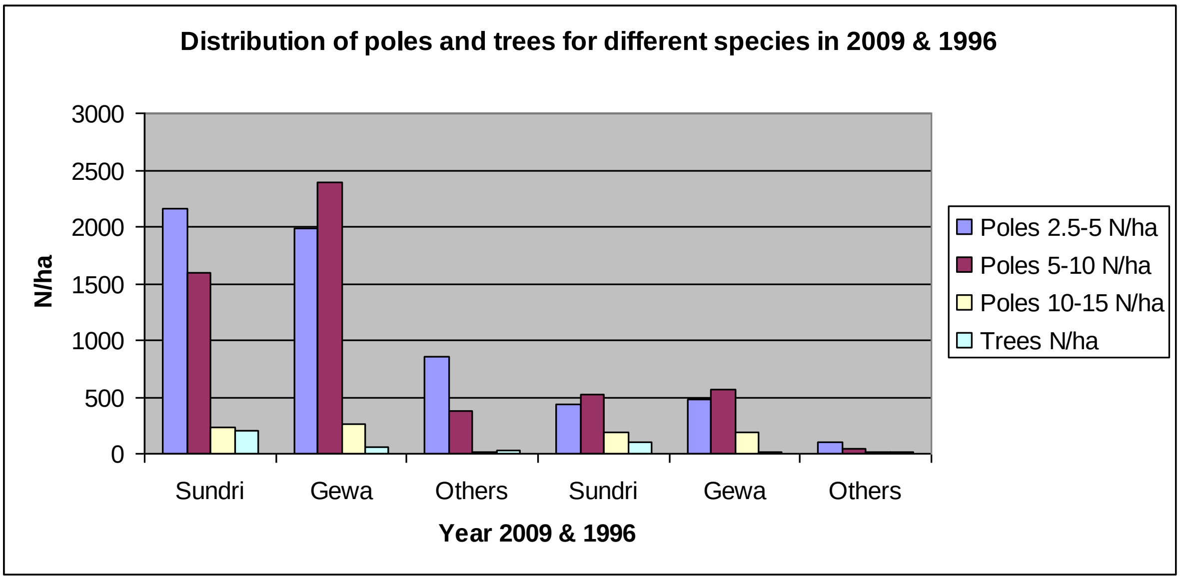
Year 2009	Seedlings	Saplings	Poles in DBH class in cm				
Size class	Ht<1.5m	DBH<2.5 cm	2.5 – 5	5 -10	10-15		
Species	N/ha	N/ha	N/ha	N/ha	N/ha	BA/Ha (m^2)	V10/ha (m^3)
Sundari	34776	3044	2166	1596	234	2.818	13.922
Gewa	13235	1266	1984	2393	255	2.929	9.844
Baen	42	0	0	0	0	0.001	0.005
Keora	5	5	3	9	1	0.016	0.067
Others	5748	1231	850	366	17	0.199	0.651
Total	53806	5547	5003	4364	507	5.963	24.490
Year 1996							
Species	**N/ha**	**N/ha**	**N/ha**	**N/ha**	**N/ha**	**BA/Ha(m^2)**	**V10/ha (m^3)**
Sundari	20522	3957	428	523	188	2.165	10.397
Gewa	5971	2627	476	560	184	2.045	6.647
Baen	23	6	1	1	1	0.002	0.005
Keora	5	3	1	0	0	0.006	0.025
Others	8203	1495	100	49	10	0.118	0.384
Total	34723	8088	1008	1133	384	4.336	17.457

Table 3.3: Differences/Changes in seedlings, saplings and poles between 2009 and 1996

	Seedlings H<1.5 m	Saplings D<2.5	Poles 2.5-5	Poles 5-10	Poles 10-15 cm DBH (D)		
Species	**N/ha**	**N/ha**	**N/ha**	**N/ha**	**N/ha**	**BA/Ha (m^2)**	**V10/ha (m^3)**
Sundari	14255	-913	1737	1073	46	0.653	3.525
Gewa	7264	-1361	1508	1833	70	0.884	3.197
Baen	19	-6	-1	-1	0	-0.001	0.000
Keora	0	1	2	9	1	0.010	0.042
Others	-2456	-264	750	317	7	0.082	0.267
Total	19083	-2542	3995	3231	123	1.627	7.032

The number of trees (N/ha), Basal Area (BA/ha, m^2)) and volume up to 10 cm top end diameters (V10/ha, m^3) for the poles with DBH 10-15 cm have increased for all the important species (Table 3.4). The number of trees per hectare (N/ha), BA/ha and V10/ha have increased for all the species sundari, gewa, baen and others (Table 3.5). Only, keora has decreased. The N/ha for poles and trees as presented in Figure 3.3 show these change.

Figure 3.3: The number of poles of different sizes and trees (N/ha) in 2009 and in 1996



From the data, it is observed that although the number of seedlings is high, there is reduction in number of saplings. So there is a need for taking appropriate measures to increase the number of saplings, followed by small poles, by protecting the huge number of seedlings that come up after rains. The volumes of big poles and trees for all the species (sundari, gewa, keora, baen, and others as others) are given in Table 3.8 and the emerging trends are presented in Figure 3.4.

The distribution of numbers of saplings, poles and trees for sundari, gewa, keora, baen and others in different DBH classes have been estimated for 1996 and 2009 (Table 3.9) and the emerging trends presented in Figures 3.5, 3.6 and 3.7 for sundari, gewa and others.

Table 3.4: Trees Statistics (N/ha, BA (m^2) and V10 (m^3) in 2009 for different DBH (cm) classes and important species

Year 2009												
DBH Class	**15-20**			**20-25**			**25-30**			**30-40**		
Species	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha
Sundari	117.4	2.733	16.028	54.02	2.084	14.479	21.69	1.235	8.883	10.64	0.931	6.917
Gewa	50.0	1.116	5.143	8.78	0.323	1.613	2.18	0.121	0.623	0.73	0.065	0.344
Keora	0.2	0.004	0.012	0.18	0.007	0.039	0.18	0.010	0.070	0.36	0.033	0.271
Baen	0.7	0.018	0.088	0.68	0.028	0.148	0.73	0.042	0.234	0.82	0.075	0.449
Others	7.4	0.171	0.648	6.09	0.238	0.948	4.64	0.276	1.076	4.23	0.392	1.381
Total	175.7	4.042	21.919	69.76	2.680	17.227	29.42	1.684	10.885	16.78	1.496	9.362
DBH Class	**40-50**			**50-60**			**60+**			**Total**		
Species	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha
Sundari	1.09	0.164	1.203	0.32	0.066	0.485	0.09	0.029	0.211	205.26	7.242	48.204
Gewa	0.14	0.022	0.118	0.00	0.000	0.000	0.00	0.000	0.000	61.80	1.647	7.840
Keora	0.27	0.041	0.379	0.05	0.009	0.083	0.09	0.034	0.212	1.32	0.139	1.066
Baen	0.50	0.076	0.471	0.36	0.085	0.535	0.82	0.655	3.147	4.64	0.978	5.071
Others	1.36	0.199	0.578	0.50	0.112	0.242	0.23	0.072	0.111	24.46	1.461	4.984
Total	3.36	0.502	2.748	1.23	0.272	1.344	1.23	0.790	3.681	297.48	11.467	67.166
Year 1996												
DBH Class	**15-20**			**20-25**			**25-30**			**30-40**		
Species	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha	N/ha	BA/ha	V10/ha
Sundari	63.4	1.509	7.874	30.4	1.157	6.613	8.4	0.473	2.880	2.6	0.217	1.413
Gewa	14.4	0.320	1.473	3.0	0.116	0.580	0.6	0.032	0.164	0.1	0.010	0.052
Keora	0.4	0.010	0.034	0.3	0.013	0.070	0.1	0.007	0.045	0.8	0.072	0.611
Baen	0.6	0.014	0.068	0.6	0.022	0.115	0.3	0.015	0.082	0.4	0.034	0.206
Others	4.4	0.104	0.395	3.3	0.130	0.516	3.3	0.191	0.746	2.9	0.258	0.922
Total	83.1	1.957	9.844	37.6	1.438	7.893	12.6	0.718	3.917	6.7	0.590	3.203
DBH Class	**40-50**			**50-60**			**60+**			**Total**		
Sundari	0.0	0.007	0.035	0.0	0.009	0.038	0.0	0.040	0.165	104.8	3.412	19.016
Gewa										18.1	0.477	2.268
Keora	0.5	0.085	0.778	0.2	0.043	0.368	0.2	0.097	0.523	2.6	0.327	2.429
Baen	0.1	0.017	0.109	0.1	0.025	0.159	0.4	0.217	1.214	2.4	0.345	1.953
Others	0.5	0.071	0.207	0.1	0.019	0.037	0.1	0.038	0.054	14.5	0.811	2.877
Total	1.2	0.180	1.128	0.4	0.096	0.602	0.8	0.393	1.956	142.4	5.372	28.543

Table 3.5: Differences in between 2009 and 1996 for trees Statistics in DBH (cm) Classes and Species (data 2009 - data 1996)

DBH	15-20			20-25			25-30			30-40		
Species	N/ha	BA/ha (m^2)	V10/ha (m^3)	N/ha	BA/ha (m^2)	V10/ha (m^3)	N/ha	BA/ha (m^2)	V10/ha (m^3)	N/ha	BA/ha (m^2)	V10/ha (m^3)
Sundari	33.672	0.750	5.372	14.281	0.565	5.353	9.546	0.548	4.462	6.238	0.553	4.303
Gewa	26.945	0.603	2.777	4.209	0.151	0.753	1.240	0.068	0.351	0.489	0.044	0.232
Keora	-0.263	-0.007	-0.024	-0.188	-0.007	-0.037	0.038	0.002	0.012	-0.451	-0.045	-0.387
Baen	-0.038	0.001	0.005	0.000	0.001	0.007	0.338	0.020	0.112	0.301	0.027	0.165
Others	1.766	0.038	0.140	1.729	0.067	0.267	0.564	0.037	0.143	0.564	0.067	0.220
Total	62.084	1.384	8.271	20.031	0.777	6.344	11.725	0.674	5.079	7.140	0.646	4.534
DBH	**40-50**			**50-60**			**60+**			**Total**		
Species	**N/ha**	**BA/ha (m^2)**	**V10/ha (m^3)**	**N/ha**	**BA/ha (m^2)**	**V10/ha (m^3)**	**N/ha**	**BA/ha (m^2)**	**V10/ha (m^3)**	**N/ha**	**BA/ha (m^2)**	**V10/ha (m^3)**
Sundari	0.864	0.128	0.959	0.225	0.046	0.363	0.038	-0.016	0.010	64.865	2.573	20.822
Gewa	0.113	0.018	0.097	0.000	0.000	0.000	0.000	0.000	0.000	32.996	0.884	4.211
Keora	-0.301	-0.051	-0.464	-0.150	-0.035	-0.300	-0.150	-0.069	-0.348	-1.466	-0.212	-1.548
Baen	0.301	0.045	0.280	0.188	0.045	0.283	0.301	0.324	1.387	1.390	0.463	2.239
Others	0.639	0.093	0.271	0.338	0.073	0.163	0.075	0.021	0.037	5.675	0.396	1.242
Total	1.616	0.234	1.143	0.601	0.129	0.509	0.263	0.260	1.086	103.46	4.105	26.966

Table 3.6: The Change for different statistics expressed in percentage (%)

	Seedlings	Saplings	Pole 2.5-5	Pole 5-10	Poles 10-15			Tree		
Species	N/ha	N/ha	N/ha	N/ha	N/ha	BA/ha (m^2)	V10/ha (m^3)	N/ha	BA/ha (m^2)	V10/ha (m^3)
Sundari	578	-23	-19	-51	398	421	436	62	75	109
Gewa	787	-52	-33	-32	453	473	492	183	185	186
Others	182	-18	33	20	564	588	599	29	44	27
Total	520	-31	-21	-38	428	450	461	73	76	94

Table 3.7: Volume of poles (DBH 10-15 cm) and Trees in Sundarban in 2009 and 1996

	Year 2009	Year 1996	Year 2009	Year 1996
Size class	**Pole 10-15**	**Pole 10-15**	**Tree**	**Tree**
Species	**V10/ha (m^3)**	**V10/ha (m^3)**	**V10/ha (m^3)**	**V10/ha (m^3)**
Sundari	13.922	10.397	48.204	19.016
Gewa	9.844	6.647	7.840	2.268
Others	0.723	0.414	11.121	7.259
Total	24.490	17.457	67.166	28.543

Figure 3.4: Volumes of big poles and trees in Sundarban in 2009 & 1996

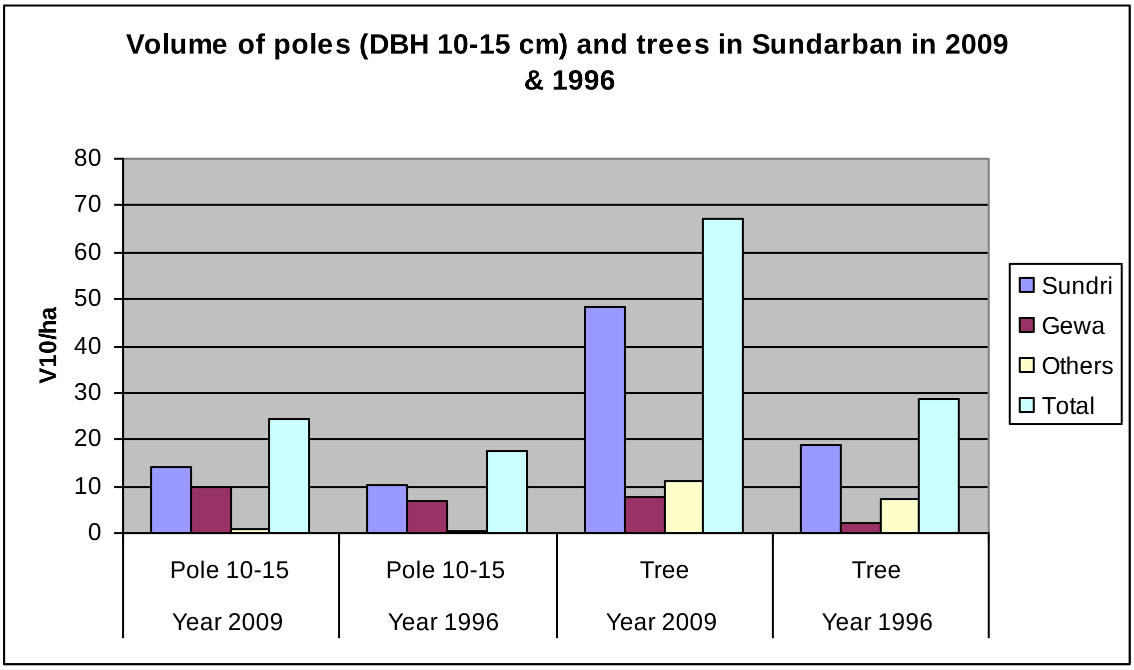


Table 3.8: DBH (cm) class distribution of different important species of Sundarbans in 2009 & 1996

	2009	1996	2009	1996	2009	1996
DBH Class	**Sundari**		**Gewa**		**Others**	
Saplings	3044	3957	**1266**	2627	1236.0	1503.0
Pole 2.5-5	2166	428	1983	476	853.0	102.2
Pole 5-10	1596	523	2393	560	375.1	176.4
Pole 10-15	**234**	**188**	**255**	**184**	18.1	10.7
15-20	117.4	63.4	50.0	14.4	8.3	5.4
20-25	54.0	30.4	8.8	3.0	7.0	4.2
25-30	1.2	8.4	0.1	0.6	0.3	3.6
30-40	10.6	2.6	0.7	0.1	5.4	4.1
40+	1.4	0.1	0.1	0.0	3.8	2.2
	4180.7	1243.8	4690.7	1238.1	1271.0	308.8

Figure 3.5: Diameter class distribution (N/ha) for sundari in the Sundarban in 2009 and 1996

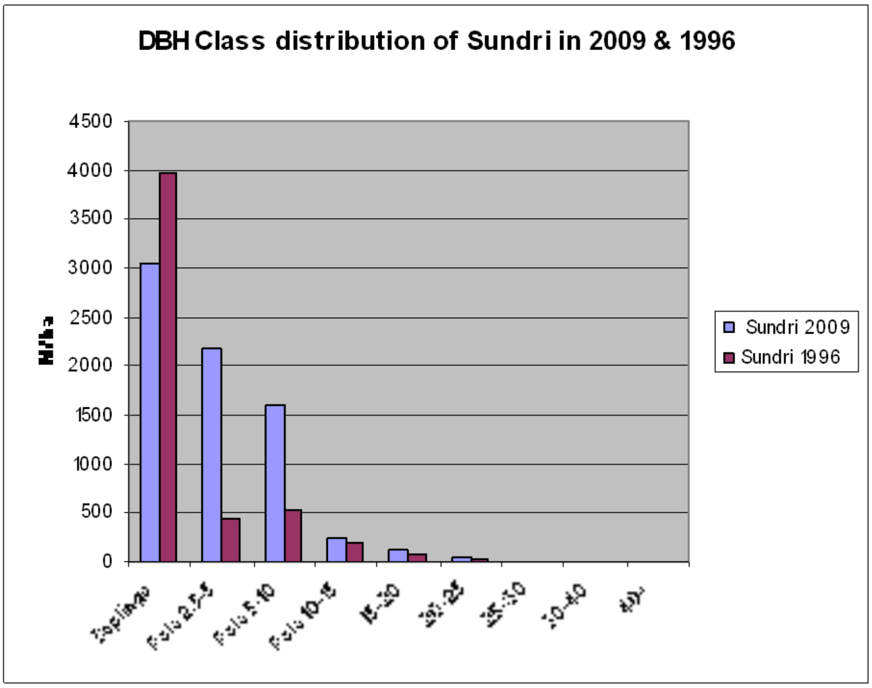


Figure 3.6: Diameter class distribution (N/ha) for gewa in the Sundarban in 2009 and 1996

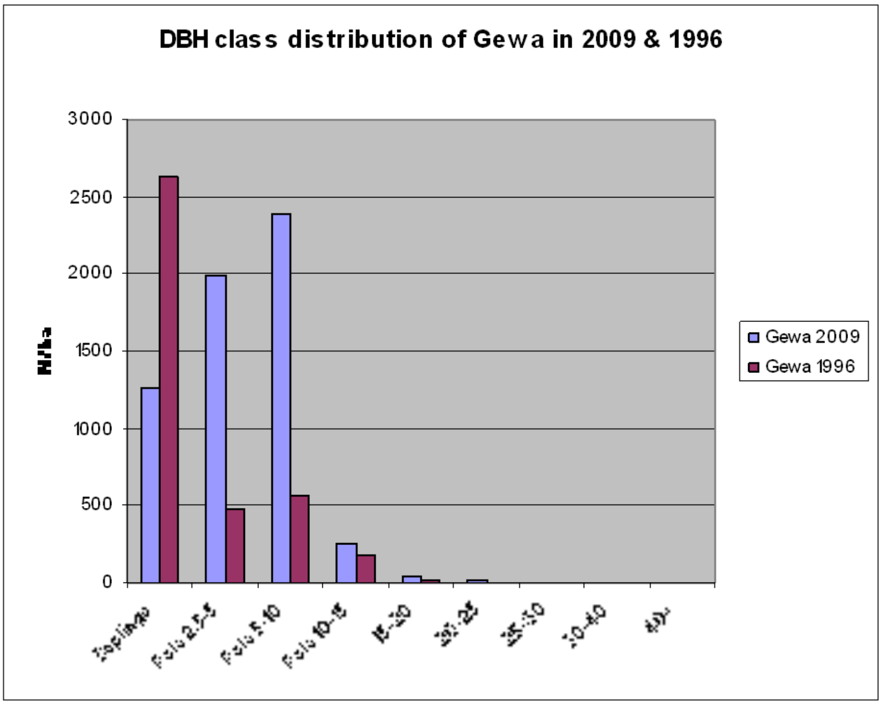
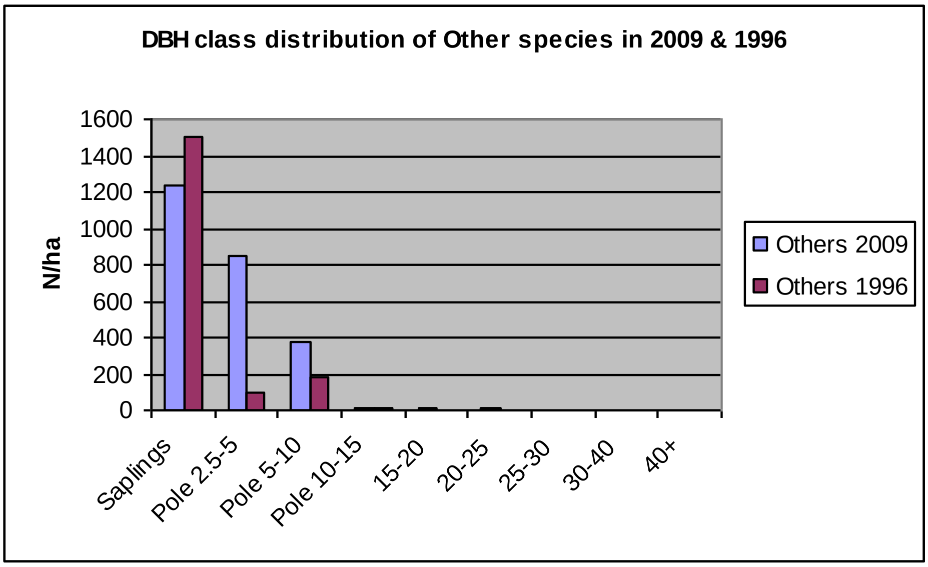


Figure 3.7: Diameter class distribution (N/ha) for other species in 2009 and 1996



Analyses for Goran

Goran is an important fuel wood species present in some compartments of the Sundarbans. Therefore, an estimate for number of goran stems, volume and weight per hectare were estimated and the summary is given in Table 3.9. The detailed estimate for the compartments is given in Table 28 (Annexure 3.1). The data collection procedures in 1996-97 and 2009-10 were not the same : The data were collected in 2009-10 as small stems, medium stems, large stems and x-large stems based on basal diameters classes as 0-0.6, 0.6-2.5, 2.5-7.6 and above 7.6 cm respectively, whereas the data in 1996-97 were collected for seedlings (Height<1.5 m), saplings (DBH<2.5 cm) and poles/trees with DBH≥2.5 cm. The data were divided into two basal diameter classes, 0-2.5 cm and 2.5+ cm for comparison. It is observed from the Table 3.9 that N/ha, Volume/ha and weight/ha have increased.

Table 3.9: Goran in different size classes (N/ha, Volume & Weight) in Sundarban in 2009 & 1996

	Size Class (Basal diameter in cm)	Small Stems	Medium Stems	Large Stems	X-large Stems		Total
		0-0.6	0.6-2.5	2.5-7.6	>7.6		DBH>=2.5 cm
2009	N/ha	5853	9734	4270	471		4741
	Vol/ha	6.64	7.09	28.22	3.74		31.96
	Wt/ha (KG)	6482	8632	28260	3711		31971
	Size Class	Seedlings	Saplings	2.5 – 4.9	5 – 9.9	10 cm & +	Total 2.5 cm +
		Seedlings	Saplings	2.5-5	5-10	10+	
1996	N/ha	4719	2306	2497	186	22	2704
	Vol/ha		1.68	5.58	2.14	5.87	14
	Wt/ha (KG)		2045	6091	2082	5359	13532
Increment	N/ha						2036.14
	Vol/ha						18.37
	Wt/ha (KG)						18439.04

Species Composition Analyses

The species compositions of the SRF are dynamic and, therefore, an attempt was made to make a realistic assessment of the present situation. The number of trees of sundari, gewa and others (keora, baen and others) were estimated and converted into percentages of the total (Table 3.10). The results show that the percentage of sundari trees has reduced to about 4.58% followed by others. The percentage of gewa trees has increased by 8.08%. The results are shown in Figures 3.8 and 3.9. The species compositions were also estimated including the poles with trees. It is also observed from the Table 3.10, that if the poles are included with trees then the species compositions are changed in a same way. Latif *et al* (1992) also reported from 13 years study that sundari is in the similar decreasing trend and gewa in increasing trend.

Table 3.10: Comparative species compositions in 2009 and 1996

	Composition with trees					Composition with trees and poles						
	2009	**1996**	**2009**	**1996**	**Change**	**2009**	**1996**	**2009**	**1996**	**2009**	**1996**	**Change**
Species	N/ha	N/ha	%	%	%	Poles	Poles	Tree+ Poles	Tree+ Poles	%	%	%
Sundari	205	105	69.00	73.58	-4.60	3996	1140	4201	1244	41.30	46.69	-5.39
Gewa	62	18	20.77	12.70	8.10	4631	1220	4693	1238	46.14	46.46	-0.32
Others	30	20	10.23	13.72	-3.60	1247	163	1277	183	12.56	6.85	5.71
Total	297	142	100	100	0	9874	2523	10172	2665	100	100	0

Figure 3.8: Change in species (Trees) compost ions in the Sundarban during the period 1996 to 2009

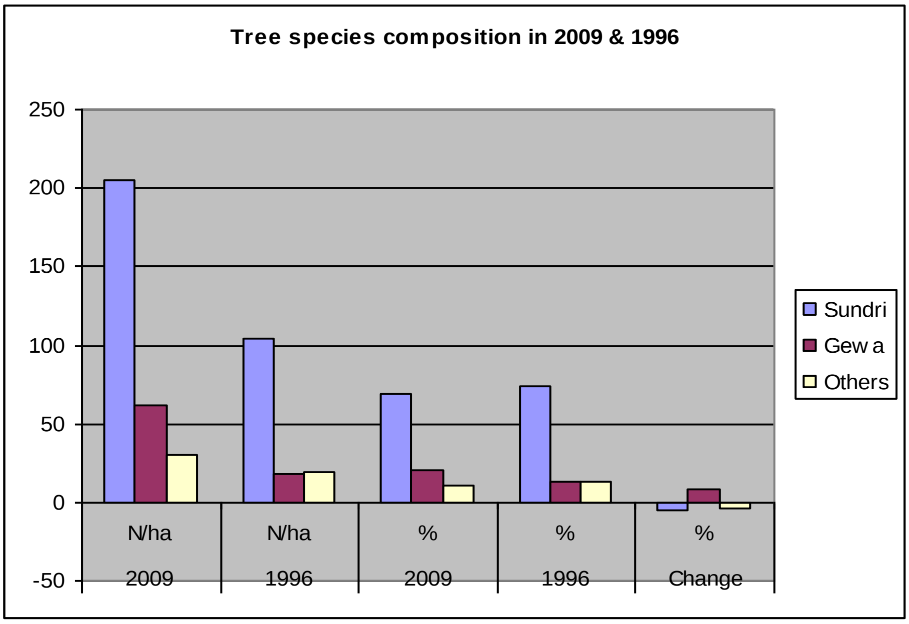
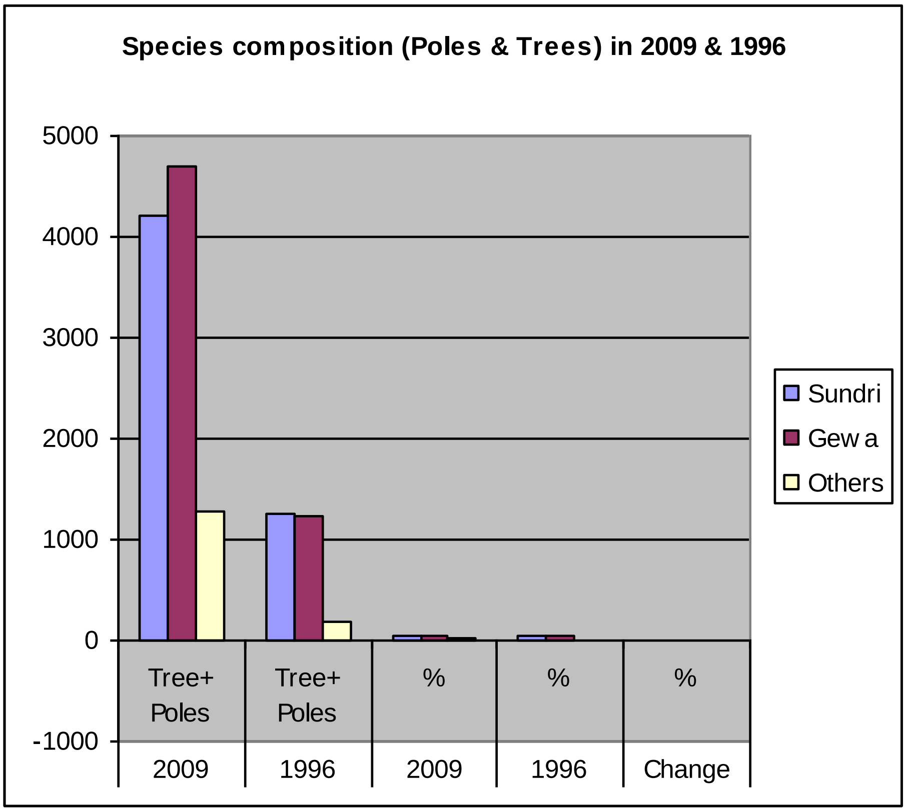


Figure 3.9: Change in species (Poles+ Trees) compost ions in the Sundarban during the period 1996 to 2009



Sundari Top-Dying and Forests Degradation

Sundari top-dying syndrome has been afflicting the Sundarbans forests for many years, and has been cited by several authors as a significant ecological and management problem. The 2009-10 inventory indicates that top-dying was not a major factor at that time. While 58% of plots with sundri trees had some sign of top-dying, on an average just 3% of trees were affected within plots. The maximum proportion of individuals affected within a plot was 28%. Moreover, it was not always clear in the field whether a given tree with a partially dead top was actually affected by top-dying versus some other factor; as such, these percentages may be overestimates. However, a study should be taken up by the FD for assessing plausible reasons for the sundari top-dying and appropriate recommendations to be made for resolving the issue.

On average, two or three cyclones strike Bangladesh per year. Several cyclones recently impacted the Sundarbans area, most notably Cyclone Sidr in 2007 and Cyclone Aila in 2009. Aerial reconnaissance in late 2009 and the IPAC inventory plot data both indicated a range of apparent cyclone damage, but only a small portion of the forest area was affected overall. Additionally, there was apparently high resilience to all but the most severe storm effects. According to the crew's assessment at each inventory plot, a total of 22 plots, or 14% of the total sample, showed some evidence of cyclone damage. However, nearly half of these 22 plots showed only light damage. A total of 8 plots, or only 5% of the total sample, showed severe damage. Ten plots, or 4.3% of the sample, were classified by the crews as 'degraded' or 'deforested', as indicated by recent evidence of significant illegal tree cutting, abundant stumps, skid trails, and loss of canopy cover. On the basis of those data, it would appear that illegal timber cutting or overharvest has not recently been a major factor affecting forest C storage.

3.5 Harvesting Prescriptions

The IFMP came into effect after its approval (in January 1998) for a period until 2010. But the plan for purposes of sustainability analysis carried out timber harvest planning over a period of 22 years, to the year 2020. Accordingly, the IFMP, based on the forest inventory of 1205 plots and growth statistics, estimated by using increment data from the BFRI, formulated regulatory prescriptions over a period of 22 years including an initial 2 year interim period (1998-2000) and the remainder period of 20 years, categorized into 4 phases of five years each: 2000-05, 2005-10, 2010-15 and 2015-2020. The regulatory prescriptions for main tree species including sundari could not be implemented as the tree felling ban continued during the plan period and beyond, and even the felling of other tree species including gewa has also since been banned. In case the ban on tree felling is lifted, the felling prescriptions of the IFMP can be implemented during the remainder two phases of the periods 2010-15 and 2015-20.

This two decades IFMP planning accommodated harvesting recommendations for 20 year cutting cycle with start from the year 2000. For example, it is specifically mentioned in the IFMP that this analysis also provides opportunity for the next plan to carry out the second harvest schedules. However, the applicability of these prescriptions were examined in order to validate them by employing the data from the forests inventory that was carried out during 2009-10 by enumerating 150 plots. In view of similar results (see Section 3.6 for comparisons) obtained by analyzing the inventory data of the two periods, it was confirmed that the Annual Allowable Cuts (AAC) prescriptions of the IFMP, as discussed below, can still be employed for carrying harvesting during the IRMP period in case the GOB decides to lift the moratorium on commercial tree felling.

3.6 Estimation of Annual Allowable Cut

The AAC for different species in the Sundarban Reserved Forest was estimated using the following formulae:

1. AAC = (Present standing mature volume+ ½ growth during the period)/Period of cutting cycle

This formula was suggested by Professor M. M. Pant of Chittagong University for the Sundarbans. For sundari the estimated AAC as per this formula is about three times of the prescribed value as per the IFMP (see Table 3.11, column 7). The AAC is about similar for “others” species but about 1/5th and 1/7th for gewa and keora. Keeping in view a conservation-oriented management, the IFMP volume recommendations are validated to be largely acceptable and can so be implemented in case the GOB decides to lift the present ban on commercial felling.

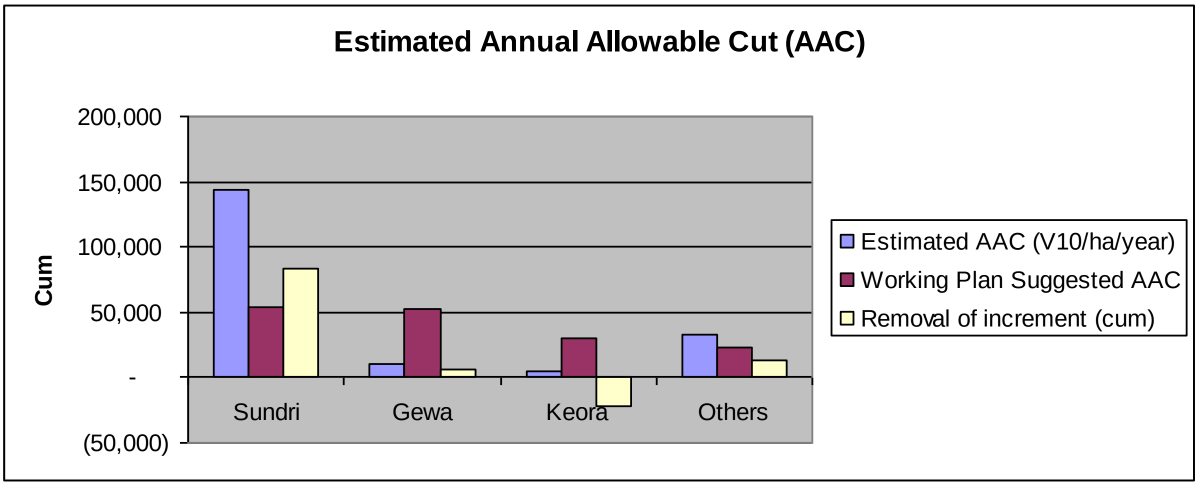
2. As per the Austrian formula:
   AAC = I + (Ga – Gr)/A
   where, I = annual increment,
   Ga = present growing stock,
   Gr = desired growing stock (indicated by yield table or some other empirical standards)
   A = an arbitrary adjust period, which may be a full rotation or any selected period

Here, if we consider Ga = Gr, then we can harvest only the increment and the AAC estimated following this assumption is given in Table 3.11 (column 9) and presented in Figure 3.10. It is evident that the figures for AAC are close to the IFMP prescriptions, except for keora. Thus both the above-mentioned methods justify the implementation of harvesting prescriptions of the IFMP.

Table 3.11: Annual Allowable Cut for different species in the Sundarbans

Species	Growing Stock (V10/ha)	Increment (V10/ha)	AAC (V10/ha /year)	DBH limit (cm)	Total area (ha)	Estimated AAC (V10/ha/year)	Working Plan Suggested AAC (cum)	Removal of increment (cum)
1	2	3	4	5	6	7	8	9
Sundari	8.815	7.165	0.620	30	231159	143285	54000	82808
Gewa	0.462	0.410	0.033	15	296698	9887	53000	6081
Keora	0.945	-1.335	0.014	25	319201	4424	29852	-21308
Baen	4.601	2.914	0.303			0		0
Others	2.313	1.092	0.143	25	231159	33041	23000	12626
Goran (Volume)	1.357	0.346	0.077	2.5				0
Goran (kg)	1458	402	82.96					0

Figure 3.10: Estimated Annual Allowable Cut for different species in the Sundarbans



3.7 Temporal Analyses

An attempt was made to compare the results as inferred from the current inventory with those of the previous inventories. The result are summarized in Tables 3.12 and 3.13 and presented in Figures 3.11, 3.12 and 3.13. The comparisons show that the number of stems and volume/ha decreased after the Forestal inventory (in 1959-61) but the growing stock condition has improved after ODA inventory (in 1983).

Table 3.12: Comparative per hectare estimate of no. of trees and volumes of trees 15-cm DBH and bigger

				Species		
Year		Sundari		Gewa		Others
	N/ha	V10/ha	N/ha	V10/ha	N/ha	V10/ha
2009	205	48.2	62	7.8	30.4	11.2
1996	106	17.8	20	2.1	20	7.5
1983	125	19.9	35	2.7	20	7.1
1959	211	33.6	61	5.0	24	5.9

Figure 3.11: Comparison of stems/ha with previous inventories of the Sundarbans

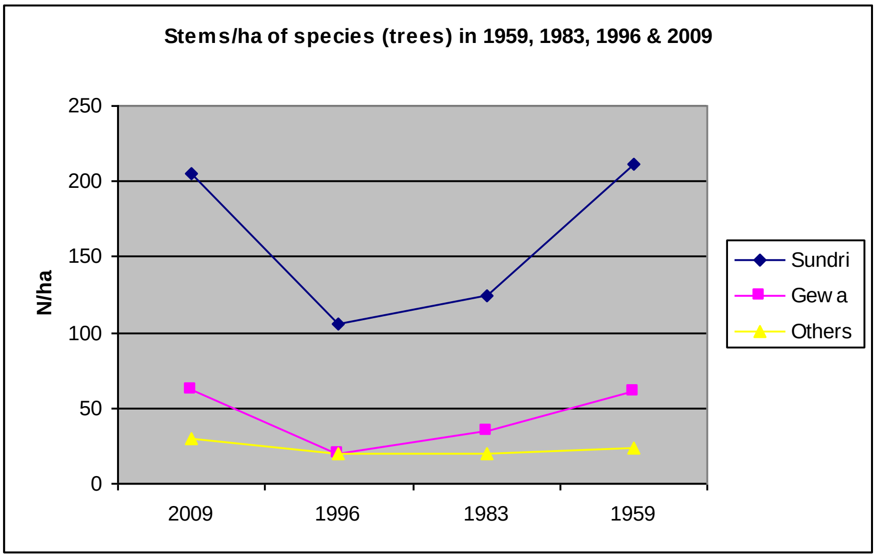


Figure 3.12: Comparison of V10/ha (cum) with previous inventories of the Sundarbans

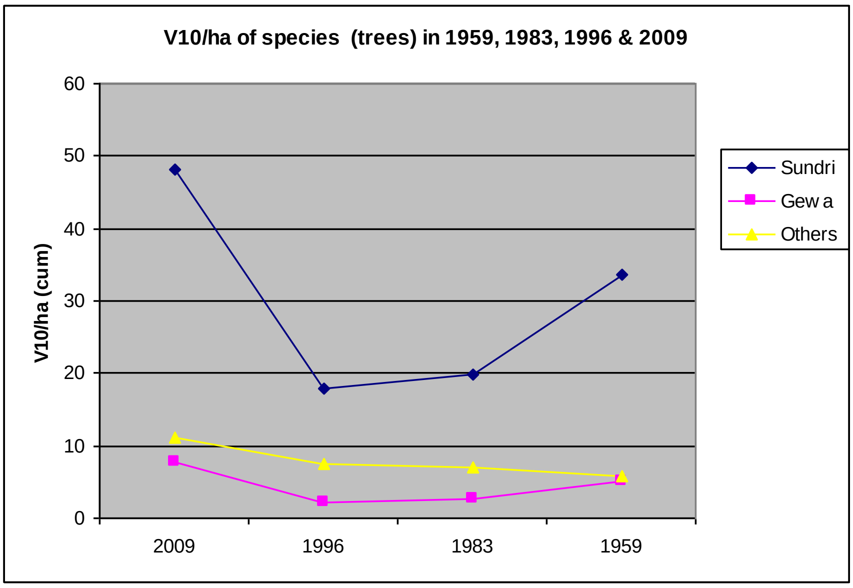
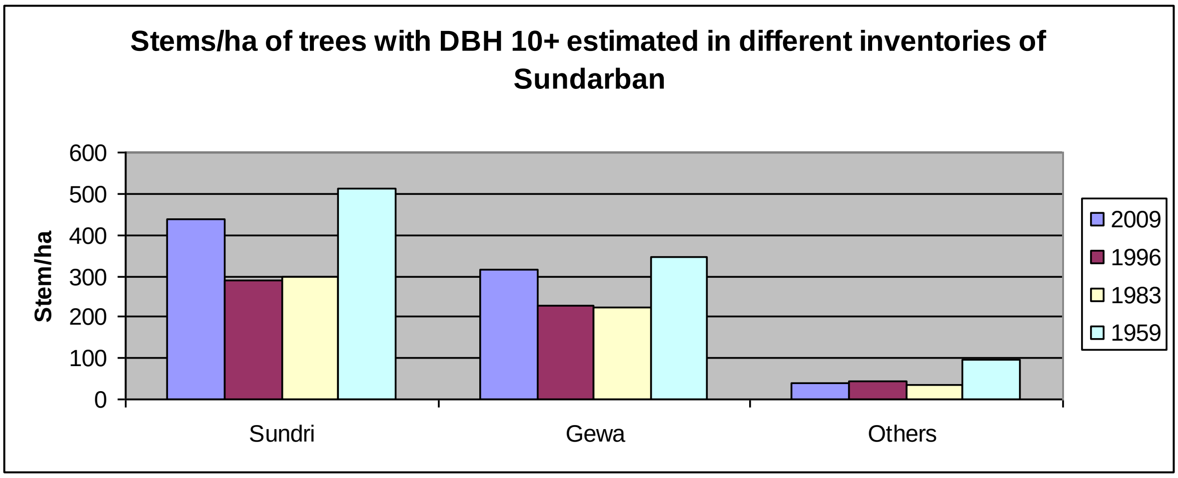


Table 3.13: Comparative per hectare estimate for number of stems of big pole & trees 10-cm DBH and bigger

	Species						
Year	Sundari		Gewa		Others		Total
	N/ha	%	N/ha	%	N/ha	%	
2009	439	55	317	40	41	5	797
1996	290	51.79	228	40.71	42	7.5	560
1983	296	53.14	224	40.22	37	6.64	557
1959	511	53.68	345	36.24	97	10.19	952

Figure 3.13: Estimate for number of stems/ha of big pole & trees 10-cm DBH and bigger



The whole of the SRF has been divided into 8 Blocks and 55 Compartments for its proper management. Therefore, the FD might need some basic information for each Compartment. Hence, tables have been prepared to give estimates for number of trees per hectare (N/ha), basal area per hectare (BA/ha), volume per hectare (V10/ha) for tress and the change of these statistics since 1996 to 2009 (Table 15-19 in Annexure 3.1). Similarly, volume per hectare and number of stems per hectare in different DBH classes for the species sundari, gewa, keora, baen and others have also been prepared and presented in Tables 19-28 (Annexure 3.1). A table has been prepared for goran in different compartments and size classes (Table 29 in Annexure 3.1). An estimate for number of seedlings, saplings and poles has been given in Table 30. The distribution of volume estimates and number of stems for the poles of DBH class 10-15 cm have been given in Tables 31-32 (Annexure 3.1).

3.8 Harvest Planning for Sundari

As per the IFMP, the sundari production areas (SPA) comprised the compartments 3 to 40 (the remainder compartments contain very little or no sundari at all), except the existing and proposed wildlife sanctuaries. The forests will be managed by following the Selection-cum-Improvement Silvicultural System with the recommended minimum exploitable diameter as corresponding to the lower cell boundary of the 30cm diameter class in all the compartments with a cutting cycle of 20 years. Three felling series (Sarankhola, Chandpai and Khulna) will continue over a 10 year felling schedule with the following annual cutting area and AAC details to be applicable in the various compartments where sundari is available:

Table 3.14: Sundari Felling Schedule, Annual Allowable Cut and Felling Area

Felling Series	Compartment No.		Compartment Area (ha)		Period Area (ha)		Annual Area (ha)		Annual Allowable Cut (cum)	
	2010-15	2015-20	2010-15	2015-20	2010-15	2015-20	2010-15	2015-20	2010-15	2015-20
Sarankhola	3, 12B	11, 24	9397	10935						
Chandpai	14, 27, 28, 36	9, 10, 22, 26	17227	27784						
Khulna	19, 32, 37, 39	18, 35, 36, 40	25215	29541						
Total					51859	68260	10368	13652	52363	51835

An area control method will be followed as whole compartments are scheduled to be worked during specified periods. The annual scheduling of compartments in terms of annual coupes will jointly be done both by the DFOs of Sundarbans and the DFO, Khulna Management Plans Division. The GOB will decide to grant extraction rights. All the trees of and above the exploitable diameter (30cm) shall be marked and a list of marked trees will be prepared. Improvement felling will be carried out through removal of dead, dying and unsound stems. The dead pasur and kankra trees will be removed during the felling operation for sundari at the time of main felling.

3.9 Harvest Plan for Gewa

As per the IFMP, the gewa production areas (GPA) comprised all the compartments, except the existing wildlife sanctuaries. In continuation to earlier working plans, the IFMP recommended a reduced estimate (based on 12cm and above diameter limit) of AAC of 53,000 cu.m to be granted to Khulna Paper Mill (KPM). Although the KPM implemented a felling plan in the initial period, the Mill has since been closed. However, in case the GOB decides to lift the felling ban, the forests will be managed by following the Selection-cum-Improvement Silvicultural System with the recommended minimum exploitable diameter 15cm (15 diameter class and above), corresponding to the lower cell boundary of the 15cm diameter class in all the compartments with a cutting cycle of 20 years. As in case of Sundari Working Circle three felling series (Sarankhola, Chandpai and Khulna) will be worked over a period of 10 year felling schedule with the following annual cutting area and AAC details (Table 3.15) to applicable in the various compartments where gewa is available:

Table 3.15: Gewa Felling Schedule, Annual Allowable Cut and Felling Area

Items	2010-15	2015-20
Compartments	2, 3, 9, 10, 11, 12A, 15, 21, 36, 49	30, 32, 33, 34, 35, 38, 39, 40, 48
Period area (ha)	62,556	51,606
Annual area (ha)	12,511	10,321
AAC (cum)	50,203	57,472

As in case of sundari an area control method will be followed as whole compartments are scheduled to be worked during specified periods. The compartments 8 and 45 are not included in the above table as these are designated as special areas (Winter Fishermen Coupe) for the wood supply to winter fishermen of Dubla Island with a conservative AAC of 5,000 cu.m as recommended in the IFMP. This measure is not only consistent with the recommended co-management approach but will also be helpful in soliciting gainful participation of fishermen in the sustainable management of the adjoining wildlife sanctuaries.

The annual scheduling of compartments in terms of annual coupes will jointly be done both by the DFOs of the Sundarbans and the DFO, Khulna Management Plans Division. The GOB will decide to grant extraction rights. All the trees of and above the exploitable diameter of 15cm and above shall be marked and a list of marked trees will be prepared. But at least 20 healthy and sound phenotypes of 15cm and above diameter will be marked and retained per ha as mother trees for encouraging natural regeneration of gewa. While felling, attention will be given to the fact that permanent blanks are not created by removing a group of trees. Improvement felling will be carried out through removal of dead, dying and unsound stems at the time of main felling. The dead pasur and kankra trees will be removed during the felling operation for gewa.

3.10 Harvest Plan for Keora

As per the IFMP, the pure keora production areas (KPA) comprised the compartments 40, 41, 42, 45, 46, 47, 50 and 51, and the remainder compartments contain keora in mixture with other species including sundari. An AAC of 23,000 cu.m was prescribed as per the IFMP based on data as collected from the Permanent Sample Plots (PSP); it was assumed that keora in mixed conditions grows at 0.1 cu.m/ha/year with an annual ingrowth rate of 10% from the 5-10 cm diameter class, whereas in pure condition the growth was determined to be 0.848 cu.m per ha per year based on the FRMP yield data for keora stratum.

The forests will be managed by following the Selection Silvicultural System and the recommended minimum exploitable diameter 25cm shall be followed in all the pure keora and mixed compartments with a cutting cycle of 20 years. Only one overlapping felling series with a 10 year felling schedule and with the following annual cutting area and AAC details (Table 3.16A) will be taken up in the pure keora compartments. In mix species compartments (with other species including sundari) the felling of keora trees of 25 cm and above diameter will be taken up simultaneously with the felling of other trees species such as sundari and gewa.

Table 3.16A : Felling Schedule, Annual Allowable Cut and Felling Area of Keora in Pure Stands

Felling Series	Compartment No.		Annual Area (ha)		Annual Allowable Cut (cum)	
	2010-15	2015-20	2010-15	2015-20	2010-15	2015-20
Sundarbans	41, 42, 46, 47	40, 45, 50, 51,	84	800	4424	4424

Table 3.16B presents the harvest and growth details for keora in mixed stands of sundari (sundari working circle).

Table 3.16B : Harvest (in cum) summary for keora in pure and mixed stands

Period	Timber harvest in sundari production area	Timber harvest in non-sundari production area
2010 – 15	33,347	16,055
2015 – 20	209,351	6,345

An area control method will be followed as whole compartments are scheduled to be worked during specified periods. The annual scheduling of compartments in terms of annual coupes will jointly be done both by the DFOs of Sundarbans and the DFO, Khulna Management Plans. The GOB will decide to grant extraction rights. All the trees of and above the exploitable diameter shall be marked and a list of marked trees will be prepared. At the time of main felling, improvement felling will be carried out through removal of dead, dying and unsound stems. The dead Pasur and Kankra trees will be removed during the felling operation. After main felling, subsidiary felling from crown wood will be started and an ttempt should be done to complete the work in a coupe in two years.

3.11 Harvest Plan for other Timber Species

As per the IFMP, all the sundari production areas comprising the compartments 3 to 40 have trees species such as baen, dhundal, passur, kankra, etc. These species clubbed under other timber species will be managed simulateneously with the sundari by following the Selection-cum-Improvement Silvicultural System with the recommended minimum exploitable diameter 25cm in all the SPA compartments with a cutting cycle of 20 years. Three overlapping felling series (coterminus with the Sarankhola, Chandpai and Khulna felling series for sundari) will continue with a 10 year felling schedule. The IFMP used the 69 PSP data to arrive at an area-weighted average increment rate as 0.1259 cu.m per ha per year whereas the ingrowth rate from the 10-15 cm diameter class into the 15+cm growing stock as 0.001366 cu.m per ha per year. The AAC estimate of the IFMP is justified when compared to the AAC figures arrived at by using the data from the present inventory (see Table 3.11) and so should be continued under the present plan period as well.

An area control method will be followed as whole compartments are scheduled to be worked during specified periods. The annual scheduling of compartments in terms of annual coupes will jointly be done both by the DFOs of Sundarbans and the DFO, Khulna Management Plans Division. The GOB will decide to grant extraction rights. All the trees of and above the exploitable diameter shall be marked and a list of marked trees will be prepared. Improvement felling will be carried out at the time of main felling through removal of dead, dying and unsound stems.

3.12 Harvest Plan for Goran

The current inventory results show an increase of 2036 stems or 18.4cu.m per ha of goran over the period since the last inventory was done in 1996. But in order to follow a conservation-oriented management, the recommendations of the IFMP should be followed as described in this section. In the absence of growth information, no harvest and growth analysis similar to sundari and gewa was done for goran, and so a strict area control should be exercised in the compartments that have significant amount of goran. All the three wildlife sanctuaries and goran low-yielding compartments (in 1, 2, 13, 15, 21, 22, 23, 25-37, 39 and 40 compartments, no felling is suggegested in view of very low yield) were excluded from the goran production areas to arrive an estimate of 202,207 ha, which over a felling cycle of 20 years gives an annual cutting area of 10,110 ha. This annual cutting area will continue to be harvested for the remainder two phases (equivalent to 50,552 ha each for 5 years periods, 2010-15 and 2015-2020; excluding Winter Fishermen Coupe) in the 4 Ranges (treated as Felling Series) as given below (Table 3.17):

Table 3.17: Area distribution for Goran

Range	Range Goran Area	Annual Coupe Area
Sarankhola	50,215	2,511
Chandpai	25,589	1,279
Khulna	47,652	2,383
Satkhira	78,751	3,938
Winter Fishermen (Comp. 8 & 45)	22,503	1,125

The forests will be managed by following the Selection-cum-Improvement Silvicultural System with the recommended minimum exploitable diameter 2.5cm to be followed in all the compartments with a cutting cycle of 20 years. The above-mentioned 5 felling series will continue with a 10 year felling schedule with the following annual cutting area (Table 3.18):

Table 3.18: Felling Schedule and Area of Goran

Felling Series/Range	Compartments	Felling Schedule and Area (in ha)	
Sarnkhola		2010-15	2015-20
	11		5,660
	12B	2,777	
	7	5,132	2,248
	45	3,666	5,626
	8	1,960	-
Chandpai	10	6,044	-
	12A	-	2,141
	14	-	4,306
Khulna	19	1,765	6,000
	20	2,794	
	18	5,967	5,914
	16	2,141	-
	17	1,388	-
Satkhira	51B	-	5,954
	49	-	6,946
	42	5,695	-
	52	11,688	-
	50B	-	5,633
	51A	2,305	1,125
Winter Fishermen Coupes	8	1,960	-
	45	3,666	5,626

The above-stated harvesting schedules are planned in such a way that adjoining compartments are worked during the period. Based on this distribution of felling series, the expected yield in metric tones for utilizable goran will be as follows (Table 3.19):

Table 3.19: Expected Yield of utilizable goran

Range	**Expected Yield (in metric tones)**	
	2010-15	**2015-2020**
Sarankhola	26,657	22,250
Chandpai	5,047	3,061
Khulna	20,925	25,975
Satkhira	68,760	58,486

Except goran no other fuelwood species will be harvested. The whole compartments are scheduled to be worked during specified periods and the annual scheduling of compartments in terms of annual coupes will jointly be done both by the concerned DFO of the Sundarbans and the DFO, Khulna Management Plans Division. However, the DFO, Management Plans Division will be consulted for verification of the quantity of goran before commencing harvesting each year. The GOB will decide to grant extraction rights. All the trees of and above the exploitable diameter shall be marked and a list of marked trees will be prepared. The dead pasur and kankra trees will be removed during the main felling operation.

3.13 Harvest plan for Non-Timber Forest Produce

Aquatic resources, although categorized as NTFP, are not included in this section as their harvesting is discussed in detail in the following Chapter 4.

3.13.1 Harvest Plan for Golpata

Golpatta (*Nypa fruitcans*) is an important NTFP, extensively found in the SRF with an official recorded harvesting of 67,000 metric tons per ha per year. FD issues permits every year for golpatta harvesting during the non-growing months of October to March in the identified annual coupes on first-cum-first serve basis. The recommendations included in this section for golpatta harvesting are based on the prescriptions of the IFMP for which a detailed survey for assessing golpatta stock was done under the FRMP. This inventory estimated that 113,888 metric tons (green weight) of golpatta split fronds are available in the SRF and this included 22,477 metric tons in the three wildlife sanctuaries where golpatta may not be harvested during the plan period. There should not be any regular extraction of gopatta in the three wirldlife sanctuaries unless it is essential for the natural regenerationof golpatta, in which case the Wildlife and Nature Conservation Division will make suitable recommendations. A 30% unrecorded use is assumed in the IFMP to arrive at 64,000 ha metric tons of golpatta harvest. The overlapping golpatta working circle constituted under the IFMP with the following 7 coupes comprising the listed compartments (Tables 3.20 A and Tables 3.20 B) will continue under this plan period as well.

Table 3.20 A: Range-wise distribution of Golpata (in metric tons)

Sl. No.	Forest Range	Wildlife Sanctuaries	Other Compartments	All Sundarbans
1	Sarankhola	7,680	22,675	30,355
2	Chandpai	0	17,804	17,804
3	Khulna	8,130	32,839	40,969
3	Satkhira	6,666	18,093	24,759
4	All Ranges	22,477	91,411	113,888

Table 3.20 B: Estimated Annual Allowable Cut (AAC) of Golpatta (in metric tons) in different Coupes and Compartments

Sl. No.	Forest Range	Coupe	Compartments	Avaliable Stock	AAC
1	Sarankhola	Sarankhola	1,2,3,7,8,11,12B,24,25	22,675	16,000
2	Chandpai	Chandpai	9,10,15,21,30,31	10,366	7,200
3	Chandpai	Sela	12A,13,14,22,23,25,26,27,28,29	7,438	5,400
4	Khulna	Sipsa	16,17,32,33,34,35,36,39	14,300	10,000
5	Khulna	Arup-Sipsa	18,19,20,37,38,40	18,539	13,000
6	Satkhira	Satkhira	41,42,46,47,48,49,50,51,52	18,093	12,700

In the 6 identified coupes the golpatta will be harvested once in a year by meticulously following cutting rules by the purchasers, who will be allotted a khal or part of it for harvesting under the supervision of a FD field staff. However, any cutting rules will be prescribed by FD time to time. The areas in different coupes towards sea surface will be worked during calm season. During the growing period of April-September no golpatta cutting will be allowed. The central leaf and the side leaf (unopened frond) will be retained at the time of harvesting when no flowers and fruits will be disturbed. Similarly young plants with one utilizable leaf will not be cut. All the unutilizable plant materials will be left on forest floor for rotting. It is recommended that the FD should carry out an inventory for golpatta assessment as this was not covered under the IPAC inventory. Similarly a sample survey of golpatta can be carried out to verify (preferably by the Management Plans Division) the harvestable quantity of golpatta before starting extraction each year.

3.13.2 Harvest Plan for Honey and Bee's Wax

In the absence any survey, no prescription for sustained yield is possible and so until reliable information is available during the plan implementation the current practice of issuing FD permits may continue. As per the FD records, the permits are issued for harvesting on an average 117 and 29 metric tons of honey and bee's wax annually, and this level of harvesting during April-July may continue for the Plan period of ten years. However, improved harvesting practices and safety measures may be discussed with the Mowalis (honey gatherers) by organizing workshops locally.

3.13.3 Harvest Plan for Grasses

The harvesting of grasses before flowering by the poor community under the overall management of CMCs is recommended as their harvesting will help regenerate the forage for wildlife and also benefit poor community. Moreover, as grasses mainly have annual cycle, it should be possible to regenerate them by cutting regularly, which will also help avoid forest fires and improve sanitation.

3.13.4 Harvest plan for Hantals and Shells

Hantal (*Poenix paludosa*), a small, straight and slender palm, found throughout the Sundarbans, will be harvested with an annual limit of 1,000 metric tons during the plan period. But no harvesting is recommended inside the 3 wildlife sanctuaries.

The commercial extraction of Shells will be allowed only in Sundarbans West forest Division. No limits are set for shell harvesting in view of its fairly constant production in previous years.

3.14 Summary of Main Prescriptions for the Buffer Zone

Main prescriptions outlined under the above-developed sustainable forests management programs are summarized in Table 3.21 with respect to timing of each proposed activity and responsibility assigned.

Table 3.21: Summary of Main Prescriptions: Sustainable Forests Management Programs

Yr	Main Activities	Main Outputs/ Success Criteria	Responsibility
1 & 2	-Protecting the buffer zone's forests & wetlands and comprising biodiversity against biotic interference (illicit removals, poaching, over-fishing, etc.)	Reduced level of biotic interference including illicit felling and fishing	Stakeholders/ FD/CMCs/ SEALS
	-Carrying out improvement activities for wildlife, including maintenance of open patches of grasses	Enhanced wildlife	FD
	-Implementing habitat improvement works (special habitats maintainance, waterbodies maintainance, excavation for khal connectivity, etc.)	Improved habitat	FD
	- Involving floating fishers in forest protection, and in income generation activities	Villagers' income enhanced	FD/CMCs
	-Protection of tigers and other wildlife by employing response teams and flying squad	Protected habitat	FD/CMCs
	-Signing benefit sharing agreements with the villagers of the landscape villages for protecting nearby forests and associating them in income generation and value chain activities	Income of villagers enhanced and forests protected	FD/CMOs
	-Existing FD facilities including buildings maintained by following environmental friendly guidelines	FD buildings maintained	FD
	-In case ban on commercial felling is lifted by the Government, implement harvesting prescriptions in the identified felling series as per the recommended yearly schedule	Prescribed yield is harvested	FD
	-Implement harvesting of NTFPs by following the recommended practices	Field checks	FD
3 & 4	-Continue protecting forests and other biodiversity against biotic interference (illicit removals, poaching, etc.)	Reduced level of biotic interference	FD/CMOs
	-Implementing habitat improvement works (grassland maintenance, special habitats maintainance, waterbodies maintainance, etc.)	Improved habitat and enhanced wildlife	FD
	- In case ban on commercial felling is lifted by the Government, implement harvesting prescripts in the identified felling series as per the recommended yearly schedule	Yield as per the Plan	FD
	-Implement harvesting of NTFPs by following the recommended practices	Filed checks	FD
5	-Protecting forests and wetlands and their comrising biodiversity	Reduced level of	Stakeholders/

& 6	includining tiger and its prey, deer against biotic interference -Implementing habitat improvement works -Implementing habitat restoration works (rainwater conservation, pond development, drinking water facilities) -Continue involving the landscape villagers and CMCs in forest protection based on their involvement in income generation activities and other benefits -Continue motivating the landscape villagers to adopt biodiversity friendly practices in their homesteads -Villagers of peripheral villages continue protecting nearby forests and their wildlife -In case ban on commercial felling is lifted by the Government, implement harvesting prescriptions in the identified felling series as per the recommended yearly schedule -Implement harvesting of NTFPs by following the recommended practices	biotic interference Improved habitat Rehabilitated habitat Villagers' income enhanced Biodiverse homesteads wildlife protected Harvested timber and fuelwood Filed checks	FD/CMOs FD FD FD/CMCs FD/Villagers FD/Villagers/ CMCs FD FD
7 & 8	-Continue protecting forests and other biodiversity against biotic interference -Continue involving the landscape villagers in forest protection, and in income generation activities -In case ban on commercial felling is lifted by the Government, implement harvesting prescripts in the identified felling series as per the recommended yearly schedule -Implement harvesting of NTFPs by following the recommended practices	Reduced level of biotic interference Rehabilitated habitat Timber yield Field checks	FD/CMOs FD FD FD
9 & 10	As above -Design and implement an exhaustive forest inventory	 Inventory reports	 FD

4. Food Security and Wetland Management Program

Main goal of the National Food Policy (2006) is to ensure a dependable sustained food security system by ensuring availability of food, access to food, and utilization of food by all people of the community. Food security programs in the context of the Sundarbans would focus on enhancing the ecosystems' resilience functions and increasing community access and availability of acquatic and NTFP-based food resources through improved wetland, fisheries and NTFP management. Marine and open water capture fishing in the Sundarbans is extremely important due to its role in food security, employment, nutrition, livelihood and export. Although food production has recently increased, food insecurity is widespread in the interface landscape due mainly to poverty, lack of cultivable land and employment, high family size, frequent nautral disasters and absence of safety net programs.

Main threats to the Sundarbans wetlands emanate directly from the increasing human population, and consequent overexploitation of fisheries resources. Over the last three decades, several man-made and natural causes (e.g., salinity increase, reduced freshwater flows, water pollution, over-fishing, fish poisoning) have resulted in reduced fish production and wetlands degradation in the Sundarbans. For instance, it is estimated that up to 60% of the shrimp post larvae (PL) collected from nature die during sorting, transportation and stocking. During collection of PL, the local people destroy nearly 90 to 95 % of fish and prawn seeds, which is leading towards the destruction of large number of estuarine and marine species. But the PL harvest of shrimp and prawn is probably the most lucrative local economic activity available to a large proportion of the population in the interface landscape.

4.1 Program Objectives

Main objectives of the food security and wetland management program are to ensure the long-term food security through improved wetlands and fisheries co-management. Other objectives include to provide guidelines to manage the fisheries resources, and implement management activities for long term sustainability of the Sundarbans fisheries by enhancing environmental preservation and conservation; introducing rational wetlands resources exploitation, increasing public participation and benefits from fisheries resources management, expanding the biological base; improving management performances; and undertaking effective wetlands resource management.

4.2 Wetland Co-Management

One-third of the SRF is wetlands, which play vital role in enhancing human welfare by providing livelihoods, climate change mitigation and adaptation, and securing other life support ecological and food security services. A secure basis for the Sundarbans wetland co-management is to ensure that local community, dependent on its resources, obtain better livelihoods from their conservation, than from their degradation. These wetlands are the transitional zones between the aquatic ecosystem comprising the Bay of Bengal and the dry terrestrial ecosystem comprising south- and north-western Bangladesh. The Sundarbans has been designated as a wetland of international importance under the Ramsar Convention (ratified by Bangladesh in 1992), which provides for its conservation and wise use. The Sundarbans is endowed with a high concentration of ichthyo fauna, which makes its coast a unique nursery ground for many species of marine fish and shrimp. The spawning ground of most of the marine fish and shrimp is associated with the mangrove forests. The Sundarbans ecosystem houses 177 species of fishes, 24 species of shrimps, 20 species of cartilaginous fishes, 11 species of crabs and lobsters, 36 species of mollusks and other invertebrates. Species composition and community structure vary east to west and along the hydrological and salinity gradients.

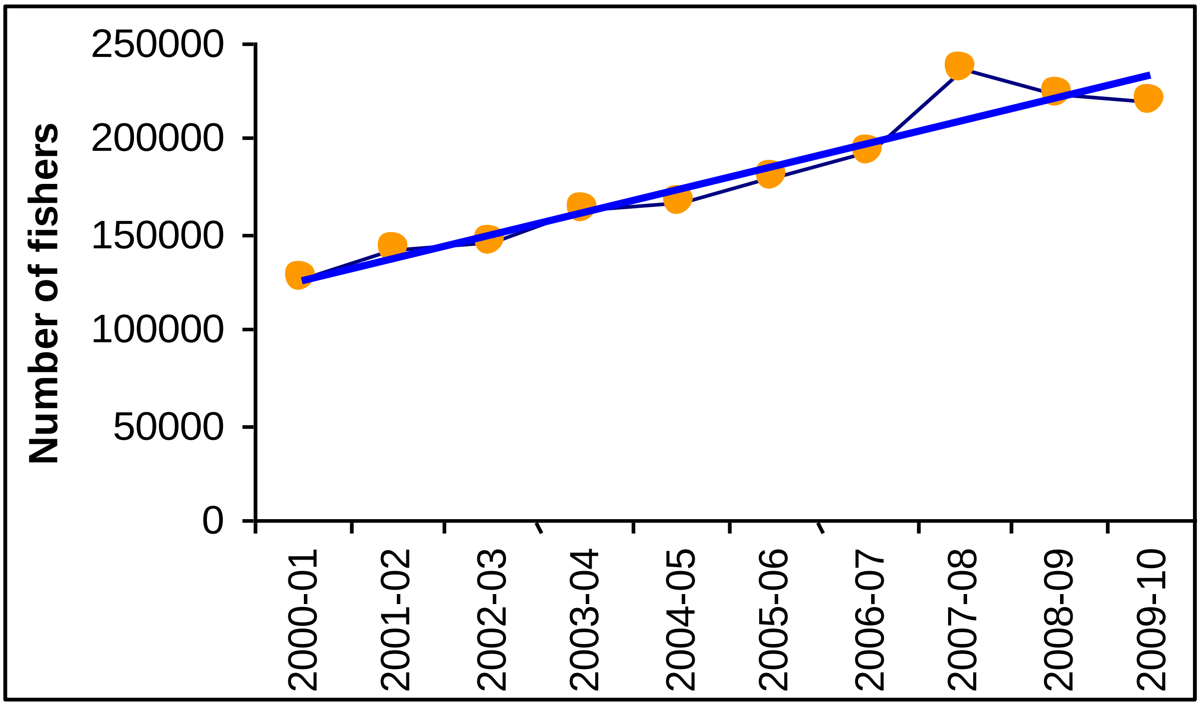
The Ramsar Convention defines wetlands as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tides does not exceed six metres. In Bangladesh there is no formal system of wetland regulation outside the international commitments made in respect of Ramsar sites. The Sundarbans wetlands, as important part of the hydrological cycle, are highly productive, support large biodiversity and provide a wide range of ecosystem services including flood mitigation, fish breeding and production, waste assimilation, water purification, erosion control, ground water recharge, livelihoods, microclimate regulation, climate change mitigation and adaptation, habitat for indigeneous and migratory birds, and other socio-economic and recreational functions.

Eco-restoration of the wetlands that have degraded due to siltation, salinity intrusion over-fishing, and waste pollution is necessary through community participation, particularly in excavation required for re-connecting channels and khals. The wetlands of the Sundarbans need to be managed as an ecosystem that will naturally regenerate to provide ecological functions and economic wellbeing in perpetuity. The economic values of the Sundarbans wetlands significantly exceed the value from their alternative use. A holistic view of these wetlands in terms of causal linkages with other natural entities including mangroves, human welfare and needs, and their own attributes, is necessary. The wetlands conservation needs to be integrated with sustainable landscape manaqgement and livelihood improvement.

4.3 Fisheries Production

The fisheries production figures from the SRF as gathered by the FD field staff show sharp fluctuations from year to year: Some reduction is noticed particularly with respect to white fish, marketable shrimp, undersize shrimp and hilsa. However, the fishers' assumption is over 50% decrease in fish catch during last 10 years; the reduction is obviously somewhat less in the lower part and more in upper part of the SRF. However, in general, the perception of the fishers' community, FD, Dadondars and local people reveals that production of fish and other aquatic resources of the Sundarbans have decreased over the years. The PRA/RRA studies conducted in 2009-10 reveal that fisheries production has been reduced by 56% in last four decades and the trend is slightly higher in the east (59%) than the west (56%). In recent years, poison fishing in the canals of the Sundarbans has increased and is recognized to be highly detrimental for the water resources in general and fisheries in particular. There is an increasing trend in number of fishers as well as fishing effort (Figure 4.1).

Figure 4.1: Increase in Fishers



In view to maintain ecological balance and to develop the fisheries resources for sustainable utilization, the Government of Bangladesh has formulated different management policies and action plans. At the same time, various non-government organizations and private organizations have engaged themselves in fisheries research, management and development processes. The Government also provides institutional, infrastructural and legal support to encourage participation of such organizations.

4.4 Sustainable Fisheries Management

Fisheries management is an integrated process of information gathering, analysis, planning, consultation, decision making and implementation with enforcement of rules and regulations. A key aspect of fisheries resource management and sustainable use is an assessment of the present status of resources. There is inadequate monitoring of fish stocks in the SRF and fisheries resources have not been inventoried. Local fishermen have noted that they are spending more time and effort to capture fewer and under size smaller fish. The following two-fold requirements are suggested for the sustainable management of the SRF fisheries resources:

- **Resource Conservation Measures:** Maintain the fisheries resources to a level that does not degrade from the present level (i.e. ensuring sustainable harvest) by controlling the number of fishers and checking the type of gears used.
- **Resource Improvement Measures:** Improve the fisheries resources through different management and conservation interventions

Besides, there are many other issues that need to be considered and the eventual target of the Sundarbans fisheries management and conservation should focus on the following:

- Compartment based (rivers and major canals) management.
- Periodic assessment of the aquatic resources.

- Regular monitoring and evaluation.
- Creation of ownership feeling amongst the resource users and fisher communities.
- Access, control and priority to the local people from the interface landscape.
- Fishers' participation to follow closed season regulations.

4.4.1 Fisheries Resources Conservation Measures

The following measures are suggested for the fisheries resources management and conservation:

1. Fishing Area Ban: Year round fishing ban in:

- All water bodies in the existing three and proposed wildlife sanctuaries. In addition, a 1-km wide zone on the northern periphery areas of the sanctuary may also be included under fishing area ban.
- Permanent fishing ban by FD to be enforced in the 18 canals that have been declared closed in the buffer zone.
- Canals less than 25 feet wide within 3 km area of FD permanent Camp office/Petrol Office located throughout the Sundarbans.

2. Fishing Ban during Breeding Season:

- Fishing ban in all canals during the months of July and August.
- Fishing ban in the Beels/Chatals of the Sundarbans during February-March.

3. Seasonal Gear Ban: Seasonal gear ban is important for the sustainable management of the Sundarbans fisheries**:**

- Ilish jal/Fash jal: Fishing ban in September and October.

4. Complete Gear Ban:

- Bhendi/bebdi/bendi/bhasan (Set bag net).
- No fishing by de-watering, particularly in the Beels/Chatals.
- Net jal and current jal for post larvae collection of Golda and Bagda.
- Khal pata jal.

5. Mesh Size Control:

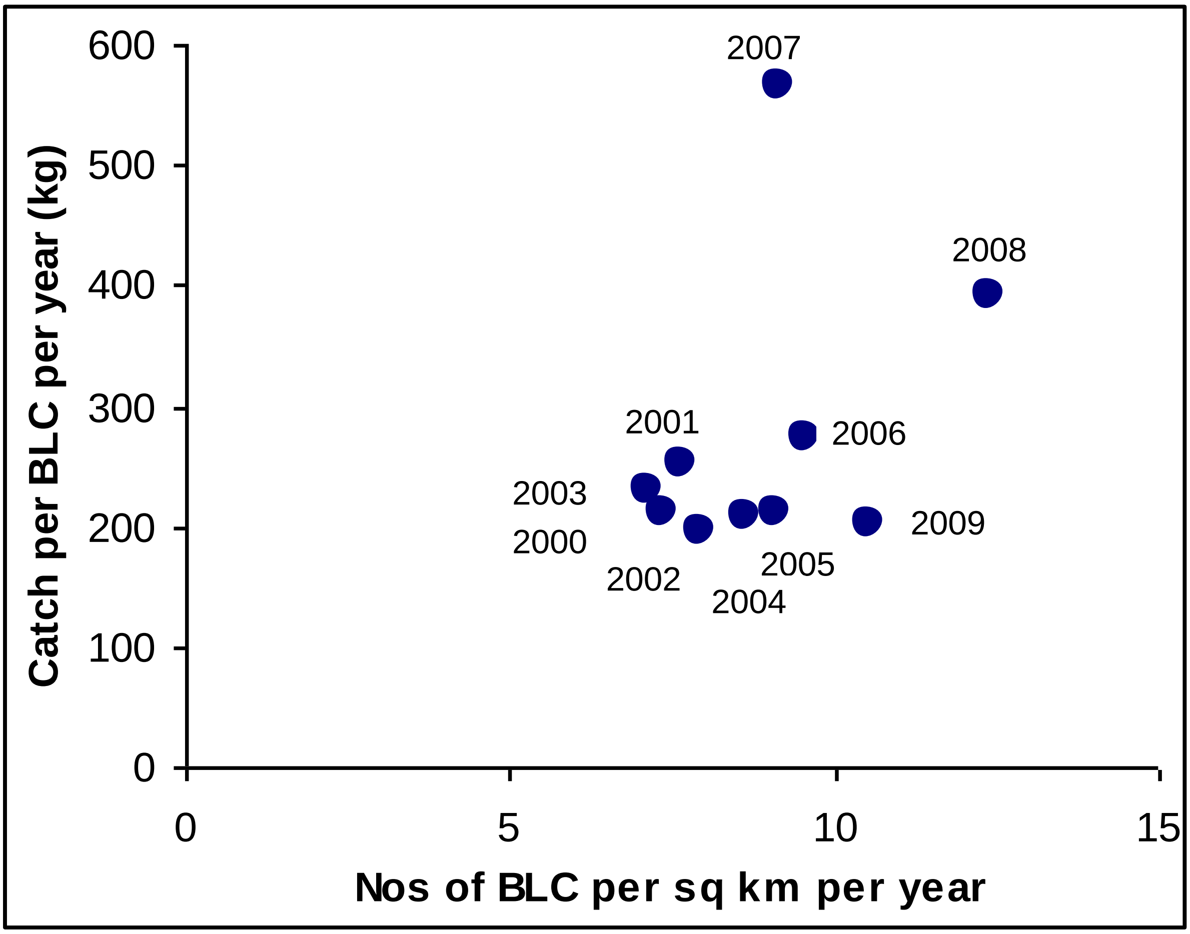
- Fishing net with mesh below 15mm/1 inch (knot to knot at stretch condition) will not be allowed for fishing. However, fishing traps and hooks will not have any limit.
- Ban on using insecticides and poison for catching fish

6. Boat License Certificate (BLC) Limit:

- The maximum number of annual BLC issuance will be 12,000 (8x12,000 = 96,000 permits) for the Sundarbans and it will be equally distributed for the two Divisions of East and West (6,000 each). This should be implemented from the financial year 2011-2012. The respective DFO will determine and distribute BLC numbers among different Range Offices on the basis of relevant actual figures from previous years. The distribution of BLC among Ranges and Stations may not be equal and the concerned DFO will determine the numbers in consultation with Range Officers based on the water area/effective fishing area within the Range as well as fisher entrance suitability. It is found that the BLC number is already higher than the suggested number (12,000) in the year 2010-11 and most of the boats are interested for renewal. New BLC and permits can be issued in lieu of old BLC and permits that are either cancelled or surrendered but such new issuance sholulkd be within the presecribed limits of a particular Forest Station/Range. The catch/BLC/year versus number of BLC per sq km showed that in the SRF, the number of BLC has an increasing trend starting from 2004 (Figure 4.2). The annual catch/BLC increased from 2006 to 2008, but decreased in 2009. An initial analysis indicates that prior to over exploitation the FD could have provided BLC not more than 10 per sq km per year. The following approach will be followed in controlling the number of BLC.

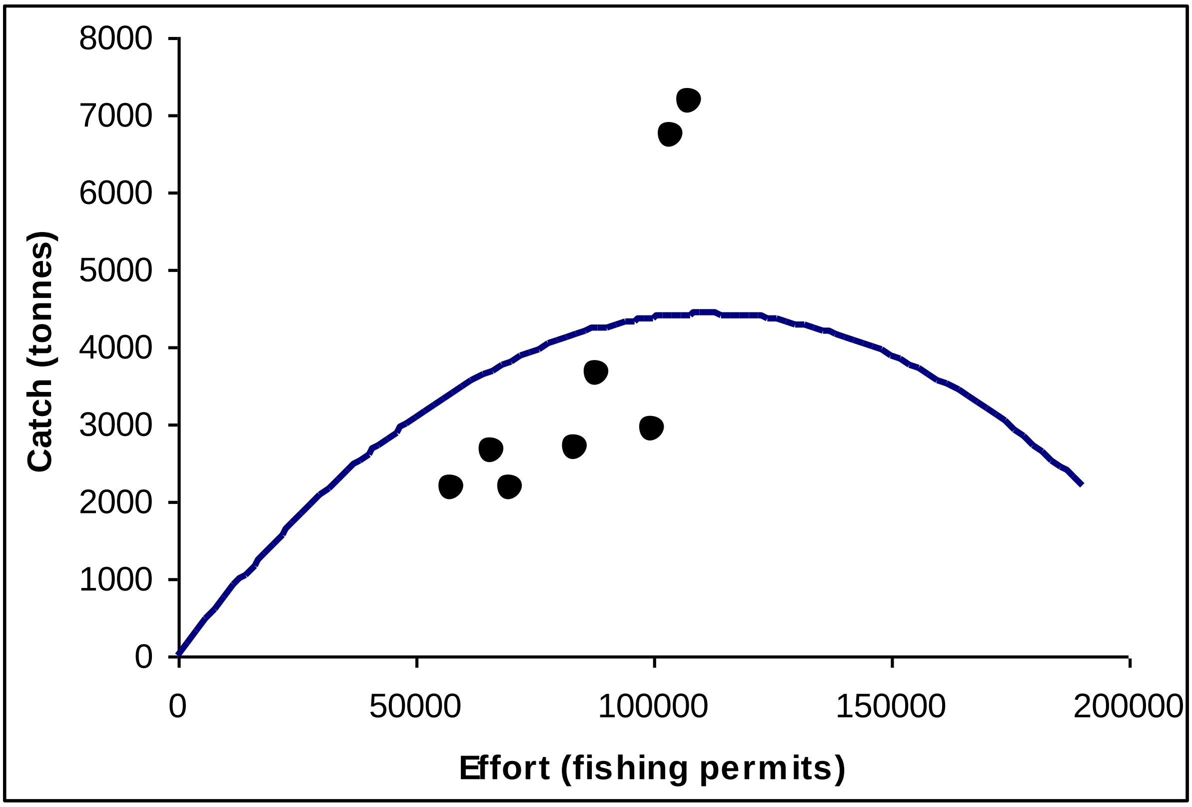
- BLC receivers from one Forest Division (say East Division) will not be allowed to fish in the other Division (i.e West Division). Preferably, fishing permit restrictions will be exercised within a Range. Catch monitoring will be done by the FD field staff.
- Range-wise color (e.g green for Chandpai, yellow for Sarankhola, blue for Satkhira, and red for Khulna) signage will be used at the top of a boat, facilitating indentification of BLC receivers for each of the 4 Ranges and thereby controlling illegal fishing.
- The present practice of submitting BLC to Station Offices without any weight measurements will be changed. At the time of permit submission, fish weight measurements will be taken at camps/offices in order to control over fishing.
- No new BLC license will be issued, if the total limit of 12,000 exceeds.
- First priority in issuing new BLC will be given to those boat owners who live within 5km area around the Sundarbans. If 5km area does not fulfill the targeted BLC, then 10 km area in the interface landscape should be considered.

Figure 4.2: Catch – BLC Scenario



It should be mentioned that the BLC number fixation should be done on yearly basis. Each year a review should be made on the production/catch amount, based on information from the fisher and observation of the Forest Department personnel (Forest Guard, Station Officer and Range Officer). If the production goes down, the BLC number would be reduced and if it increases, the BLC number would be increased. Monitoring of fish catch against the permits issued will be done by the FD field staff. The number of BLC increase or decrease would be selected based on the estimation of production change. However, the changes of BLC number should not be more than 10% compared to the previous year. The Surplus Production Model of Schaefer (1954) was used to estimate the maximum sustainable yield (MSY) for the fisheries production, based on the catch and effort (nos. of permit) data during 2000-01 to 2009-10 from the SRF. The estimated MSY from this study was found to be as 4421m.t per year (Figure 4.3). The corresponding effort fisheries maximum sustained yied (FMSY) needed to achieve the value was found as 110,000 permits per year (Figure 4.3).

Figure 4.3: Estimation of Maximum Sustained Yield



Precautionary management has to be adopted to protect the Sundarbans fisheries resources and to maintain sustainable availability of resources. Clearly, maximum number of permits has been reached and sufficient indications of overexploitation of the fishery in SRF have been found. The suggestion to reduce number of permits below 110,000 per year is an important step towards sustainable fisheries management.

7. Fishing Permit Limit

- One BLC holder boat will get fishing permit in a year for all gears or fishery type. However, 8 times fishing permit on an average will be attained for each Range, in order to take on board the fact that some BLC holders take permit seasonally.
- Maximum number of permit below 110,000 per year.
- The maximum limit of permit for a month will be 3 times.
- 5-7 days fishing under a permit.

- Compliance with the Bangladesh Fish Act of 1950 is important through active participation of communities.

At the time of BLC issuance/renew the fisher should be informed about the conditions. He should be advised for his fishing planning of the year. The respective station office of FD will keep record of permit issuance number to track down and control the specified limit.

8. Fishing Duration

The maximum fishing duration against a permit will be 7 days. The days will be counted from the date of permit issue and ends on the day of permit submission.

9. Species Ban

The following species will *be* covered under fishing/catching *ban*:

- Pangas (*Pangasius pangasius*) and Sea bass (*Lates calcarifer*): Ban on each alternating year.
- Ilish Fish: Fishing ban in September and October.
- Mussel (Jhinuk): Ban in March to October.
- Crab : Ban in January and February

10. Fish Size Limit

- Catching of Ilish and Pangas below 23 cm is prohibited during November-April as specified in the Fish Act, 1950.
- Crab: For male, the minimum weight size for catch is 200gm and for female as 120 gram.

Along with the above-mentioned measures, the existing rules and regulations for the Sundarbans fisheries management as made by FD time to time will be followed. The applicable rules include Hunting, Shooting and Fishing Rules, 1959; Collection and Export of Live Crab Regulation, 1995; Closed Season Regulation, 2000; Fish Act, 1950; and Marine Fisheries Ordinance, 1983.

11. Penalty Options

- The FD field staff will exercise their legitmate authority in taking actions as per the applicable acts and rules if any of the conservation measures are violated by any person or fisher. A ban on khal patta and char patta may be imposed as a large no. of ploes of sundari and kankra are needed for their use.

4.4.2 Resource Improvement Measures:

The objective of sustainable fisheries resources improvement will include but not limited to conservation and improvement measures that contribute to improvement of the fisheries resources. The following measures are prescribed in order to achieve this important objective:

1. Habitat Restoration

The eventual goal of the fisheries resource conservation and resource extraction can be focused on either water body base or compartment base. In order to do so, identification of water bodies should be done for all the rivers, canals and chatals/beels inside the Sundarbans. They can be categorized as main rivers, secondary rivers, large canals and chatals/beels. In case of rivers and canals, name, origin and end point, length width and water depth should be determined. In case of chatal/beel, name, area and perennial status would be recorded. This should be recorded on compartment basis, if a river runs through more than one compartment, sub-compartments details within the compartment should be recorded. A map showing the identified water bodies with names would be produced.

Some rivers, canals and Chatals have silted up in depth and width, whereas others have been closed due to embankments and roads construction outside the Sundarbans. The fresh water flow from the upstream has been reduced, changing the salinity condition and other environmental and ecological parameters which have made unfavorable condition for fish, resulting in fish reduction. The prominent one is the Bhola River where there were lot of Pangas species available few years back, but are rare now due to the reduction of water depth due to sedimentation (Pangas prefers high depth water as habitat for breeding and nursery ground).

The Chatals are important for fresh water and beel species like koi, shing, magur, taki, shol, gajar and others. Those species were available in good quantity few years back. Most of the Chatals have been silted up due to sedimentation. The fishers have dug out the connections of the Chatal. Thus the Chatal dries up, thereby reducing the over wintering and breeding facility of fish. Some habitats which are important for fish (especially commercially and economically important species use those habitat which are important for over wintering, breeding and nursing), have of late degraded. They should be identified and restored.

2. Fish Sanctuaries

In addition to the 18 khals in the buffer zone where fish catching has been banned by FD, more fish sanctuaries should be identified and established with the help of CMCs. Effective fish sanctuaries should be set up and maintained, preferably in each compartment of the SRF.

3. Pond Fish Culture

More fish ponds should be encouraged in the interface landscape in order to lessen biotic pressure on the Sundarbans.

4. Awareness Raising

In conjunction with management options and punitive measures, effective awareness and motivation is required among the fishers and local people. The awareness program could focus on the following issues and themes:

- Importance of the fisheries resources for the livelihood of the people, and its adverse impact on livelihood, if the resources are degraded.
- Rules and regulations regarding the resource harvesting.
- Familiarization of fishing ban areas, their names and boundaries, the objective of fishing ban area, etc.
- Impact of destructive fishing practices, including poison fishing, fine mesh gear use (bag net) and PL collection.
- Bad impact of brood fish harvest.
- Placing of sign boards around the fishing ban area for demarcation and visualization.
- Bill boards showing fishing rules and penalties, to be placed in prominent places, especially at Station Offices where fishers go for permits.

The FD will use the CMOs and other project's (e.g. SEALS) assistance in this regard.

5. Capacity Building and Motivation of the FD Personnel

The staff in charge of regular monitoring of the fishing activities at station and camp levels should be oriented on the fishing rules, ban areas, etc. They also need to be made aware on the importance of the fisheries and should be motivated for playing positive role for conservation. Trained Forest Gaurds and Boatman should be posted in camps and stations.

6. Capacity Building of the Forest Department

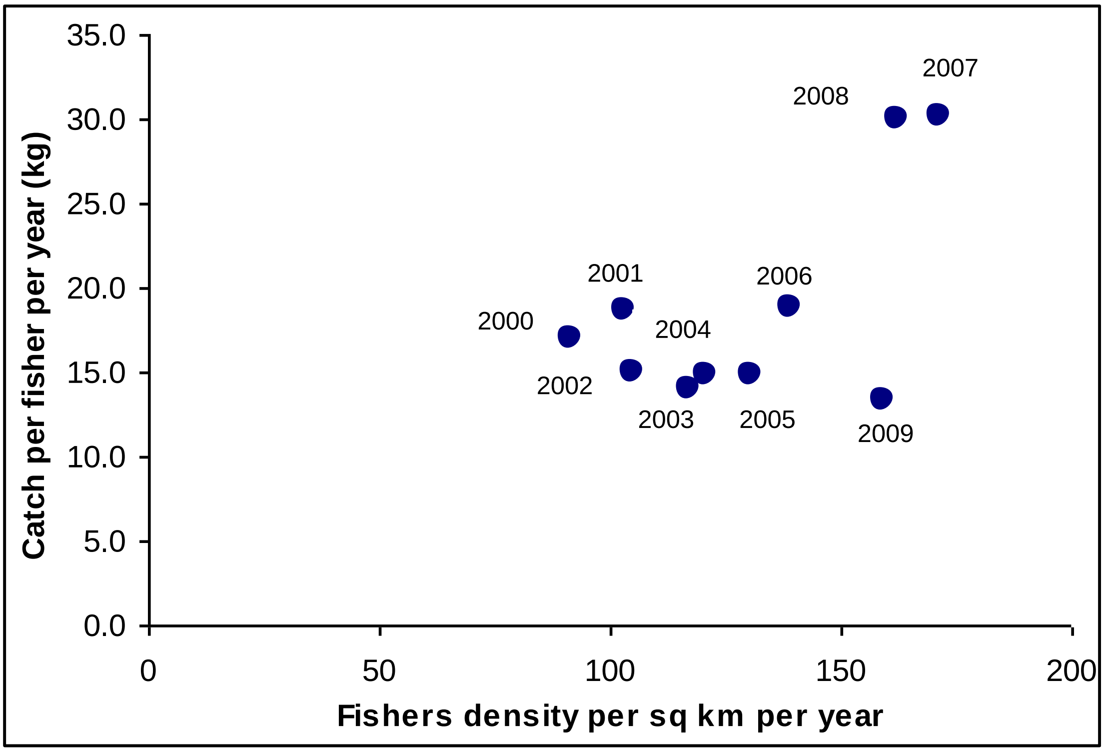
The monitoring of fishers and fishing activities has to be increased for which FD staff capacities should be developed under a medium-term plan.

7. Fisheries Stock Assessment and Production Trend

Main barrier for sound management planning of the Sundarbans fisheries is the lack of information on the status of the fisheries. The concept of catch per fisher per year was used to estimate the maximum level of fisher density per sq.km. The catch/fisher/year versus fisher density showed that fisher density is on an increasing trend in SRF. The annual catch/fisher decreased from 2001 to 2005, but increased from 2006 to 2008 and again sharply decreased in 2009 (Figure 4.4). A primary analysis indicates that prior to over exploitation; the SRF could have supported fisher density not exceeding 125 fishers per sq km. Thus the planning was made on the basis of assumption, scattered information and crude estimation. A comprehensive study should be done at five years interval to look at the following issues:

- Total production of fish and other aquatic organisms.
- Fishery-wise production.
- Gear-wise production.
- Species wise production.
- Range-wise fish production.
- Fish population dynamics.

Figure 4.4: Fisheries Production Trends in the SRF



8. Fisheries Service Providers

Main activities for providing services for local fishers would include hatchery development, more feed and medicine sellers, skill development, ice industry development, transport facilities, storage facilities, linkages with micro-finance institutions and the extension by field officials of the Department of Fisheries.

9. Fisheries Marketing

Possible activities for developing fisheries markets would include forming marketing groups of fishers, and linking with fish markets at local, upzila, zila and Dhaka levels

10. Fish Value Chains Development

Main activities will include value chain analysis, fishers selection and group formation, service/input provider/seller selection, monitoring of production and growth, skill development training for fishers and service providers, product development (grading, packaging, branding, etc.) training for fishers, exposure visits to demonstration sites, marketing group formation, and field tours for market linkages.

11. Regular Production Monitoring

The FD should have a regular fish catch monitoring on production and biodiversity measures, which will generate basic information for management decisions. This will help in allocating the number of BLC, permit issue, restriction of gear use, species caught, etc.

12. Other Studies and data collection

The following aspects should be considered for periodic studies and long-term data collection:

- Long-term data collection on some selected points on a regular basis for monitoring salinity changes.
- Study on the impact of poison fishing on the fisheries and human health.
- Study on the status and changes in water chemistry, hydrology, ecology (on selective parameters) of the waters of the Sundarbans and its impact on fisheries.
- Assessment of the presently fishing closed areas to determine how effective they are for fisheries conservation.
- Study on the feasibility of mari-culture and cage-culture on pilot basis. Success of these practices will create alternative opportunities, thereby reducing pressure on open water fisheries.
- A review/study on the breeding season of mad crab and ban period. Some fishers reported that the present ban period of December to February does not correspond well with breeding season.

13. Livelihoods Opportunities

In reducing pressure on the Sundarbans, the fishers should be supported with conservation-linked livelihood and value chain opportunities. It may include fish culture, other alternate opportunities, VGF card and food security programs. The FD will look for support from other projects, donors, and the Government.

14. Involvement of the Landscape People

A gainful partnership of local people is highly required for long-term management and sustainability of the fisheries. The process has already been initiated by the FD and Co-management organizations have been formed. The local people through CMCs will be involved with activities like fisher selection for BLC, permit issue, etc.

15. Resource Ownership

Action required for local people for feeling ownership to the resource is necessary. But it is subject to access right and resource collection authority. When a person knows that he has confirmed access to the resource and no one is competing, he will be interested in the conservation for his own sake. While issuing BLC, priority should be given to the people living around the vicinity of the Sundarbans. People living around 5 km will get 1st priority and next 5 km will get 2nd priority, and outsiders afterwards. The FD can set criteria for BLC issue that the BLC applicant will require Voter ID card which will give details about one's settlement area. The CMC and its members can help in identifying the real fishers and the poor.

For long-term consideration, a fisher list and ID card can be prepared within 0-5km and 5-10 km area and with a categorization of poverty level in 3 tiers. The FD can take assistance in preparing such a fisher list from the Local Government (e.g. UP) and fishers association. A periodic review of the list will be required at certain interval (3 to 5 years). When the water resources are assessed, it can be segmented into sections with defined boundary. Each fisher group (BLC-based) will be distributed to one or more sections, depending on need and situation. The group will have sole authority of fishing in that area in order to create ownership on the resource, and the group will conserve the section/compartment for their own interest.

16. Fisheries Sector Unit

There should be a separate unit within the office of the CF, Khulna with personnel having education background and experience in fisheries resources management. The unit will help monitor and assess the fisheries status on regular basis and provide feedback for management and planning decision. They will monitor the implementation of fisheries management actions. The team will review and find measures for fisheries conservation on periodic basis. The team will develop a comprehensive fisheries database and establish a museum of aquatic resources. The team will also conduct small studies on selective issues and any emerging issues relating to fisheries.

17. Revenue Rates

Although the resource management would not be revenue oriented and should be focused on conservation and long-term sustainability, the FD can review the present rate of revenue. However, it is important that fishers are able to have easy access to permits, which is necessary to keep faith of the fisher’s community.

18. Fish Preservation and Marketing Opportunities

The fishers are generally tied with money lenders and are deprived of fair price of their fish. They are bound to sale their catch to/through the money lenders with lower price than the market price. They have to take credit with high interest rate. The system is running since long past and is not easy to break. If the fisher get fair price, hopefully they will be happy with lower catch, which will contribute to conservation and livelihood improvement. The Forest Department can, through CMCs, assist establishing few fish landing and marketing centers, and ice factories near the SRF periphery.

19. Dubla Fish Management

The fishers in Dubla practice open fishery by using the island as their base. Dubla dry fisherman hut comprises several *chars* including Office Kella, Majer Kella, Alor Kol, Maran Char, Choto Ambaria, Maher Ali Char, Kobor Khali, CManik Khali, Narikelbaria and Selar Char. Every year the fishers go to these places in October and stay there until March. They catch fish from both inside the SRF and outside in the sea. The fishing boats leave a camp in morning and fish through the night and return back to camp early next morning (with high tide) to unload the catch. FD has permitted the fishers for dry fisheries in the above places during winter seasons. For catching and drying fish they develop local facilities including temporary hut, jetties and drying pan and beds, for which they use forest produce (gewa, goran, golpatta) from the SRF. In addition, they use fuelwood for cooking by collecting locally. Fishermen of Dubla not be allowed to fish in the SRF, except drying and storage of fish collected from the sea.

The fishers should be restricted in only 7-8 seawards iselands Office Killa, Alorkole, Narikelbaria, and Shelar Char. The fishermen huts should be avoided in winter near Kokilmoni, Tear Char and other inward iselands. The settlers in these small iselands take recourse to destructive fishing in small canals which are fish nourishing grounds. There is no fish-landing center in any of the chars and so Bahardars construct temporary residential huts having enough space to be used as rying yards as well : A typical drying yard consists of a fenced area with house at one end where the fishermen live. The fencing yard is made of gewa poles and used as vertical drying racks. Some fish species such as Bombay duck and ribbon fish dry fater when hung vertically, but nearly 90% of a drying yard is covered by fish drying in horizontal position : The fish are dried on mats which are placed on horizontal racks.

FD has started convincing the fishers to minimize the use of forest produce by bringing alternate materials from outside. The compartments 8 and 45 are earmarked for providing forest produce to the fishers by FD on payment of royalty. The fisherman will not use new areas or expand the existing areas for fish drying without the permission of FD. The fishers (or their agents) will collect pass from the concerned FD office for carrying fish from fisherman hut to a landing place. The FD field staff will check the pass at the last exit office and can *in lieu* issue another pass. An ice plant and fish landing centre can be developed at Office Kella. Transportation facilities between Dublar char and nearby marketing town (s) may be developed. Existing FD facilities nearby these char areas may be strengthened and drinking water facilities may be improved. A special study should be carried out for ascertaining the fishermen needs and suggesting improved fish drying and marketing practices, establishing appropriate value chains and developing adequate storage facilities.Necessary support will be provided to FD field staff for implementing the proposed fisheries recources conservation and improvement measures.

4.5 Summary of Main Prescriptions

Main prescriptions outlined under the above-developed food security and wetlands management programs are summarized in Table 4.1 with respect to timing of each proposed activity and responsibility assigned.

Table 4.1: Summary of Main Prescriptions: Food Security and Wetlands Management Programs

Yr	Main Activities	Main Outputs/ Success Criteria	Responsibility
1 & 2	-Protecting wetlands and comprising biodiversity against biotic interference	Reduced level of biotic interference	Stakeholders/ FD/CMCs
	-Inventoring all existing wetlands and assessing aquatic resources for all the wetlands in each compartment	List & status of existing wetlands	FD/CMCs
	-Improving wetlands as habitat for fish and aquatic vegetation	Improved tiger habitat	FD/CMCs
	-Encouraging natural regeneration of aquatic vegetation including enrichment planting of swamp species along the banks of eroding rivers/streams and estuaries	Improved habitat	FD
	-Implementing habitat improvement works including waterbodies maintainance in selcted wetlands	Rehabilitated wetlands	FD
	-Implementing habitat restoration works (identification of eco-restoration activities including water conservation and excavation, khal connectivity, and other low input land husbandry practices	Restored wetlands	FD/CMCs
	- Involving floating villagers in wetlands protection, and in fisheries as income generation activities	Income of villagers enhanced and wetlands protected	FD/CMCs
	-Implementing fisheries resources management and conservation measures as listed in the Plan	Productive wetlands with productive fisheries	FD/CMCs
	-Implementing fisheries resources improvment measures as listed in the Plan	Productive wetlands with productive fisheries	FD/CMCs
	-Conduct the listed studies including assessment of compartment-wise fish production and MSY	Study report	FD
	-Assess, declare and maintain fish sanctuaries	Protected fish sanctuaries	FD
	-Implement listed dry fish management practices for Dubla Char	Improved dry fish management	FD/stakeholders
3 & 4	-Continue protecting wetlands and comprising biodiversity against biotic interference	Reduced level of biotic interference	Stakeholders/ FD/CMCs
	-Continue improving wetlands as fish breeding ground and aquatic vegetation	Productive wetalnds	FD/CMCs
	-Continue encouraging natural regeneration of aquatic vegetation	Improved habitat	FD
	-Continue implementing habitat improvement works including special habitats maintainance, and waterbodies maintainance	Rehabilitated wetlands	FD
	-Continue implementing habitat restoration works (including	Restored wetlands	

	water conservation and excavation, khal connectivity, and other low input land husbandry practices)		FD
	- Continue involving floating villagers in wetlands protection, and in fisheries as income generation activities	Income of villagers enhanced and wetlands protected	FD/CMCs
	-Implementing fisheries resources management and conservation measures as listed in the Plan	Restored wetlands with enhanced fish production	FD/CMCs
	-Implementing fisheries resources improvment measures as listed in the Plan	Productive fisheries	FD/CMCs
	-Implement the recommendations that come out from different proposed studies	Improved management	FD
5 to 10	Continue the above-listed activities and take mid-term corrective actions in the year 6 onwards		

5. Climate Change Mitigation Programs

Although Bangladesh is a low carbon emission country due mainly to low level of industrialization, its vulnerability to climate change is very high, as for instance a sea level rise of 1-2 meter would inundate the country's substantial area, thereby adversely affecting coastal ecosystems including the Sundarbans and a large coastal population. The per capita carbon dioxide (CO_2) emissions in Bangladesh are estimated to be as 0.2 ton/year, which are much lower when compared to 1.6 ton/year in developing countries and 20 ton/year in USA. However, the consumption of fossil fuels in the country is growing by more than 5% per year and motor traffic is increasingly causing environmental pollution. Natural resources including forests and wetlands are getting severely degraded due mainly to heavy biotic pressure brought by rapidly increasingly population. So the conservation of the Sundarbans by protecting its comprising forests (green carbon sink) and wetlands (blue carbon sink) will help ameliorate climate change impacts as both mangroves and wetlands act as carbon sinks by sequestrating CO_2 from the atmosphere.

5.1 Program Objectives

Main objectives of this program are, i) to identify and review possible climate change impacts on the Sundarbans ecosystems, and ii) to quantitatively assess carbon sequestrated and stored in the mangrove forests for developing a REDD+ proposal for carbon financing.

5.2 Climate Change Impacts on the Sundarbans

The role of forests in carbon cycle is vital as they account for approximately 80% of CO_2 exchanged between land and atmosphere through the process of photosynthesis. As trees grow the carbon is stored in biomass by converting CO_2 and water (by using solar energy) into sugars and oxygen (released through leaves). Forests also release CO_2 during the process of respiration. However, forests that are growing (increasing in biomass) will absorb more CO_2 than they they release. So the climate change mitigation role of the Sundarbans in terms of sequestration and storage potential of the CO_2 depends on growing, conserving and sustaining mangroves and wetlands. The climate change adaptation role of the Sundarbans stem from the fact that nearly one million people depend on the Sundarbans for its resilience functions but also for livelihoods, thereby reducing their vulnerability by providing a coping mechanism: The forests and wetlands of the Sundarbans provide life supporting, provisioning, regulating and cultural eco-system services to local people and beyond. A large portion of the landscape population along the coast is dependent on climate-dependent land-based activities such as fisheries, agriculture and forestry.

In view of physical homogeneity of the Sundarbans, climate is one of the most important determinants of its vegetation and has significant influence on the distribution, structure and ecology of natural eco-systems including mangroves and wetlands. Although climate change, as a global public good, is global in its causes and consequences, its adverse impacts are being borne inequitably in different regions and communities of Bangladesh. Climate change thus has potential of altering the configuration by impacting both the Sundarbans ecosystems and the landscape human population. So it is important to understand vulnerability and adaptation issues arising as a result of climate change. Vulnerability to the impacts of climate change is a function of exposure to climate variables, sensitivity to those variables and the adaptive capacity of the affected ecosystems and community. Adapting to climate change would involve reducing exposure and sensitivity, and increasing adaptive capacity. Mainstreaming climatic variability and change, while designing and implementing forestry and wetlands programs, will enhance ecosystem health and benefit local community.

Bangladesh has a unique climate system dominated by monsoon, and the major physiographic features that drive this monsoon are its location (in terms of latitude, longitude and altitude) in the globe, the Himalayas, and the Bay of Bengal and the Indian ocean surrounding it. Climate change (green house gases and their concentration are one of the main drivers of climate change) impacts on forests have been highlighted in a number of studies including various reports of the Intergoverenmental Panel of Climate Change (IPCC). Climate change projections include sea level rise, temperature rise, and increased frequency of drought, cyclones, storms and of other water-induced extreme events. Bangladesh in general and the SRF in particular has a long coastline where the impacts of climate change occur at medium-term and long-term scales. As a result of climate change in this coast, the sea-level may rise and there may be changes in the occurrence of frequency and intensity of storm and cyclone surges. Recently the Sundarbans experienced Sidr and Aila cyclones, indicating that the committed (as a result of past changes in GHG concentration) climate change is already impacting it and future climate change will further aggravate this bleak situation.

The regional variations in sea-level rise in Bangladesh with respect to global sea-level rise are manifestations of tectonic changes and ocean density. For instance, a significant number of cyclones have occurred in the Bay of Bengal as compared to the Arabian sea (at the ratio of 4 to 1). The cyclonic disturbances are 5 to 6 times more frequent over the Bay of Bengal than over the Arabian sea, and one third of the Bay disturbances and half of the Arabian sea disturbances intensify into tropical storms. This may be due to the fact that the surface sea temperature over the Arabian sea is cooler than over the Bay of Bengal. The shallow depth of Bay of Bengal and the coastal flat terrain produce much larger storm surges and take a very heavy toll of human and animal life. Moreover, the Sundarbans coast having a gentle topography is more vulnerable to sea-rise and the adverse impacts of cyclones.

Important changes in the coastal forests such as the Sundarbans may be due to its coastal location but more importantly due to high sensitivity of many natural ecosystems, including forests and wetlands, to temperature rise. Possible changes may include shifts in forests and wetlands boundary, changes in species assemblage or types of forests and wetlands, changes in net productivity of forests and wetlands, and loss of forest and wetland biodiversity. Although enhanced level of CO_2 in the atmosphere may increase net productivity over forests and wetlands, but the forests biomes may be vulnerable to climate change, as a result of which the existing vegetation may be less than optimally adapted to its existing location, thereby making it more vulnerable to the adverse climate conditions as well as to the increased biotic stresses. The effects of climate change are expected to be substantial in the country’s agrarian economy, as a large majority of its population is reliant on land-based primary production (agriculture and fisheries) as a major source of income.

Conspicuous changes in annual trends in both minimum and maximum temperatures have already been noticed both globally and nationally. Variability in monsoon rainfall has been recorded in recent years. Most of the observed increase in global average temperature is due to the observed increase in anthropogenic GHG emissions (IPCC, 2007). A study by the Indian Network for Climate Change Assessment (MOEF, 2010) concludes that discernable human influences now extend to other aspects of climate including ocean warming, continental average temperatures, temperature extremes and wind patterns. It states that because human activities, such as the emission of GHG or land-use change, do result in external forcing, it is believed that the large scale aspects of human-induced climate change are predictable. However, one has to rely on carefully conducted scenarios of human behavior and determine climate projections on the basis of such scenarios.

Global mean sea level change results mainly from two processes, mostly related to recent climate change, that alter the volume of water in the global ocean : i) thermal expansion, and ii) the exchange of water between oceans and other reservoirs (glaciers and ice caps, ice sheets, other land water reservoirs) including through anthropogenic change in land hydrology, and the atmosphere. Regionally, oceanographic factors such as changes in ocean circulation or atmospheric pressure cause changes in sea level. In addition, sedimentation and vertical land movements influence local level sea variations.

5.2.1 Climate Change Impacts on the Sundarbans Fisheries

Fisheries play an important role in food supply, food security and livelihood security of nearly 1 million fishermen and other stakeholders in the Sundarbans landscape. Temperature is known to affect fish distribution and migration. Increasing temperatures may have negative impacts on the physiology of fish because oxygen transport to tissues will be limited at higher temperatures, and this constraint in physiology will result in changes in distribution, recruitment and abundance. Fish have strong temperature preferences to spawning as the process of spawning is known to be triggered by pivotal temperatures. Phonological changes are expected with climate change, and species with short life spans and rapid turnover of generations such as planktons and small pelagic fish are most likely to face such changes.

The changes in distributions, recruitment and abundance of many species will be acute at the extremes of species' ranges. Changes in abundance will alter the species' composition and result in changes in the structure and functions of the ecosystems. Changes in the net primary production and its transfer to higher trophic levels are possible. The eggs of most of the fish species are pelagic, directly exposed to higher temperatures and currents. With temperatures increase, the development duration of eggs and larvae size decrease. The adults may grow faster in warmer years but afterwards the growth rates would start decreasing as metabolic cost continue to increase. The more mobile species will be able to adjust their ranges over time, but less mobile and sedentary fish species may not. Depending on the species, the area it occupies may expand, shrink or be located and this will include increases, decreases and shifts in the distribution of the Sundarbans fish including marine fish, with some areas benefiting while others losing.

5.2.2 Climate Change Impacts on the Sundarbans Ecosystems

The Sundarbans socio-ecological system is highly complex as a result of an intimate interplay of climate change, environment, ecological, oceanographic and socio-economic factors. Ecological resilience can be defined as the extent to which an ecosystem can recover from natural and human disturbances without losing their functions or shifting into alternate states. The Sundarbans ecosystem is important for providing goods and services that are essential for coastal people, and so a more resilient Sundarbans will improve their resilience to climate change. Social resilience is the capacity of the affected coastal people to withstand and recover from disasters such as Sidr and Aila. Socio-ecological resilience thus encompasses both the Sundarbans ecosystem and local community. Resilience-based management recommended in this Plan focuses on enhancing the capacity of both the Sundarbans ecosystem and local community to adopt together and be resilient to changes and disturbances.

The Sundarbans, like any other ecosystem, is able to tolerate some level of climate change and so will continue to persist in short-term as they have done in past. However, in long-term weather its resilience will be sufficient enough to tolerate future anthropogenic climate change is not known. The implications of possibly transient increases in productivity for resilience are also very important and these may occur through likely atmospheric CO_2 fertilization effects and/or modest warming, and as a consequence of increased radiation due to reduced cloudiness. The understanding of time-lags in ecosystem responses is not adequate, and they may take several centuries before responses to climate change are played out. However, there is a likely link between biodiversity and ecosystem functioning in the maintenance of ecosystem services, and thus extinctions critical for ecosystem functioning may reduce societal options for adaptation responses.

Sea-level rise along the Sundarbans coast would submerge the mangroves but would also increase the salinity of its wetlands. This would favor salinity tolerant plants but may reduce the vegetation and aquatic diversity. On the other hand increased snow melt in the Himalayan glaciers (releasing more water in a drought year and less water in a flood year) could bring large quantity of fresh water, with consequences for the composition of the mangroves and fisheries, favoring species that have the least tolerance to salinity. Changes in local temperature and rainfall will also influence the wetlands salinity and aquatic plant composition.

5.3 Inventory of Current Carbon Stock

In order to estimate benchmark carbon stock in the Sundarbans forests, a regorous forest inventory was designed and implemented. Field-based carbon (C) stock estimates for the Sundarbans Reserve Forest of Bangladesh are discussed in this section. First, it presents an estimate of current C stocks, obtained from the 2009-2010 field-based forest inventory. Second, it contains an estimate of change in C stocks since the previous inventory, which was conducted in 1996-1997. This latter analysis provides an estimate of certain "emission factors" over the recent past, which, when combined with remote sensing and other data on land-cover change ("activity data"), is used to establish a baseline C trend against which future changes in C stocks can be evaluated. Methods are briefly summarized here where relevant, but comprehensive methodological information can be found in the separate protocol and meta-data documents (hereafter 'the protocol'; see "Protocols for Measuring & Reporting Carbon Stocks in Mangrove Forests" by USFS (2009). For this carbon inventory, a Tier 3 approach (per IPCC sourcebooks) was considered most appropriate for the Sundarbans Reserve Forest. The reserve represents a key terrestrial carbon stock or sink/source for the country. The measurements required for a typical forest resource inventory and a Tier 3 carbon inventory are generally quite similar. An existing forest inventory plot grid in the Sundarbans provided an opportunity to leverage past data to compare historic and future carbon stocks and emissions.

5.3.1 Inventory Design

Boundary

The inventory area is defined as the SRF, the boundaries of which are well defined by relevant legislation and are well mapped. Aquatic portions of SRF—the rivers and sea channels—are not considered with respect to carbon storage under current regulations or markets. Carbon accounting and markets are currently focused on terrestrial carbon stores only, particularly forests. This means that, although the total area within SRF is ~600,017 hectares, only the ~412,000 hectares of actual land area are currently eligible for carbon accounting and carbon markets. This means that total carbon stocks in the SRF were computed over the 412,000 hectares of land, not by the 600,017 hectares of total area.

Stratification

In some cases it may be desirable to stratify the study area into subpopulations, or 'strata,' that form relatively homogenous units. Because each stratum should have lower variation within it, fewer plots may be needed to achieve the same level of precision. Stratification could be based on, for example, land use or vegetation type, but should be carried out using criteria that are directly related to the variables to be measured—for example, the carbon pools in trees.

For Sundarbans, it was recommended not to *a priori* stratify the project area. This recommendation was for several reasons. First, an existing systematic sampling grid is already in place, with historic data available from those ground points. This will allow past, current, and future data to be evaluated in a consistent manner. Second, as long as a systematic sampling grid was started from a random point (which the SRF inventory grid was), that sample layout is considered the most rigorous and intuitive. Third, the Sundarbans is a dynamic region, with short- and long-term changes in forest cover and biomass occurring due to changes in hydrology, sedimentation, disease, and human factors. Thus, a stratification employed today may not make sense in the future as vegetation communities and lands shift spatially. For information purposes, in addition to presenting reserve-wide estimates (non-stratified), summaries by vegetation type and management unit are also presented.

Carbon Pools

Most international standards divide forests into roughly five carbon pools: 1) aboveground and belowground biomass of live trees, 2) non-tree vegetation, 3) dead wood, 4) forest floor (litter), and 5) soil. Not all pools are required to be measured in every project; decisions can be made at the project level to streamline the effort involved in carbon assessment. A pool should be measured if it is large, if it is likely to be affected by land use, or if the land-use effects or size of the pool are uncertain. Small pools or those unlikely to be affected by land use may be excluded. For the SRF carbon assessment, consultation with FD personnel suggested a recommendation to measure trees, non-tree vegetation, dead wood, and soil. Trees are the most susceptible to land use activities, and soil may be the largest and most uncertain carbon pool in mangroves. Dead wood and non-tree vegetation may be a significant biomass component in SRF and may change significantly with logging activities. Forest floor is usually a minor or even negligible biomass component in Asian-Pacific mangroves; as SRF is similar, this pool was excluded.

Methods for measuring trees, non-tree vegetation, and dead wood were adapted from relevant IPCC-associated sourcebooks (see the protocol for full descriptions of measurements for each C pool). In brief, trees were quantified by stem surveys for large and small trees, non-tree vegetation was quantified by counts combined with allometric destructive harvests, and dead wood was quantified by line-intercept transects. Because mangrove soils are often C-rich and vulnerable to land-use change to deeper layers, soils were measured to 1-meter depth rather than only 30 cm as commonly recommended. To reduce the amount of material to be processed, subsampling was employed, taking advantage of the fact that mangrove soils are typically non-differentiated over the top meter of soil. Thus, rather than taking a core of the entire top meter, manageable subsamples of 5 cm were taken representing 0-30 cm depth and 30-100 cm depth, respectively.

Determining Type, Number, and Location of Measurement Plots

Type— Permanent or Temporary:
Sourcebooks describe options for ‘permanent’ sample plots, in which all trees within plots are tagged and tracked through time, or ‘temporary’ sample plots, in which trees are not tagged. In the latter method, trees are treated like other C pools and are tracked at the plot level over time, rather than as individuals. For the time and logistical constraints imposed by mangrove field work, it was recommended here that trees are not tagged.

Plot shape and clustering:
The shape and size of sample plots is a trade-off between accuracy, precision, time, and cost for measurement. Plots can either be one fixed size or ‘nested,’ meaning that they contain smaller sub-units for various C pools. Nested plots are generally more practical and efficient in forests with a range of stem diameters and densities, and were used in this inventory.
Clustered plot designs (using multiple ‘subplots’) tend to capture more microsite variation in vegetation, soils, etc., thereby reducing among-plot variation (increasing overall precision). For the SRF carbon assessment, a clustered plot composed of five circular subplots was employed, thus taking advantage of the increased precision of clustered sampling, and the fact that this plot design was employed during the previous forest inventory for the SRF.

Number and location of plots:
Plot locations can be selected randomly or systematically (plot grid with random origin). However if some parts of the project area have higher carbon content than others, systematic selection usually results in greater precision than random selection. Systematic sampling is also easily recognized as credible.The last SRF inventory, conducted in 1996-97, sampled 1204 plots situated on a systematic grid at 1-minute intervals of latitude/longitude. Based on logistical constraints communicated by the Forest Department, approximately 150-300 plots is the maximum number that can be sampled in a given census effort now (300 would take two field seasons). Although 300 is the desired and recommended number, 150 may be adequate to achieve reasonable precision. The lower number is still likely adequate for the C assessment given local circumstances, and is similar to plot densities in difficult-access roadless areas that has been used by the United States’ Forest Inventory and Analysis program.

To facilitate these options, the original plot grid was subsampled by selecting every second plot in both the x and y directions. This yielded 295 plots (the full option). To attain a lower plot density, every second row of this new grid was sampled; this yielded 155 plots. To determine that plots are representative of the entire project area, periodic checks should be made to ensure that the overall activity is performing in the same way as the plots. Field indicators of carbon stock changes or high-resolution satellite imagery can be used to accomplish this task.

5.3.2 Field Inventory

The field inventory started with four days of *in-situ* field training, during which the first plots were surveyed. Officials from the USFS, Bangladesh Forest Department, and IPAC accompanied the participants. Participants learned the field protocols, practiced the use of instruments, and discussed probable questions regarding the inventory process. The actual inventory started in December, 2009, led by two Assistant Conservator of Forests (ACFs). IPAC organized the logistics including the hiring of vessels, labor for the team, medical support, and purchasing miscellaneous supplies. Of the 155 inventory plots (originally established in 1996-97) targeted for re-sampling, 5 were now under water due to erosion, subsidence, or canal migration (and possibly sea-level rise). At least two of these five losses were apparently due to recent cyclone damage. Thus, a total of 150 plots were sampled in the 2009-10 inventory. Plots which were partially under large canals were recorded as such, with an estimate of the percent of the plot area under water and measurements taken as normal in above-water portions.

Two field inventory groups, each led by an ACF, were formed for the SRF inventory team. Each group consisted of one ACF, one Forest Ranger/Deputy Ranger, two foresters, two students, two laborers, and two armed guards. Each group was assigned a small engine boat with boatman. The team leaders and some of the crew had participated in the USFS training. The students were from the Forestry Program at Khulna University, which is located near the SRF. The team leaders and the Forest Ranger/Deputy Ranger worked mostly as recorders and reviewers of data. The foresters and students worked as enumerators. Each trip was seven to ten days long depending on stored food and availability of fresh water. Before starting each journey, both groups sat together with detailed maps and GPS units to plan for the next plots. Local knowledge of laborers, guards, FD district staff, and even fisherman aided the crews' efforts to find suitable routes to plots and minimize hiking time. Generally each group completed one plot per day, but often this pre-planning activity helped the groups to complete more than one plot a day.

5.3.3 Data and Sample Management

Field data were entered into computerized spreadsheets periodically and backed up electronically in multiple physical locations. Strict precautionary measures were taken in the process of data collection and data entry to minimize error (see QA/QC section below). Completed data forms were checked and reviewed in the field and data entry was also reviewed. At the end of the inventory, completed data forms were photo-copied and stored in two physically separate secure locations (Forest Department and IPAC offices). The final electronic data files, including one version with only field-collected numbers and one version with C computations, are stored with FD personnel, IPAC offices, and USFS personnel. Soil samples were air-dried in the field, oven-dried to constant mass at 60 °C at the Khulna IPAC cluster office, then sent to Chittagong for carbon analysis. Soil carbon analyses were conducted in the laboratory of the soil sciences division of the BFRI.

5.3.4 Data Analysis

Aboveground and root C pools were computed using both locally derived allometries (via destructive harvests of various shrub species outside the plots) and international standard common mangrove tree allometries (see protocol and references therein) combined with local tables of wood density by tree species. Soil C storage was calculated as the product of soil C concentration (% of dry mass determined by wet oxidation techniques by BFRI), soil bulk density, and soil depth range. All plot-level computations were corrected for the portion of the plot falling on a canal >30 m width, so as not to bias the land-based C density estimates with areas that are officially considered water.

5.4 Summary of Findings – Current C Stocks

5.4.1 Carbon Density

Estimated current carbon pools are shown in Table 5.1. Mean total C density (excluding soil) was 136 Mg/ha (95%CI: ±16 Mg/ha), or moderate to high compared to other mangroves around the world. Total C density of non-soil pools ranged from a low of 20 Mg/ha in one Gewa-dominated stand to a high of 446 Mg/ha in one Sundri-dominated stand. Trees constituted the bulk of the C density across the forest reserve, with a mean of 82 Mg/ha aboveground and 36 Mg/ha belowground, which combines to account for 87% of all non-soil C.

Table 5.1: Mean carbon pools in the SRF, 2009-2010 inventory

C pool	C density (Mg/ha)	95% CI
Trees aboveground (stems + foliage)	82	*± 11*
Trees belowground (roots)	36	*± 4.2*
Saplings + seedlings aboveground	1.4	*± 0.1*
Saplings + seedlings belowground	1.0	*± 0.1*
Non-tree vegetation	2.8	*± 1.1*
Goran	7.9	*± 2.0*
Down wood	4.3	*± 0.9*
Soil 0-30 cm	TBD	*± TBD*
Soil 30-100 cm	TBD	*± TBD*
TOTAL (not incl. soil)	136	*± 16*

Uncertainty estimates (95% confidence intervals, or 95% CIs) were computed using standard techniques outlined in the protocol. The 95% CI for the total C density was derived through basic error propagation (square root of the summed squares of component pools), as outlined in the protocol. As some pools were highly correlated, pools were aggregated in an ecologically sensible way for error propagation (e.g., tree aboveground and belowground pools were obviously correlated and were combined into a single ‘tree’ pool for the uncertainty propagation step).

Although the plot sampling was not strictly stratified a priori, the grid-based sample covered all major land types and allowed post adhoc analysis of different strata (e.g., vegetation types, management units). With respect to vegetation type, plots classified as Sundri-dominated forest contained by far the highest C density at 169 Mg/ha, followed by Gewa-dominated classifications which contained 102 Mg/ha (Table 5.2). Low-stature Goran-dominated vegetation contained the lowest C density at 64 Mg/ha, with Goran shrubs comprising 41% of C pools in that vegetation type (Table 5.2).

Table 5.2: Mean carbon pools (Mg/ha) in SRF from 2009-2010 inventory, by major forest type

C pool	SUNDRI dominated		GEWA dominated		GORAN dominated	
	C density	95% CI	C density	95% CI	C density	95% CI
Trees aboveground (stems + foliage)	109	*± 15*	56	*± 15*	20	*± 4.1*
Trees belowground (roots)	47	*± 5.5*	25	*± 5.9*	11	*± 2.3*
Saplings + seedlings aboveground	1.5	*± 0.2*	1.4	*± 0.2*	1.0	*± 0.3*
Saplings + seedlings belowground	1.1	*± 0.1*	1.0	*± 0.1*	0.7	*± 0.2*
Non-tree vegetation	2.1	*± 0.8*	4.0	*± 3.1*	2.8	*± 3.8*
Goran	2.6	*± 0.9*	11	*± 3.6*	26	*± 7.8*
Down wood	5.4	*± 1.4*	3.5	*± 0.9*	1.7	*± 0.8*
Soil 0-30 cm	TBD	*TBD*	TBD	*TBD*	TBD	*TBD*
Soil 30-100 cm	TBD	*TBD*	TBD	*TBD*	TBD	*TBD*
TOTAL (not incl. soil)	169	*± 21*	102	*± 21*	64	*± 11*

Note: Forest type was determined by cross-referencing the inventory plot grid with the vegetation map layer created by FD RIMS office in 1990s, supplemented with cross-checking a subset of plots to verify that stand composition corresponded with mapped classification. Future in-depth analyses of stand composition in 2009-10 may shift the designation of some plots in the new inventory.

Separated by management unit (Range; see Table 5.3), the Chandpai Range contained the most C-rich forests at 193 Mg/ha; the Satkhira Range contained the lowest C density at 57 Mg/ha.

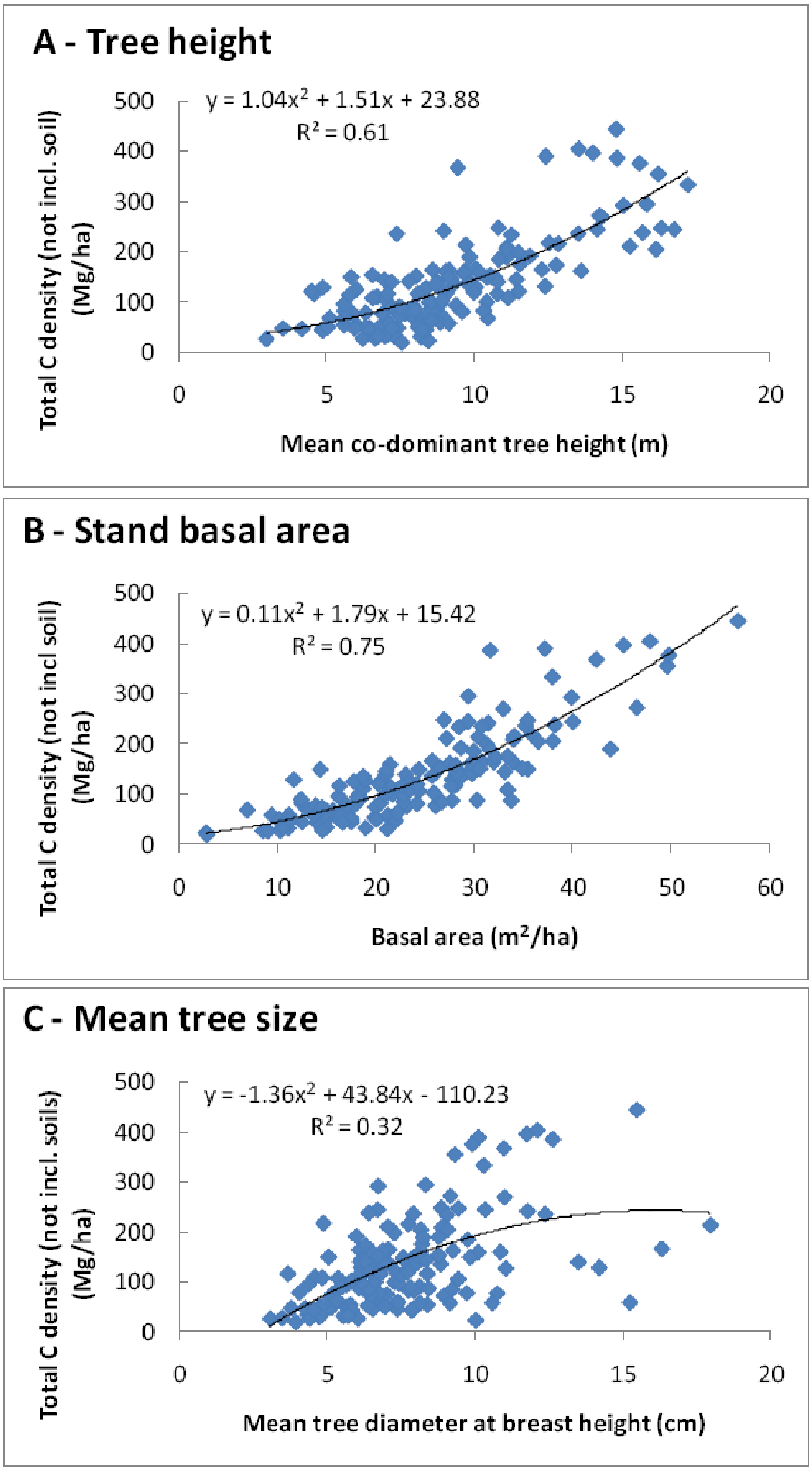
Table 5.3: Mean carbon pools (Mg/ha) in SRF from 2009-2010 inventory, by management range

C pool	CHANDPAI C density	CHANDPAI 95% CI	KHULNA C density	KHULNA 95% CI	SATKHIRA C density	SATKHIRA 95% CI	SHARANKHOLA C density	SHARANKHOLA 95% CI
Trees aboveground (stems + foliage)	127	*± 36*	93	*± 14*	20	*± 3.1*	101	*± 19*
Trees belowground (roots)	52	*± 13*	43	*± 5.5*	11	*± 1.7*	41	*± 6.7*
Saplings + seedlings aboveground	1.5	*± 0.3*	1.4	*± 0.2*	1.0	*± 0.2*	1.7	*± 0.2*
Saplings + seedlings belowground	1.1	*± 0.2*	1.0	*± 0.1*	0.8	*± 0.1*	1.2	*± 0.2*
Non-tree vegetation	2.7	*± 2.0*	3.2	*± 1.8*	2.5	*± 2.3*	2.6	*± 3.0*
Goran	1.2	*± 1.2*	4.6	*± 2.4*	19	*± 4.7*	4.7	*± 3.1*
Down wood	7.2	*± 3.0*	3.0	*± 0.7*	1.9	*± 0.5*	6.4	*± 2.0*
Soil 0-30 cm	TBD	*TBD*	TBD	*TBD*	TBD	*TBD*	TBD	*TBD*
Soil 30-100 cm	TBD	*TBD*	TBD	*TBD*	TBD	*TBD*	TBD	*TBD*
TOTAL (not incl. soil)	193	*± 48*	150	*± 20*	57	*± 7.1*	158	*± 26*

Several measures of stand structure were also assessed for their relationship to C density (Figures 5.1 and 5.2). The two attributes most strongly related to C density were height of co-dominant trees and stand basal area (Figure 5.1). Mean tree diameter (at breast height; dbh) was also correlated to C density, although not as strongly as height and basal area (Figure 5.1). This latter relationship included all trees including small saplings; future analyses may improve the correlation by including only medium to large trees. The strong relationship between tree height and C density suggests good potential for using LiDAR, which can measure forest height remotely, to track changes in C stocks in the future.

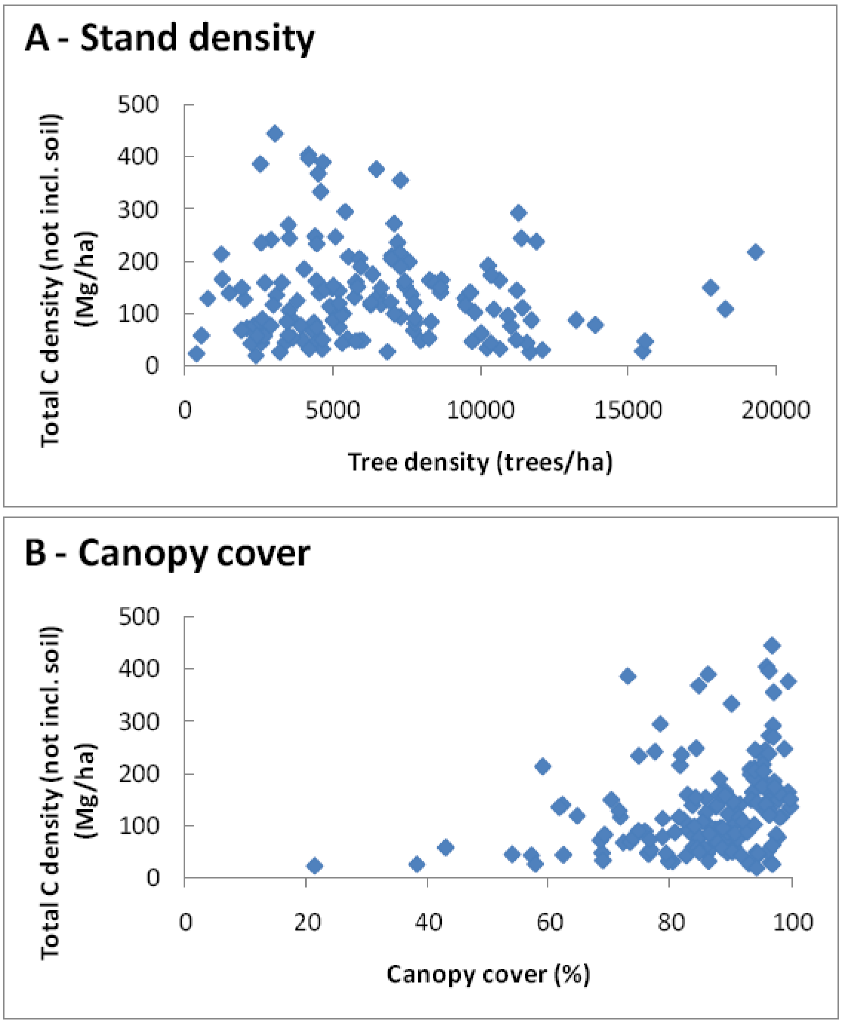
Stand density (trees per hectare) and canopy cover were not strongly related to total C density (Figure 5.2). These attributes can be high even when overall forest stature is low, for example when dominated by low shrubs.

Figure 5.1: Relationship between total carbon density (sum of all non-soil pools) and plot-level estimates of (A) co-dominant tree height, (B) stand basal area, and (C) mean tree size.



Total carbon density is fairly well correlated with these measures of stand structure. The relationship between tree height and C density suggests good potential for using LiDAR imagery to predict C density.

Figure 5.2: Relationship between total C density (sum of all non-soil pools) and plot-level estimates of (A) tree stem density and (B) canopy cover.



These measures of stand structure are poor predictors of C density ($R_2 < 0.15$).

5.4.2 Carbon Stock

The total C stock (forests only) of the SRF (see Table 5.3), which is obtained by multiplying the mean per-hectare C density by the land area, is estimated to be 55.8 Megatonnes (Mt, or 55.8 x 10^6 Megagrams). The 95% CI for the total C stock is 49.4 to 62.5 Mt. If the values C storage in soils are included, the total SRF carbon stcok is estimated as 105.06 Megatonnes (equivalent to 255.20 Megagram/ha).

The amount of carbon dioxide (CO_2) equivalents contained in the SRF (forests only), obtained by multiplying by a molecular conversion ratio of 3.67, is estimated at 205 Mt (± 24.5 Mt), or over 4 times the annual CO_2 emission rate of Bangladesh from fossil fuel consumption. If C storage in soils are included, the amount of total SRF carbon dioxide equivalent (CO_2e) is estimated at 385.57 Megatonnes.

Table 5.3: Total C stock CO_2 equivalents across the SRF, 2009-2010

Mean total C density (Mg/ha)	Land area (ha)	Total C stock over whole SRF (Mt)	95% CI for total C stock (Mt)	CO_2 equivalents (Mt)	95% CI for CO_2 equivalents (Mt)
136 (± 16)	411,693	55.8	49.4 - 62.5	205	181 - 230

Notes:
- 1 Mt = 106 Mg.
- Land area is from RIMS office GIS data.
- 95% confidence limits for total C stock and CO2 equivalents are simple propagation of lower and upper confidence limits of C density multiplied by the land area. No uncertainty estimate was available for land area, precluding full error propagation incorporating uncertainties in both parameters.

5.5 Assessment of Change in C-Stocks, 1997-2010

The current inventory re-sampled a subset of a previous field inventory, which was conducted in 1996-97. This allows a direct comparison between C stocks at the different time points, and an assessment of associated C emissions or uptake during the interim. The two main approaches to estimating land-use emissions are the stock-change approach and the gain-loss approach. The stock-change approach estimates the difference in carbon stocks at two points in time, while the gain-loss approach estimates the net balance of additions to and removals from a carbon stock. The stock-change approach is used when carbon stocks in relevant pools have been measured and estimated over time (such as in forest inventories), and is the approach used here.

Tracking of plot-level data is currently the primary way to assess forest degradation, the reduction in forest carbon density in lands remaining technically as forest cover. Deforestation, the loss of forest cover, is best assessed using remote sensing data ("activity data"). The latter analysis will be underway later this year, led by the FD RIMS office. Upon completion of that analysis, the activity data can be combined with the plot-level ground data to complete a comprehensive baseline assessment.

5.5.1 Methods – Change Assessment

All effort was made to conduct the change assessment using consistent methodologies. Computations of C density and C stocks in the 1996-97 inventory followed the exact same procedures as that for the 2009-10 inventory. For consistency, only the 155 plots in common between both surveys were included in the change assessment (rather than using all 1204 from the 1996-97 inventory). It should be noted that the re-sampled plots were in the same locations in both inventories, but some spatial error likely existed. In some cases the crews noticed markings of old plots; however, these were inconsistent and not reliable overall (durable plot markings are especially challenging in mangroves). This error is difficult to avoid but, over the course of >150 plots, any associated sampling error should balance out (i.e., not result in directional bias).

Certain differences existed in the 1997 dataset, requiring some adjustment of method and limiting what could actually be compared between time points. Mainly, the 1997 inventory was largely a timber resource inventory rather than a carbon inventory, so effectively only trees were measured. Non-tree pools were largely ignored in the previous survey (golpatta was measured in some plots in 1996-97, but the sample size was insufficient to include in the change assessment.). Therefore, only tree pools (aboveground and belowground) could be tracked over time. Trees are the most ready indicator of forest change and degradation, so this change assessment should still yield quite valuable insight.

Because of a local desire to track non-tree C pools, this assessment also evaluates whether there are strong enough correlations between tree and other pools to estimate changes in non-tree C pools between inventories (i.e. by knowing tree pools, it may be possible to predict/estimate other pools, allowing a comparison of total C density between surveys). The five inventory plots that were surveyed in 1996-97 but were under water in 2009-10 due to land subsidence, erosion, channel migration, sea-level rise, or cyclone damage, were included in the change assessment. The loss of standing C stock in these sites (reduction to zero tree biomass) was factored into the estimate of change. Because these five plots were included, this necessarily used an adjusted estimate of mean C density for the 2009-10 dataset compared to the estimate presented above, which excluded areas now under large canals. This difference was relatively minor.

5.5.2 Summary of Findings – Change Assessment

5.5.2.1 Carbon Density and Carbon Stocks

Estimated 1997 carbon pools and comparisons with 2010 pools are shown in Table 5.4. Mean C density in 1997 (trees and sapling/seedlings only) was 76 Mg/ha (95%CI: ±6.6 Mg/ha). Carbon density ranged from a low of 15 Mg/ha to a high of 188 Mg/ha.Multiplying by land area to obtain total C stock, the 1997 inventory indicates a C stock of 31.4 Mt at that time (95% CI: 28.6 - 34.0 Mt). Molecular conversion to CO2 yields an estimate of 115 Mt CO2 equivalents (95% CI: 105 – 124.8 Mt) stored in SRF in 1997.

Table 5.4: Comparison of mean C pools in SRF between 1996-1997 and 2009-2010 inventories

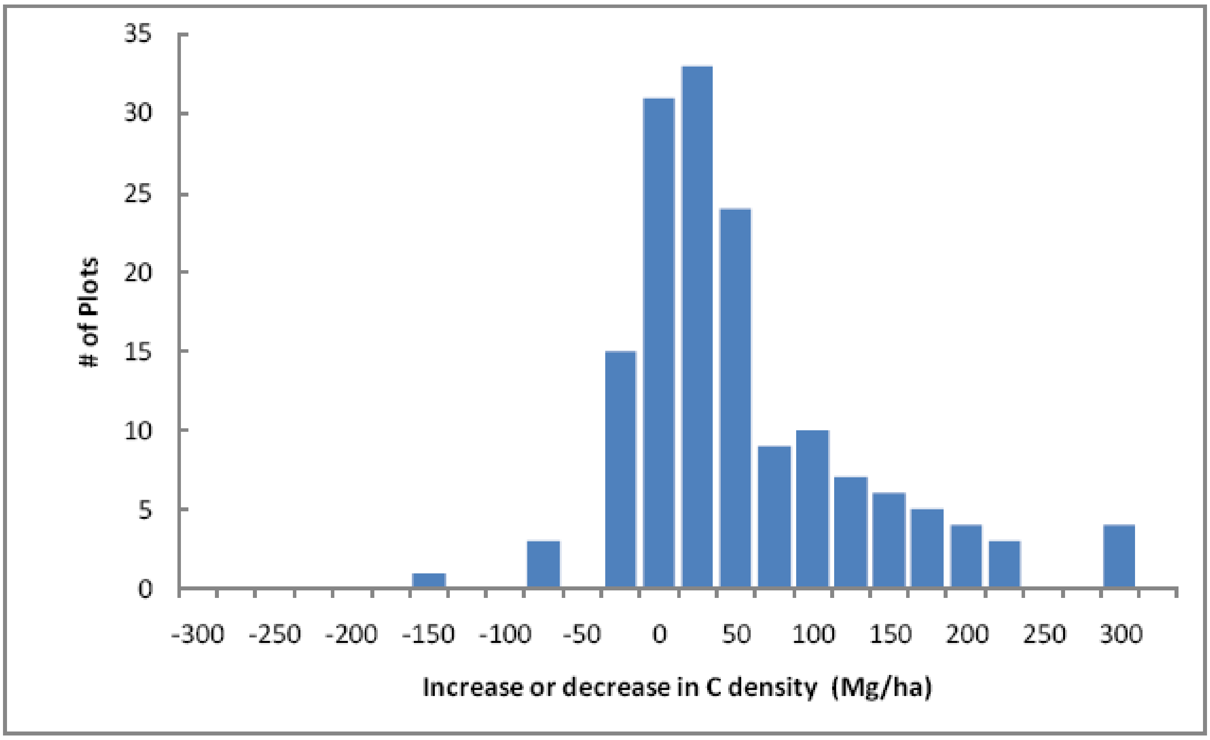
C pool	1997 inventory		2010 inventory		Change (2010 minus 1997)	
	C density (Mg/ha)	95% CI	C density (Mg/ha)	95% CI	Δ C density (Mg/ha)	95% CI
Trees aboveground (stems + foliage)	46	*± 4.3*	80	*± 11*	**(+)** 34	*± 12*
Trees belowground (roots)	27	*± 2.3*	35	*± 4.2*	**(+)** 7.2	*± 4.8*
Saplings + seedlings aboveground	1.6	*± 0.2*	1.3	*± 0.1*	**(-)** 0.3	*± 0.2*
Saplings + seedlings belowground	1.0	*± 0.1*	1.0	*± 0.1*	0.0	*± 0.1*
TOTAL (tree + sapl/seed only)	76	*± 6.6*	117	*± 15*	**(+)** 41	*± 17*

Notes: Only tree and sapling/seedling pools could be compared because these were the only pools measured in the 1996-97 inventory.
(+) and (-) in change column indicate increases or decreases, respectively, during the 1997 to 2010 time period.
Estimates for 2010 pools are slightly adjusted from previous section because this analysis included plots that were land in 1997 but now submerged in 2010 (land subsidence, etc.). These were excluded from the land-based

C density estimate for the current C stock analysis, but were included as negatively changing plots in the change assessment. The difference is minor.
Comparing the two time points, the 2010 tree C pools were significantly higher than those from the same plots in 1997, suggesting an increase in C storage over this time period (Table 5.4). The estimated total increase, accounting for trees only, was 41 Mg/ha (95%CI: ±17 Mg/ha). The majority of plots, 68%, showed an increase in C density between the time points, while 32% showed a decrease (Figure 3). The distribution of changes was positively skewed, with the median change being +17 Mg/ha, but the mean change being +41 Mg/ha due to several plots that apparently showed very large increases (Figure 5.3).

Converting this difference to changes in C stocks (multiplying the mean per-hectare change by the entire land area of SRF) indicates an increase of 16.9 Mt of C storage over this time period (95% CI: 10.0 – 23.7 Mt). The confidence interval is strongly different from zero and suggests that the change is significant. Over the 13-year time interval, this change in C stocks suggests an average annual sequestration rate of 1.3 Mt C per year (95% CI: 0.8 – 1.8 Mt C per year). In CO_2 equivalents, the estimated change in stocks was 62.0 Mt CO_2 (95% CI: 36.7 – 87.0 Mt C). The estimated annual sequestration rate over the 13-year period was 4.8 Mt CO_2 per year (95% CI: 2.9 – 6.6 Mt CO_2 per year), or ~10% of Bangladesh's annual fossil fuel CO_2 emissions.

Figure 5.3: Histogram showing the number of plots that increased or decreased in C density between 1997 and 2010.



Overall, 105 plots (68%) showed an increase in C density over this time period, while 50 plots (32%) showed a decrease. The shape of the histogram is skewed, with the median change across the whole sample being +17 Mg/ha, but the mean change being +41 Mg/ha due to several plots apparently showing quite large increases (see also Table 5.5).

Table 5.5: Estimated changes in total C stock and CO_2 equivalents across the SRF, 1997-2010

Δ C stock		Δ CO_2 equivalents		Annual sequestration rate	
Change in C stock over whole SRF (Mt)	95% CI for change in C stock (Mt)	Change in CO_2 equivalents (Mt)	95% CI for change in CO_2 equivalents (Mt)	Sequestration rate in CO_2 equivalents (Mt/yr)	95% CI for sequestration rate (Mt/yr)
16.9	10.0 – 23.7	62.0	36.7 – 87.0	4.8	2.9 – 6.6

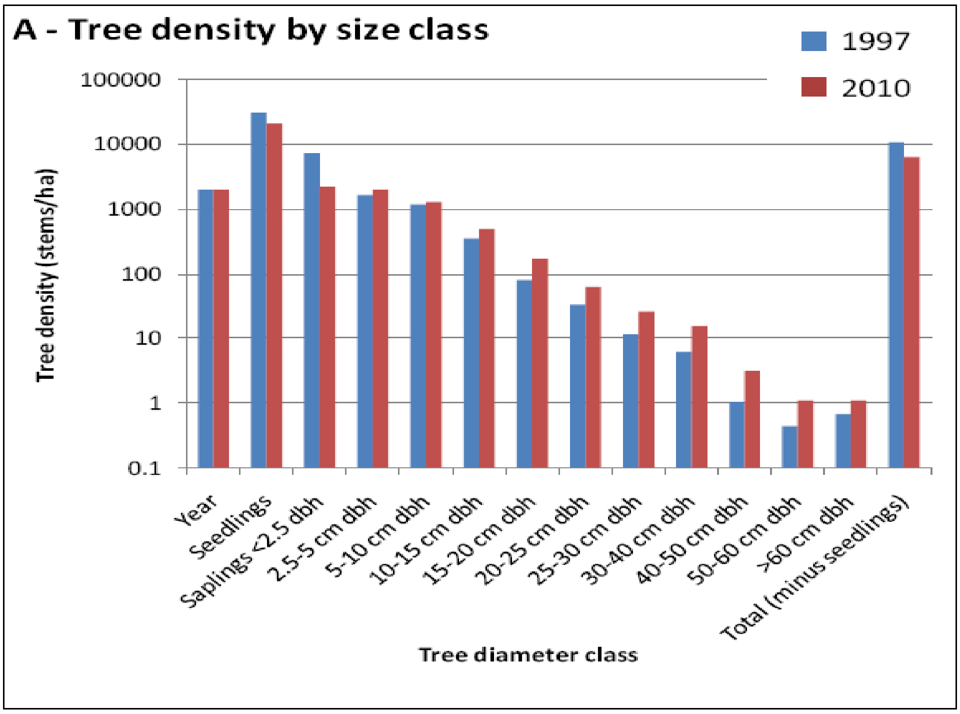
Note: Only includes trees pools, as these were the only pools measured in 1996-97 inventory.

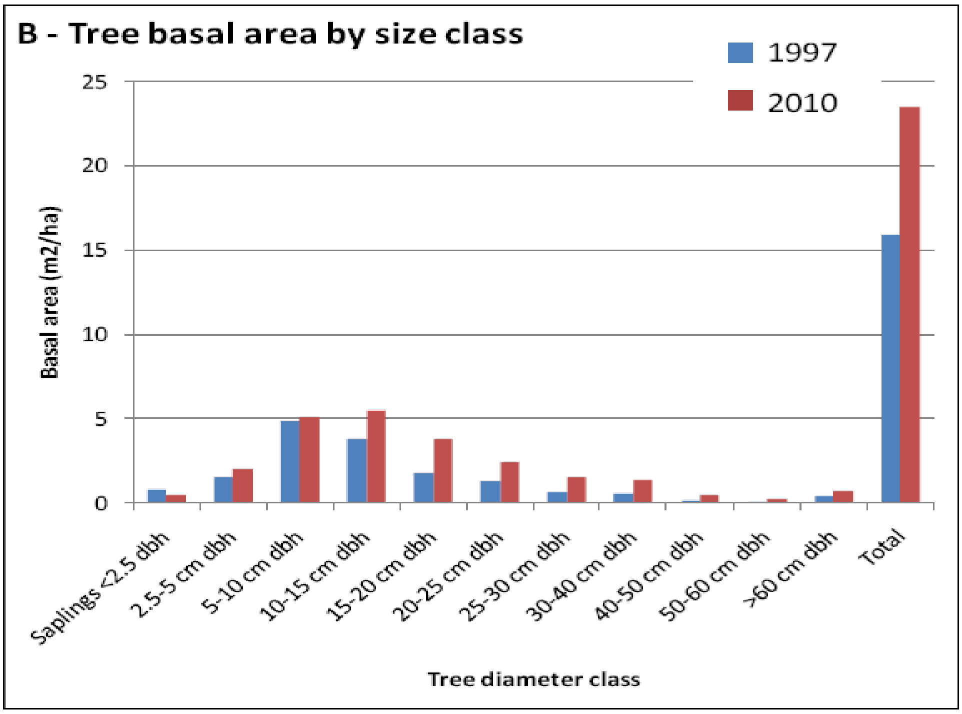
The observation that C stocks apparently increased over the past 13 years was unexpected. Although most or all of the SRF is officially protected from most resource extraction, it is commonly stated/assumed that forests of the Sundarbans are being degraded due to illegal timber extraction, overharvest of fuel wood, etc. Thus, the expectation for this assessment was that the change in forest C storage would be negative (i.e., a loss of C stocks resulting in emissions rather than sequestration). However, the change quantified here was strongly positive, with confidence intervals significantly different from zero. A significant portion of this difference could be an artifact of sampling error.

For example, some of the changes in C density within particular plots were extremely high (e.g., >200 Mg/ha change in 13 years) and likely unrealistic in biological terms. Errors in re-locating exact plot locations could also play a role. In addition, metadata and protocol descriptions for the 1996-97 inventory were lacking, meaning that the data had to be interpreted through the inventory report results only. (For example, it is not clear whether dead trees were measured in that survey; if not, adding those would have increased the 1997 C stocks and reduced the amount of positive change between surveys.) Finally, the quality of the 2010 field data collection and data management was documented for the current inventory, but documentation of QA/QC for the 1997 inventory was not available. The degree to which any or all of these errors may have affected the change estimate is almost impossible to know with certainty.

It is worth noting that the general pattern of observed change is ecologically sensible. In the absence of major disturbance, a typical stand development pattern is that tree densities thin out over time (through competitive exclusion and other mortality), with the remaining trees increasing in size. Indeed, compared to the 1997 data, the 2010 inventory showed lower stem densities, especially of small trees, but larger mean stem size and total basal area (Figure 5.4). The magnitude of this difference was large for a 13-year period, but the general pattern is fairly reasonable. Whether due to actual successional dynamics, sampling error, or some combination of the two, this difference is largely what explains the higher C stocks in 2010.
Changes in the density and basal area of the major tree species of the Sundarbans show a similar trend (Figure 5.5). This analysis was limited to overstory trees (>15 cm dbh), and this larger size class showed increases in density and basal area for most of the major species, especially Sundri and Gewa.

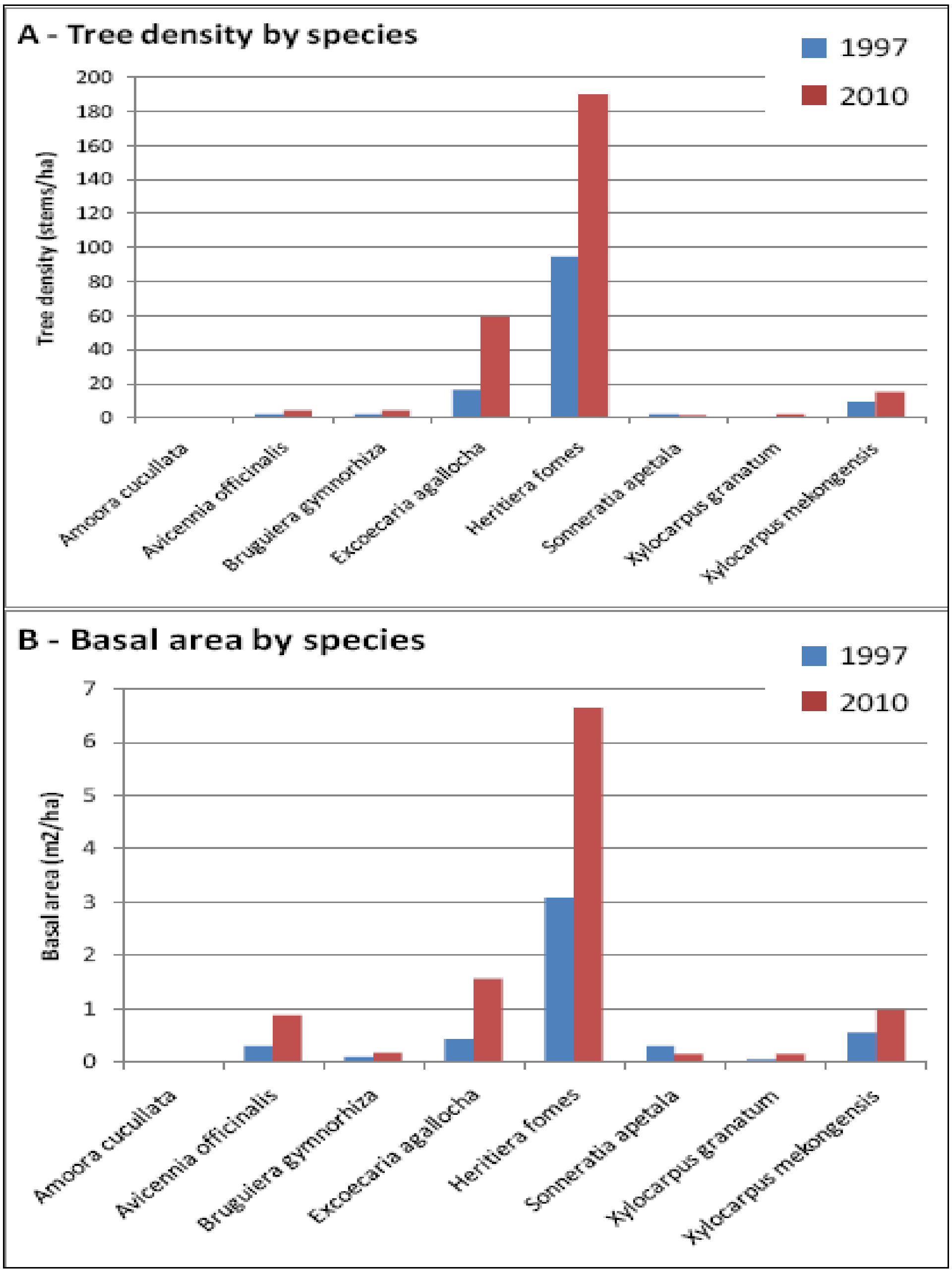
Figure 5.4: Tree density (A) and basal area (B) *by tree diameter class* in the 1997 and 2010 inventories





Note log-transformed y-axis in panel A. The 2010 inventory showed fewer small stems, and fewer total stems (apparent reduction in stem density), but more large stems. The basal area trend was similar.

Figure 5.5: Tree density (A) and basal area (B) by species in 1997 and 2010 inventories

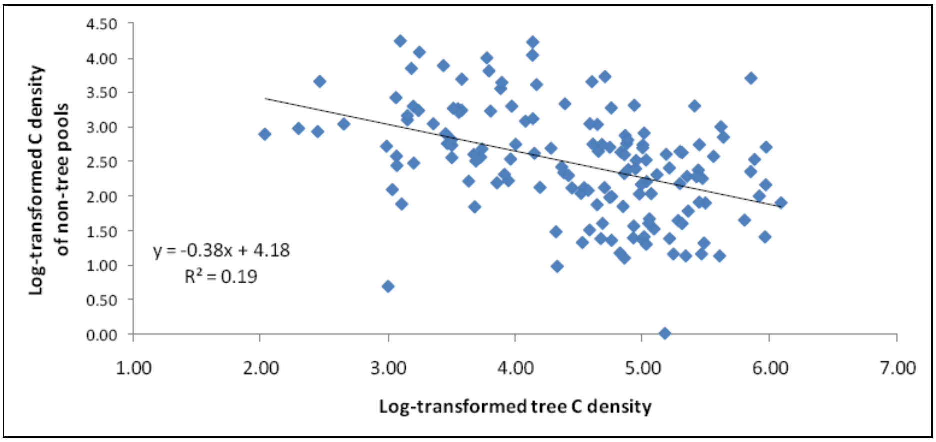


Only overstory trees (>15 cm dbh) of the 8 most common species are included here. Trends in stem density and basal area were generally similar. Sundri (*Heritiera fomes*) and Gewa (*Excoecaria agallocha*) dominated compositionally, and both were substantially higher in density and basal area in 2010 compared to 1997.

5.5.2.2 Assessment of Other (non-tree) C Pools

To see whether tree C density was strongly related to that of other C pools, thereby allowing predictive ability for other pools based on tree pools, a regression was made between tree C density and all other pools combined from the 2010 dataset (Figure 6). Data were log-transformed to better meet the assumptions of linear regression. The observed relationship was quite weak, with tree C density explaining less than 20% of the variation in other C pools (Figure 5.6). For this reason, assessment of changes in non-tree C pools in the recent past is not reasonably possible based on the inventory data alone. This report therefore focuses on changes in tree C pools only.

Figure 5.6: Relationship between tree C pools and non-tree C pools for the 2010 dataset

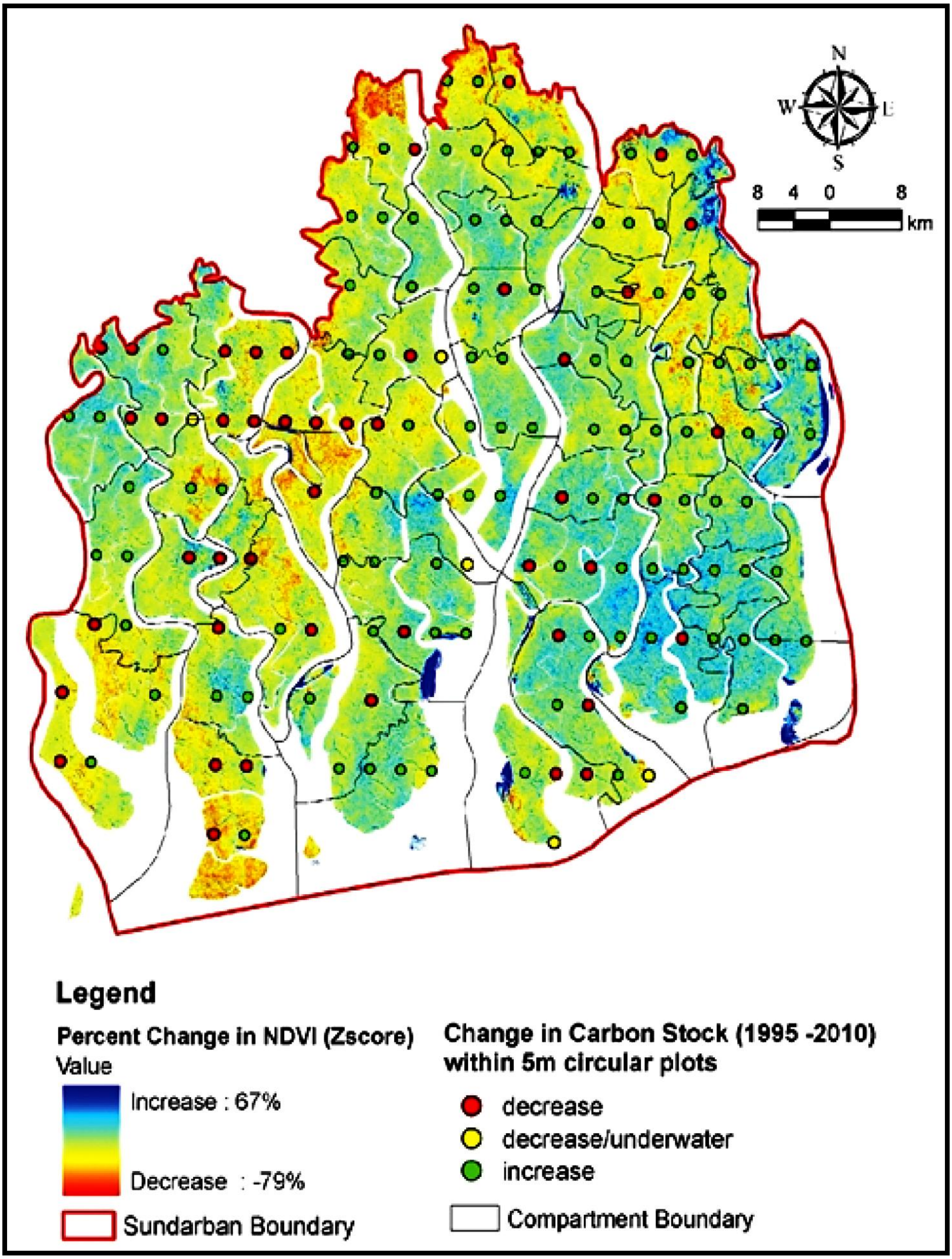


The relationship is weak and does not support prediction of other C pools (e.g., down wood, shrubs, soils) based on knowledge of tree pools. As such, the change assessment was limited to tree pools only.

5.5.3 Assessment of Forest Degradation using Remote Sensing Technology

Three LANDSAT data (the entire SRF is covered by two satellite scenes) from 1989, 1999 and 2009 were employed for developing a vegetation change detection based on Normalized Difference Vegetation Index (NDVI). The results from this study were found to be aligned well with the change in carbon stock and biomass as estimated above. The 10m circular plots that showed a decline in carbon stock were located within the compartments with a decline in NDVI or canopy cover (Figure 5.7). This agreement among the two studies conducted independently confirms that the pattern observed at a plot level is a representative of the overall compartment level pattern and vice versa.

Figure 5.7: Change in C-stock (1995-2010) sampled from 10m circular plots overlaid on percent change in NDVI Z-score of pixels from 1999 to 2009.



5.6 Monitoring, Reporting and Verification System

Main elements of a feasible monitoring, reporting and verification (MRV) system are presented in this section. Sundarbans mangrove forests form an important bio-geographical zone (the country's other such strata/zones include hill forests, sal forests, social forests and homestead forests) and shall thus form a stratum when a national MRV system is designed and implemented. Within the two Sundarbans Forest Divisions (East and West) and four field Forest Ranges, sample plots (temporary and permanent) will be laid out by deciding appropriate sampling design, sampling intensity, number and location of sample plots on a grid, and the methodology adopted in this chapter is recommended for application. A two-year cycle inventory will be carried out in the sample plots laid out in the field as per the grid. Mangrove forests of the Sundarbans can be categorized in the following categories:

- Dense forests (more than 70% crown density)
- Moderately dense forests (30-70% crown density)
- Open forests (10-70% crown density)
- Scrub forests (less than 10% crown density)

As stated above there are two methods for estimating carbon inventory: Carbon gain-loss method estimates net balance of additions to and removals from a carbon stock (based on annual growth rates), whereas the carbon stock change method estimates the difference in carbon stocks at two periods (described in this chapter). The following carbon pools will be estimated:

- Above-ground carbon (tree, sapling, seedling, bamboo, cane, crown foliage, branches)
- On-ground carbon (woody debris, dead trees, leaf litter, grass)
- Below-ground carbon (soils, roots)

Average carbon stock for each of the above-identified stratum will be estimated by following the carbon inventory methods as described in the Inventory Manual (USFS, 2009). Species specific volume equations and specific gravity will be used in estimating carbon stock. Historical deforestation and degradation rates can be assessed either by employing temporal inventory data and/or temporal analyses of imageries such as LANDSAT/IRS. Maps can be generated by using facilities at RIMS of FD and/or SPARSO. Base maps of the LGED available at 1:50,000 scale will be helpful in generating these maps. However, it is important to know that carbon inventory and mapping pose some challenges as forests inventory are generally characterized by uncertainty and data limitations. Emission factors are neither available for the country nor for the Sundarbans. Land-use changes in Bangladesh are happening rather fastly due to heavy biotic pressure. RIMS of FD requires being equipped with the latest equipments and technology, and manned with trained staff

5.7 Quality Assurance / Quality Control

Quality assurance / quality control activities were emphasized from the outset of the 2009-10 inventory. Field procedures were subject to strict oversight and review by the project leaders. The crew carried the protocol at all times in the field, and any confusion could be solved by referring to the protocols as well as the local knowledge of team members. Before starting the journey, the plot location and access route were thoroughly studied using GPS units and detailed maps. The latitude/longitude points in the GPS and duly checked by the team leaders. An important quality control activity was re-arrangement of team composition. Every week the team leader was changed; thus each team had the experience of working with both leaders. In this way, any gaps or methodological differences were minimized. The team composition itself was also changed occasionally during the field season. This shuffling helped in reducing observer/team biases and also improved efficiency.

Each completed data sheet was reviewed in the field. The bottom of every data sheet provides room to document quality control activities. At the end of every field outing, all data sheets were reviewed by a crew member for completeness, legibility and accuracy. Once satisfied by the quality of data recorded, the data reviewer recorded their name and the date of the review, along with any notes on issues that were noticed during the check so that they can be prevented in the future. The soil samples were re-packed from the plastic sample containers to whirl packs/zip bags after air drying. This re-packing was done by the crew on the main vessel. The team leaders monitored these processes to minimize mistakes. Completed data sheets were filed separately by plot and stored in a safe location in the vessel. Upon return from a 7-10 day sampling trip, a copy of each data sheet was made and kept in the Khulna IPAC office. At the end of the inventory, completed data sheets were photo-copied and stored in two physically separate secure locations (Forest Department and IPAC offices).

Field data collection procedures were also observed and checked by higher officials of the Forest Department and IPAC. The officials accompanied the inventory team to a subset of plots to observe the data collection procedure. They also visited a subset of plots from where data had already been collected two months earlier, to check for actual visitation and accuracy of measurements (the plots were re-sampled by the crew with the officials present). It was found correct with the previous data, and the marking tape was found precisely at the center of the plot. The officials were satisfied with the quality of inventory work.

The data entry process was also conducted very carefully, with close oversight by the team leaders. Entered data were also checked and reviewed. After completion of data entry, a randomly selected 10% of plots were cross-checked for data entry errors, plus spot-checking of others. The observed error rate was less than 1%, which was deemed acceptable and highly unlikely to affect overall estimates significantly. The database was also checked for extreme outlier values (e.g., trees larger than 200 cm) to eliminate potentially influential errors. The final electronic data files, including one version with only field-collected numbers and one version with C computations, are stored with FD personnel, IPAC offices, and USFS personnel. For data analysis, all data steps were recorded in understandable fashion in spreadsheet files, with separate meta-data documenting how various decisions and approaches were arrived upon during the computations.

5.8 Summary of Main Prescriptions

Main prescriptions outlined under the above-developed climate change mitigation programs are summarized in Table 5.6 as below:

Table 5.6: Summary of Main Prescriptions: Climate Change Mitigation Programs

Year	Main Activities	Main Outputs/Success Criteria	Responsibility
1 and 2	-Assessing possible drivers and implications of climate change in the Sundarbans coasts	Assessment Report	FD/MOEF
	-Conducting climate change impacts assessment for sensitive land-uses (including forestry, biodiversity, ecosystems, wetlands, agriculture, hydrology, etc.)	Assessement report	FD/MOEF
	-Holding discussions with local stakeholders on possible climate change vulnerability, risks and impacts	Aware stakeholders	SEALS/FD/ Stakeholders/ CMCs
	-Finalizing a short list of priority mitigation options including reducing deforestation and land-use degradation, carbon stock enhancement and sustainable land-use management	Short lists of possible mitigation options	FDSEALS/CMCs
	-Developing carbon project proposal methodologies and procedures	Project Preparartion manual	FD
	-Mobilizing capable groups and enterprenuers taking responsibility for project development and implementation	Groups identified	SEALS/FD/CMCs Stakeholders
	-Preparing training & publicity material on climate change impacts and mitigation	Training materials prepared	SEALS/FD
	-Designing and developing demonstration projects on REDD+ and A/R	Project proposals	FD
	-Identifying trainees	Trainees identified	FD/SEALS
	-Finalizing preparations for imparting training & demonstrations to local stakeholders	Preparations for training completed	SEALS/FD
3 and 4	-Publicise widely about climate change impacts assessed for sensitive land-uses	Aware planners and stakeholders	FD/MOEF
	-Continue holding discussions with local stakeholders on possible climate change drivers, vulnerability, risks and impacts	Aware stakeholders	FD/CMCs
	-Expand the list of priority mitigation options including reducing deforestation and land-use degradation, carbon stock enhancement and sustainable land-use	Expanded list of possible mitigation options	FD/ CMCs

	management -Developing carbon project proposal -Promote public-private partnerships for capable groups and enterprenuers taking responsibility for project development and implementation -Updating training & publicity material on climate change impacts and mitigation -Designing and developing demonstration projects on REDD+ and A/R -Identifying trainees -Continue imparting training & demonstrations to local stakeholders	 Project Proposals Private investors and partners identified Updated training materials Project proposals Trainees identified Training completed	 FD FD/MOEF SEALS/FD FD FD/SEALS SEALS/FD
5 to 10	As above with a mid-term evaluation in the year 6 after the continueing activities will be adjusted and consolidated		

6. Climate Change Adaptation Programs

Climate change adaptation role of the Sundarbans from the fact that approximately one million people depend on the Sundarbans for its ecosystem resilience functions and community livelihoods, thereby reducing their vulnerability to climate change by providing coping mechanisms: The Sundarbans provide ecosystems services in terms of life supporting, provisioning and regulating functions and products, and so has tremendous impacts on the livelihoods of coastal community in particular and the people of this country in general. Apart from providing timber and fire wood resources, it is an important source of food, crops, fish, medicinal plants, ecotourism and recreation. A large proportion of the landscape population depends on climate-sensitive livelihood options including fisheries, agriculture and forestry. Besides deriving economic value of directly extracted goods, the Sundarbans serves as carbon sink and coastal protection from cyclones and tidal surges, thereby enhancing the resilience of both local people and ecosystems on which they depend for meeting their subsistence consumption needs. It provides livelihoods to the local community and contributres in the national economy. That sustainable management and use of the mangrove forests would yield higher welfare benefits than any other activities towards its development is now well known, particularly after Sidr and Aila.

Given physical homogeneity of the Sundarbans, the climate and the Bay of Bengal are important determinants of its vegetation in terms of the distribution, structure and ecology of the natural ecosystems including wetlands and mangrove forests. Climate change is though a global public good in terms of its causes and consequences, its adverse impacts are being borne inequitably in the Sundarbans landscape. Climate change thus has potential of altering the Sundarbans configurations by impacting its ecosystem and the landscape community. It is, therefore, important to understand relevant climate change adaptation issues including vulnerability and livelihood situation of the landscape people. Vulnerability to climate change impacts is a function of exposure and sensitive to climate variables and the adaptative capacity of the Sundarbans ecosystem and the landscape community. Adapting to climate change will, therefore, involve reducing exposure and sensitivity, and increasing adaptive capacity of both the ecosystem and local community of the Sundarbans: Chapters 1-5 have dealt with the Sundarbans ecosystem related management issues, and the interface community related issues are dealt in this chapter.

In view of no commercial harvesting in the SRF, minimum direct benefits (mainly from NTFPs) flow to local community, who are being increasingly tasked to provide community forests protection that will involve opportunity cost in terms of foregone benefits from illegal felling but also their labor spent in voluntary patrolling efforts. So other relevant mechanisms of benefits flows to local communities need to be explored. Additional benefits need to be mobilized through livelihoods activities including conservation-linked value chain development and alternative income generation activities that will generate both wage and self-employment opportunities. In this chapter the economics of extraction from the Sundarbans is discussed along with the presentation of identified value chains and livelihood options that can be implemented in the landscape villages by the co-management organizations and FD field staff by mobilizing financial resources from the GOB and donors (e.g. SEALS and IPAC supported by the EU and USAID respectively, Arannyak Foundation) but also from other sources such as entry fee revenue allocated to the CMCs.

6.1 Program Objectives

Main objective of the climate change adaptation programs is to quantify the economics of extraction and sale of products marketed from the SRF and develop appropriate economic interventions for improved management of the Sundarbans, ensuring economic and resilience benefits to local community. This means developing appropriate climate change adaptation programs that would comprise analyzing and developing conservation-linked value chains and livelihood options to be implemented in the landscape villages. In the process, a number of livelihoods opportunities need to be identified and conservation-linked interventions designed for providing alternative income to local community in order to reduce extractive harvesting of the Sunadarbans resources.

6.2 Value Chains Mapping Design and Implementation

There are documents and studies (e.g., SBCP, 2003; Rahman, 2007) that identify a full range of stakeholder categories with an analysis of the extent to which the hundreds of thousands of poor resource users depend on the Sundarbans. It has been observed that although the resource users undertake over-extraction, the poor users are most exploited by the moneylenders, only to expedite the process of pauperization. Based on a structured questionnaire survey and spatial sampling, data was collected and an analysis was done for estimating the number of resource collectors and actors involved in extracting from the Sundarbans. The study area comprises the identified landscape zone with 5 districts, 10 upazilas, 151 unions/wards and 1,302 villages. The SRF products are broadly divided into five major categories: timber, non-timber, fish, aquatic, and non-aquatic resources. The timber category consists of sundari and other trees, followed by non-timbers consisting of golpata, grass and hantal, fish consisting of gura fish, sada (large) fish, hilsha, shrimp, and shrimp fry, aquatic resources consisting of crab and mollusc, and non-aquatic resources consisting of honey. The study identified 159 markets, 138 primary centers (landing places) and 21 secondary markets. These primary landing places for various SRF products were the sampling units that were identified based on a systematic random sampling method: The ultimate sample size was 237 and a total of 47 focus group discussions (FGDs) were conducted across all the 10 upazilas and activities.

Apart from value chain analysis, main activities centered around the SRF products were assessed in terms of value added, starting from resource collectors to ultimate consumers. Focus was given, however, on social relationships among actors involved across a supply value chain. The basic structure of marketing chains for the SRF products is shown below. Main theme was to map the monetary value throughout the chain and so the ultimate output looks like something involving the following steps:

A simplified and typical SRF marketing system and value chain of the actors (% of retail price)

Collector	Faria/Bepari	Choto Mahajan	Boro Mahajan	Aratdar	Wholesaler	Retailer
VA = ? C = ? M = ?	VA = ? C = ? M = ?	VA = ? C = ? M = ?	VA = ? C = ? M = ?	VA = ? C = ? M = ?	VA = ? C = ? M = ?	VA = ? C = ? M = ?

VA = Value addition; C = costs; M = Margin = VA - C

6.3 Characteristics of the SRF Actors

The marketing and distribution system of major SRF products follow a complex system in a unique economic zone. For many of the items, which are dependent to some extent on the FD rules and regulations, the number and type of major intermediaries (e.g., Aratdars) are rather limited, causing an oligopolistic behavior to carry out such activities. In this backdrop, concerns with regard to resource control of the leading powerful agents and intermediaries are strongly voiced from time to time. This has given rise to the possibility of inequity and anti-competitive behavior (for example, price manipulation, ownership of productive resources and control of supply in the market, earning extraordinary profit) through a well-coordinated oligopolistic behavior. The number of important and powerful players in the marketing and distribution system of the SRF goods is limited and such a network of powerful actors has created an unequal income distribution among the landscape populations through widespread exploitations.

6.4 Estimation Procedures

Data generated through various methods are summarized and analyzed to seek estimates of the main research parameters. For example, to get an estimate of the average Gross Marketing Margin, GMM = (Sale Price - Purchase Price) for a particular agent of a specific product, average is made over all the collected/validated sample values. Similarly, agent and product specific Net Marketing Margin NMM= (GMM - Marketing Cost) is estimated. In a similar way, gross and net monthly returns are estimated from GMM and NMM by incorporating average volume of products traded. In normal situations, average selling prices of one actor should be equal to average buying prices of the next actors in the hierarchy in turn. But due to various reasons, this was not true in this study. Consequently, the average selling prices were not used in estimating gross returns as buying prices were different than selling price of the preceding actors. In the case of the original resource collectors, cost of collection includes associated living expenses, or any official and unofficial payments. The estimates of margins or returns have also to consider investment. Returns over working capital, both in terms of gross returns over working capital (GRWC) and net returns over working capital (NRWC) are estimated to offer an idea about its rate, and to see if such returns are abnormally high or low.

The marketing chains for the SRF products are complex and multi-dimensional, involving, again, innumerable combinations. As generally applicable for all SRF products, the calculation of value additions, and costs and returns is fraught with the problem in that resource collectors are usually engaged in harvesting multi-products (as high as more than 20 species in sada or gura fish, for example). In particular, it posed problem to estimate returns of some actors (Mahajans and Aratdars, for example) as they also have multiple roles. Some Mahajans were found to act as Aratdars and some Aratdars as Mahajans. Similar was the case with Choto Mahajans, Beparis and even some wholesalers. Furthermore, the resource collectors or even Beparis or Farias sell their products partly to Mahajans and partly to Aratdars or even wholesalers at different prices. The emphasis in this study is given on estimating gross or net returns of individual actors on a monthly basis so that their relative positions, in terms of income and inequality, for example, are revealed. The value additions for the resource collectors, who largely work for others on wages with associated costs borne by trip organizers, are considered to be merely the price at which the products are sold.

It was attempted to estimate the extent of income concentration at intermediaries level (share of income of top few traders in total income) and also at area level, in order to have an idea about possible market power and income inequality prevailing among SRF actors. The volume of products was estimated at enterprise level only. The basic, common and dominant chains for the selected SRF products are identified for investigations. In the case of multi-products and multi-grades dealing with by a single actor, the dominant product or grade is considered. Based on the mapping of flows, volumes and actors, an attempt was made to develop an approximate geographical map, however, based on first-stage movement, which may be of particular importance in the context of necessary interventions. Starting from the place of origin (i.e. where it is collected), it was possible to approximately map how and where the product travels, that is, from places of collection, to places of intermediary traders, then to places of wholesalers, retailers and final consumers.

The basis of assessing the product movements in the economy emerged from the assumption that the actors, by and large, were well informed about geographical destinations of SRF products including their end-use. They were also generally found knowledgeable about regional origins of their purchases. In estimating the production costs of collectors, family labor costs were imputed based on prevailing wage rates and considering 50 percent as opportunity costs of labor. Retailers' transport costs were estimated by taking information on total transportation cost of all types of products bought at a time, and then apportioning this for the selected items. This required some standardization of transportation cost, which could have resulted in under or over estimation although this is assumed to be counter balancing.

Given the multi-dimensional pattern of flows, the aggregate estimate of the "number of agents involved"/"jobs created" from the Sundarbans would be tentative. The ban on timber felling remains in effect until 2015 for the Sundarbans (since 1989). Some of the actors associated with timbers have been displaced; some have altogether abandoned the profession. The flows for timber were carried out with the help of some timber traders who used to be in operation in the past. Some reported unofficial logging (e.g., in Patharghata) has been contemplated to capture this. The ban on golpata has been withdrawn and during the survey the harvest of golpata was in full swing. Seasonality of the SRF activities posed a major problem in conducting interviews. Except for fish, different harvests have different time periods (see Table 6.1). A number of problem analyses were carried out with people, particularly at the bottom layers, that is, collectors of a number of the SRF products.

6.5 Socio-economic Indicators

The five landscape districts have an estimated population of 85.5 lacs, which constitute about 6.0 percent of the total Bangladesh population. The landscape districts have an area of about 15,352 sq km which represents 10.4 percent of country's area. The density of population in the landscape districts (557) is far below the national average (966). Approximately 49 percent of the total area of five districts lie in the landscape : Khulna has the highest area to lie in the landscape (72.3%), followed by Satkhira (51.0%), Bagerhat (41.4%), Pirojpur (27.0%) and lowest in Barguna (21.1%). In terms of population (estimated for 2009), about 28 percent of five-districts total population belongs to the landscape. The total population belonging to the landscape thus estimates as 0.24 million. The highest percentage of population live in Bagerhat (56.4%), followed by Khulna (24.1%), Pirojpur (23.6%), Barguna (20.7%) and the lowest in Satkhira (17.0%). Based on available information, 25 percent of the households in the landscape enjoy the electricity connection, which is below that in the coastal zone (31%) or the country as a whole (31%). Similarly, the number of active tube wells per Km^2 in the landscape is 5 compared to 7 in both coastal and national average. The percentage of households enjoying sanitation in the landscape is 44.5, which compares favorably with the national average (36.9%). Child mortality rate for every thousand is estimated at 93, compared to 103 for the coastal district and 90 for Bangladesh as a whole.

Table 6.1: SRF Resource Extraction Calender

SRF Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Golpata	M E	M E	M E									M E
			R E	R E							R E	R E
Sada fish	M E					M E			M E	M E	M E	M E
		R E	R E	R E	R E		R E	R E				
Hilsha								M E	M E	M E	M E	
						R E	R E					R E
Shrimp Galda/Bagda					M E	M E			M E	M E	M E	M E
	R E	R E	R E	R E			R E	R E				
Shrimp fry		M E	M E	M E	M E	M E		M E	M E	M E		
	R E						R E				R E	R E
Shutki	M P	M P										M P
			R P	R P							R P	
Crab	M E	M E								M E	M E	M E
			R E	R E	R E	R E	R E	R E	R E			
Honey			M E	M E								
					R E							

Major extraction: M E — Major Processing: M P
Reduced extraction: R E — Reduced Processing: R P

Based on available information, the share of agriculture to GDP in the landscape was 29 percent against the national average of 26 percent. The contribution of industries sector was 22 percent, which was same as that of coastal zone but less than that of national average (viz. 25%). The landscape shares 49 percent to service sector, while it is more or less the same in the case of both coastal and the country, as a whole. Most of the landscape districts have miserably low level of GDP per unit area, indicating low regional development. On average the landscape district has GDP per sq km of only Tk 8.5 million, compared to Tk 14.4 million in that in coastal zone and Tk 21.8 million in an average district in Bangladesh. In the landscape, 30 percent of the people or nearly four times that of the share of national figure earn their living by fishing. Generally, the landscape has experienced low cropping intensity, 134 percent as a whole. The landscape agriculture (irrigated) is still far underdeveloped as only 29 percent (approximately) of the landscape agricultural land came under irrigation as against more than 50 percent in non-landscape region.

A climate change vulnerability analysis demonstrates a very dismal picture on poverty lavel. Head Count Ratios (HCR) for the landscape districts and upazilas shows an extremely pessimistic picture. The landscape upazilas have a much higher extreme poverty rates (0.42) compared to non-landscape upazilas in Bangladesh (0.26). The poverty situation in almost all the landscape upazilas appears to be extremely severe, which have immense policy implications. The HCR for Bagerhat is estimated as 0.43 as compared with 0.24 for non-landscape upazilas of Bagerhat, followed by Khulna (0.41) and non-landscape Khulna (0.32), and Satkhira (0.65) and non-landscape Satkhira (0.45). The only exception is for Barguna (landscape – 0.36 and non-landscape -0.43). For Pirojpur, the HCR is almost identical (the landscape – 0.18 and non-landscape – 0.19). Hence, among the upazilas, the estimated HCRs are relatively higher for Shymnagar (0.65), Dacope (0.60) Morrelganj (0.50), Sarankhola (0.49) and Mongla (0.42). Relatively less worse situation prevails for Mathbaria (0.18), Bagerhat Sadar (0.32), Paikgacha (0.34), Koyra (0.35) and Patharghata (0.36).

6.6 Socio-economic Characteristics of Actors

A total of 48 (out of 159) concentration centers were covered in the sample, so as to include all the major SRF products and the major actors who were the respondents. In all, investigations were carried out with 237 actors. Nearly 13 percent of all actors in the study area have age up to 18 year, while about 87 percent have age above 18 years. Slightly less than 17 percent are illiterate. Collectors constitute the highest number of illiterates. As regards origin of the actors, slightly less than three-fifths (59.1%) reported that they were local while slightly higher than two-fifths were non-local, operating from outside the jurisdiction of the landscape. The average land holding size of all SRF actors is miserably low, by any standard; less than one acre (88 decimals) and half an acre (49 decimals) on account of ownership and operation respectively. The collectors are virtually landless. But, on the other hand, land is inequitably distributed among the actors categories. The higher level actors are relatively richer and wealthier (in terms of land holding) sections of the society.

6.7 SRF Extraction

6.7.1 Collectors Working for Other Actors

About 60 out of 63 or 95 percent of the collectors work for wages or work/collect for others. Most collectors work for Boro Mahajans (43.4%), followed by Choto Mahajans (38.3%), Aratdars (11.6%) and Farias/Beparis (4.7%).

6.7.2 Catch in Fish Sanctuaries

About 43 percent actors were aware about fish sanctuaries, while about 54 percent were not. Out of the fisher respondents who were aware of the restricted areas of fishing grounds, only 2.1 percent confessed that they always catch in sanctuaries, 19.1 percent confessed that they practice it often, followed by 38.3 percent who rarely practice and 40.5 percent who never practice. According to perception of the collectors (aquatic resources), the average proportion of total harvest from sanctuaries is estimated as 11.5 percent.

6.7.3 Distance of Harvest Place from Home Village

Economics of SRF extraction is directly related to distance of harvest place from home village. Average distance of harvest place from home village of the respondents is 34.4 km. The distribution of distance by Range shows that the distance is the highest for Khulna Range (38.1 km), followed by Satkhira Range (36.4 km), Sarankhola Range (31.4 km) and Chandpai Range (31.2 km). In terms of products, hilsha fishers have to travel longest distance (67.7

km), followed by golpata collectors (50.3 km), honey (34.8 km), crab (31.2 km) and gura fish collectors (29.5 km).

6.7.4 Distance between Collection Point and Markets

Distance from collection points to markets can be regarded as a proxy of existing marketing facilities. Average distance between collection point and primary (landing) markets is around 41 km and the average distance between primary markets and secondary markets (wholesale) is even further, around 61 km.

6.7.5 Days Spent in Collection of SRF Resources

Like distance of harvest place, costs of harvests are obviously related to days spent in collection of SRF products. Highest time is required in collecting golpata (32 days), followed by for honey (25 days-in several trips together), hantal (19 days), hilsha (12 days), crab (8 days), gura fish (6 days) and sada (white) large fish (5.5 days).

6.7.6 Working Period for SRF Products

A profile of working months and days for SRF activities (including collection, trade and other ancillary activities) shows that peak months range from 3 to 6 months, except for grass and hantal which is in the range of 9 months. Average peak months considering all the SRF products together amount to around 5 months. Non-peak months (adjusted for number of days worked) range from 2 to 6 months, but most products have non-peak months of 2 to 3 months - the overall average being around 3.7 months. On an average, SRF actors work 23 days in the peak season and 14 days in non-peak months.

6.7.7 Occupation Pattern of SRF Collectors

On an average, the collectors under study together are found to be engaged in collection activities more than half of the time (52.4%) whole year. They are engaged in SRF collection in maximum numbers, during four months such as Poush, Magh, Falgun and Chaitra, to the extent 71, 68, 65 and 68 percent of the time respectively. Besides, the collectors get engaged in SRF related business and other activities to overall extent of 18 percent of the time whole year. The collectors are engaged in such activities in relatively more numbers during the month of Baishak, Jaistha, Ashar and Sraban. As the collectors have hardly any agricultural lands they get engaged in only 2.0 percent of the time whole year; some of them get employed as wage earners, but to the extent of only 6.0 percent of the time. The collectors appear to remain fully unemployed around 16 percent of time of the year, most severe months of which are Ashar, Sraban, Bhadra and Falgun.

6.7.8 Capital Structure of Activities

Fixed capital includes value of land and buildings while working capital includes (which is traditionally called Chalan) expenses such as repair of boats, nets, salary, wage, fuel, transpiration and unofficial expenses, etc to run day-to-day business. The SRF activities are basically working capital oriented. Concentrating on such capital, among the actors, Boro Mahajans appear to employ highest working capital (Tk 512 thousand), followed by Aratdars (Tk 466 thousands), wholesalers (Tk 396 thousand), retailers (Tk 201 thousands) and so on. The small amount of dadons received by collectors can be termed as working capital (Tk 4,365). Averaged over all actors, an actor employs a little more than Tk 169,470 as working capital. On an average, fixed capital constitutes slightly more than one-fourth (27.4%) and working capital constitutes little less than three-fourths (72.6%).

6.7.9 Dadons and the Sundarbans Economy

The Sundarbans economy, centering around informal credit arrangement (dadon), is a sort of unique system. heavily accessible based on Relationships (social connection), Linkages (business connections) and Trust level (social capital formed among actors community). This network has created moderate to strong scale of both vertical (between actors along value chains) and horizontal (between actors at the same level of value chains) linkages. More than 95 percent of the working capital by SRF collectors is derived from dadons, whereas only 4 percent derived from the NGOs. For all the actors together in the value chains, dadons account for 37 percent, the banks and the NGOs accounting for 4.8 percent and 12.4 percent of total finance respectively. The remaining capital is derived from either own or personal sources. There are obvious reasons for which SRF actors such as the collectors prefer dadons to all other sources. One of the major reasons is that dadons provide physical security (e.g., from pirates), social security (in lean and hazard periods) and financial securities (fund for running extraction activities) to the collectors, a feature institutional sources seldom can provide. So, the SRF economy is characterized by a unique market and financial system indeed.

Almost all the actors starting from collectors either receive or offer dadons in this way or that way. The higher level of actors mostly offer dadons but also sometimes receive money (sort of advance) against sales obligation to their clients, which may also be termed as dadons. The Aratdars, for example, consist of Choto Aratdars who receive and Boro Aratdars who offer dadons. They also comprise local and non-local Aratdars. Boro Aratdars also receive advance. With a few exceptions with wholesalers, the retailers and wholesalers do not receive any dadons but they carry out business with Aratdars on credits at some enhanced prices of their products. Similar is the case with retailers. In fact, it is difficult to identify what are dadons and what are credits as there are many ways of repayment - repayment in cash with interest (47.6%) or without interest (4.0%), repayment in goods at market price (16.7%) and repayment at reduced market price (33.3%).

Field survey shows that the collectors have to sell their collected products at a price reduced by up to 22.5 percent compared to prevailing market price, depending on products. Besides, the purchasers also take additional share for the dadons by making pilferage in terms of weights of quantity of the purchased products, especially aquatic products (crab, fish). As the dadon-takers, more often the harvesters, usually cannot pay off the debt, the whole cycle is never ending and they remain locked for a long time, sometimes for ever. Some of the dadondars (dadon givers) charge interest (usually 2-10% on a trip basis) on sales. They also take additional share of profit for their investment, apart from making pilferage in terms of weights on the purchased quantity. In a few places the commission is as high as up to 20 percent, in aggregate, on sales. In spite of the above, dadons are preferred to bank or NGO loans as they are easily available in adequate amounts.

There has been tremendous growth of saw mills and furniture units on all counts. The growth in terms of fixed and working capital estimates as 19 and 20 percent respectively (however, at current prices). As regards growth in terms of the number of enterprises, again, there has been a tremendous growth, as high as 24 percent, in respective landscape locations. The trend growth rate of local timbers used by saw mills and furniture units in the landscape estimates as 14 percent. In contrast, timbers as SRF source experienced an overall high negative growth, 24 percent. Three has been no adverse impact of moratorium on the growth of saw mills and furniture enterprises which have thrived on the timber obtained mainly from homestead tree gardens. A number of large industries located in Khulna Division and established in the 1960s are heavily dependent on the raw materials (e.g., gewa, sundari and singra) from the SRF for their production.

6.8 Value Chains Mapping

In order to map for flows, actors and volume, and value chain analysis, it would be important first to identify the major SRF actors and their functions/roles in the value chains, which is briefly described below:

General Actors

Collectors

They collect or produce SRF products and thus constitute the primary link to the marketing chain. Collectors, largely work for wages, usually cannot sell their products directly to the market. Largely illiterate and disadvantaged, they do not own any productive resources, and they are the most exploited groups; socially and economically they belong to the bottom stratum in the value chains. In most cases, collectors work for Mahajans (Choto or Boro) and/or Aratdars, and even for, in a few cases, for wholesalers.

Farias

In the value chain of SRF products, this agent is not found to be common other than in the case of honey and fish in a few cases. Generally, Farias are petty traders operating with small capital and small volume of business compared to other intermediaries. They generally sell products to the Beparis/Aratdars. Sometimes, they work as the agent of Aratdars/Mahajans to buy from the collectors on a commission basis. At times, they act as retailers to vend their products in villages.

Beparis

Beparis are relatively more professional traders who buy a large quantity of the production from collectors or Farias, and sell directly or through Aratdars to wholesalers. They operate in both primary and secondary markets. Sometimes, Beparis also sell to Aratdars on commission basis (in the case of golpata, for example, in Shailmari, Khulna).

Majhi (Boatman)

In a few cases (e.g., fishers or golpata collectors), the group of collectors is led by one boatman, known as Majhi, who is contracted for the harvest by Mahajans or Aratdars or Bahaddars. Sometimes, they themselves act as Mahajans; sometimes, they organize the whole trip and take care of collection. Majhis (Boatmen), however, get double the share of the workers. In a few cases, Majhis (boatmen) acts as Choto Mahajan (Shailmari, Khulna for Golpata, for example).

Choto Mahajan

Choto Mahajans collect forest products commercially by engaging collectors, with investment from their own. They organize, operate and finance resource collections with workers, wages, nets, gears, ropes and boats, and often control trips; and in return buy products at fixed but usually reduced prices. At the end, they sell products to Boro Mahajan or Aratdars. In a few cases, Choto Mahajans get involved in collection process.

Boro Mahajan

Boro Mahajans are also sometimes money lenders, implicitly or explicitly. They undertake commercial collection of SRF resources with higher investment (relative to Choto Mahajan) from their own. They make business out of managing/investing in resource collection in SRF areas Organize collectors, boats and boatmen, and control trips in overall resource collection but usually do not get involved in trips. They are responsible for arranging permits for the workers in their name from the FD. Some of the Boro Mahajans can be termed as Choto Mahajans in the context of scale in broader regions.

In a few cases of fishing, Mahajans lend money to Aratdars (and vice versa) at a monthly interest rate and Aratdars lend money to boatmen (team leader of collectors) for 15 days at a specific interest rate.

Bahaddar

They usually refer to fish processing (Shutki). They are some of the main entrepreneurs who invest and manage the whole process of fishing. A bulk investment is required to procure nets and boats for fishing. The Bahaddars are usually from outside the landscape (Chittagong, for example), and own a large number of boats, nets and gears. They are responsible for arranging permits from FD. In some cases, they even sell primary products, in part or full, at the collection points, but they largely conduct fish processing.

Aratdars

The Aratdars are generally self-financed, but they require relatively small capital for operating the business as they usually serve as the commission agents. They have their own fixed establishment in their market and operate among Mahajans, Farias, Beparis, Paikars and wholesalers. Aratdars are few in numbers but powerful and apparently highly beneficial group in the value chain. Like Bahaddars, some big Aratdars maintain liaison with various departments, bureaucrats and politicians, and influence to protect their interests often at the costs of SRF. Some Aratdars are also money lenders, implicitly or explicitly, and some take part in auctions of SRF products, especially timbers, golpata and fish. In a few cases, Aratdars directly get involved in the collection process.

Paikars

Paikars, some are small and some are large; usually they operate in fish markets. Small Paikars operate in local markets while the large ones participate in fish auction process at the Arats in landing places. Only registered Paikars or traders can participate in auction before they are sold to wholesalers. They need to pay commission to the Aratdars. In some cases, they bypass the Aratdars to earn higher profits.

Wholesalers

Wholesalers are licensed traders, having fixed business premises in the wholesale market. Their performances vary according to the volume of transactions. They usually buy from Aratdars or Mahajans, and generally sell to the retailers.

Retailers

Retailers, the last marketing channel, buy products from Beparis or wholesalers, and sell to the consumers in open market places. Their volume of business is relatively small and they possess relatively small capital.

Product Specific Actors

Golpata collectors

Golpata collectors are involved in collection of golpata and other non-timber products such as goran, hantal (often called Bawails). In non-harvest period, they often become involved in fishing or honey collection but sometimes become involved in illegal felling under the leadership of big Aratdars or urban elites. Sometimes, they cut timber trees (mostly goran or sundari) illegally and get it to landing place under the cover of golpata. Sometime they take some extra trees in the name of balancing of boats. As in other collections, at times, golpata collectors become prey to tigers or dacoits.

Sada (large) Fishers

Large fish species such as Rupchanda, Pangas, Poa, Bhetki, Koral and Kawon living in areas next to SRF are known as Sada (white) fish.; some Sada fishers become involved also in fish drying in the dry season and some switch over to hilsha fishing in the monsoon.

Hilsha Fishers

Hilsha fishers are relatively more professional, conducting fishing inside and adjacent water bodies of SRF, in both dry season and monsoon. They are not used to undertake any other resource collection during Hilsha season. Some of them are often involved in Jatka collection even when there is ban, reportedly, on the ground that they have little livelihood support during off seasons.

Shrimp Fishers

Shrimp fishers constitute those involving large (galda and bagda) and small (gura chingri) shrimps. In many cases, the collectors also get a small share of profit in this case. The collectors are largely involved in harvesting multiple products : crab, mollusc, and other small fish.

Shrimp fry collectors

Men, women and children mostly from poor households catch shrimp fry; even in some cases, female members of affluent households are also involved in the fry collection. During the collection, reportedly they destroy around 100 other types of aquatic species, resulting in the loss of biodiversity in the region. Nevertheless, the shrimp fry collectors need little capital but they have few options but to sell their products to intermediary agents (e.g., Mahajans or Aratdars or Depots).

Crab collectors

Mostly from poor fishing communities, they collect crabs, mollusc and shells from SRF; there is usual ban on crab collection in specific months of the year but often not followed. In the off season, the poor crab collectors have few livelihood opportunities. Some crab collectors, however, manage to switch to fishing profession or shrimp fry collection or agricultural wage earning.

Bawails

They are the group involved in the collection of timber or non-timber forest products, especially golpata, goran, hantal and other minor plants through permits during seasons. At times, they become prey to tigers or pirates.

Mawalis

This group is involved in the collection of honey and bee wax through permits during official season. BLC is granted from FD against boat owner for one year and permit is given to individual collectors. Groups of 6 to 7 Mawalis enter into forests and it takes about a week to get harvests, which are usually sold to concerned Mahajans/wholesalers or Beparis against dadons taken.

Fish Aratdars

Large fish traders and investors, many have their own boats and gears and organize trips in SRF through Choto and Boro Mahajans. They are also money lenders in the sense that they offer loans/dadons to agents such as Beparis, Mahajans or collectors. This is the most powerful group of actors who control collection and marketing of fish from SRF.

Timber Aratdars

They used to be most powerful business group of SRF non-¬fish resources before the moratorium to harvest timbers. Investments are also large – with boats, trawlers and organize trips in SRF through Mahajans. After the moratorium they tend to have diversified their business.

Millers

Millers, referring mostly to timbers, are involved in processing activities such as log production. In a few cases, millers also perform the functions of wholesalers. In the context of mollusc/shell/oyster, millers constitute major actors who manufacture fishmeal or poultry feed.

6.8.1 Mapping Core Steps in the Value Chain

A few common and dominant chains for SRF products are identified as follows:

Timber - Sundari
Chain 1: Collector ⇒ Mahajan ⇒ Aratdar ⇒ Wholesaler ⇒ Retailer
Chain 2: Collector ⇒ Choto Mahajan ⇒ Boro Mahajan ⇒ Aratdar ⇒ Wholesaler ⇒ Retailer

Non-timber
<u>Golpata/Grass (Shon)</u>

Chain 1: Collector ⇒ Mahajan ⇒ Aratdar ⇒ Wholesaler ⇒ Retailer
Chain 2: Collector ⇒ Choto Mahajan ⇒ Boro Mahajan ⇒ Aratdar ⇒ Wholesaler ⇒ Retailer
Chain 3: Collector ⇒ Choto Mahajan ⇒ Boro Mahajan ⇒ Choto Aratdar ⇒Boro Aratdar ⇒ Wholesaler ⇒ Retailer

In a few cases, again, Beparis or Farias also exist along the chain between collectors and Mahajans. It must be noted that sometimes the chains are not systematic as shown above. Although more often collectors sell their products to Choto Mahajans or Boro Mahajans some also sell their products directly to Aratdars or wholesalers depending on from whom they have taken dadons. In other words, some Mahajans are also Aratdars or vice versa.

Fish

Among innumerable combinations, the following marketing chains are most commonly found.

Gura fish
Chain 1: Fisher ⇒ Mahajan ⇒ Aratdar ⇒ Auctioneer ⇒ Wholesaler ⇒ Retailer
Chain 2: Fisher ⇒ Choto Mahajan ⇒ Boro Mahajan ⇒ Aratdar ⇒ Wholesaler ⇒ Retailer
Chain 3: Fisher ⇒ Faria ⇒ Mahajan/Aratdar ⇒ Wholesaler ⇒ Retailer
Chain 4: Fisher ⇒ Mahajan ⇒ Aratdar ⇒ Company/Exporter

Sada (White-Large) fish
Chain 1: Fisher ⇒ Mahajan ⇒ Aratdar ⇒ Auctioneer ⇒ Wholesaler ⇒ Retailer
Chain 2: Fisher ⇒ Choto Mahajan ⇒ Boro Mahajan ⇒ Aratdar ⇒ Wholesaler ⇒ Retailer
Chain 3: Fisher ⇒ Mahajan ⇒ Aratdar ⇒ Auctioneer ⇒ Wholesaler ⇒ Retailer
Chain 4: Fisher ⇒ Mahajan ⇒ Aratdar ⇒ Company/Exporter

Hilsha
Chain 1: Fisher ⇒ Mahajan ⇒ Aratdar ⇒ Auctioneer ⇒ Wholesaler ⇒ Retailer
Chain 2: Fisher ⇒ Bahaddar ⇒ Auctioneer ⇒ Wholesaler ⇒ Retailer
Chain 3: Fisher ⇒ Mahajan ⇒ Aratdar ⇒ LC party /Exporter

Fish (Shrimp) fry (galda and bagda):
Chain 1: Fry collector ⇒ Faria/Bepari ⇒ Mahajan ⇒ Aratdar ⇒ Nursery ⇒ Retailer

Almost in all the cases, Choto Mahajans or Boro Mahajans organize the collection job while the collectors work on only wages to sell their collected products at some fixed or reduced price. As in other cases, collectors sell their products to Choto Mahajans or Boro Mahajans and some also sell their products directly to Aratdars or wholesalers. The basic structure being the same or similar, in the case of exports, Aratdars sell their fish products to exporters.

Aquatic Resources

Crab
Chain: Collector ⇒ Mahajan ⇒ Aratdar/Depot ⇒ Exporter

Mollusc/Shell/Oyster
Chain 1: Collector ⇒ Mahajan ⇒ Miller ⇒ Fishmeal/Poultry Wholesaler ⇒ Retailer

In the case of mollusc/shell/oyster, millers constitute a major actor who manufactures fishmeal or poultry feed.

Non-Aquatic Resources

Honey:
Chain 1: Collector ⇒ Faria/Bepari ⇒ Mahajan ⇒ Wholesaler ⇒ Retailer
Chain 1: Collector ⇒ Mahajan ⇒ Wholesaler ⇒ Retailer

Although sometimes honey is also exported such purchases are made directly from wholesalers.

6.8.2 Mapping for Total Number of Actors

The total number of collectors is estimated as approximately 10.8 lacs. The estimates refer to whole year, rather than only relevant harvest time. Our survey indicates that an average collector get engaged in 1.8 products in a year. On this basis, the total number of collectors estimates as 6 lacs. As regards the distribution of total number of collectors across districts, Khulna occupies the highest position (48.7%), followed by Bagerhat (22.3%), Barguna (12.7%), Pirojpur (12.3%) and, the lowest, Satkhira (4.1%). The total number of actors (including collectors) is estimated as 13.37 lacs. On the assumption that one actor deals with 1.8 products whole year, the total number of actors estimates as 7.4 lacs. Product wise distribution shows that the highest number of actors is engaged in shrimp fry (galda) (24.3%), followed by shrimp fry (bagda).

6.8.3 Mapping for Geographical Flows

The basis of assessing the product movements in the economy emerges from the assumption that the actors, by and large, are well informed about geographical destinations of SRF products including their end-use. According to first-stage movement, the SRF products are traded within the landscape upazilas to the extent more than one third (34.1%), while the proportion that are traded in other parts of the country (e.g., Khulna, Chittagong and Dhaka-presumably some for exports, and other parts of the country) estimates as about little less than two-thirds (63.7%). The traded quantity, directly from the landscape to outside the country, is estimated as about only 2.3 percent.

6.9 Value Chain Analysis for the SRF Products

A total of 12 SRF products have been included in the value chain analysis as discussed below:

6.9.1 Golpata

Value Additions and Returns

Looking at value additions in terms of price, collectors provide the highest value addition (49.8%) of the total price, the price being considered from collectors to consumers. Keeping collectors aside, retailers create the next highest value addition (13.7%), followed by Choto Mahajans (12.7%), Majhis/Beparis (11.2%). Aratdars (6.1%), wholesalers (5.1%) and the lowest for Boro Mahajans (1.5 %).

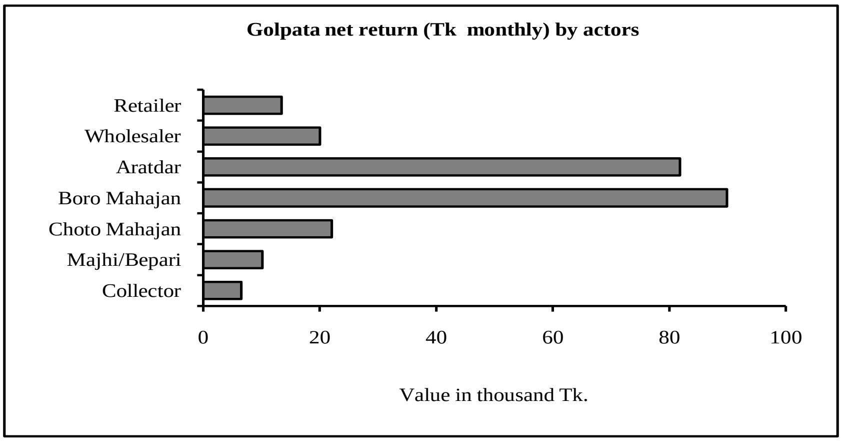
Table 6.2: Value addition and return for golpata

	% of value addition & return for golpata			
	Price Value Addition	Av. Volume (Pon) per month	Net Return (month)	Net Return as % WC
Collector	49.7	0.6	2.7	-
Majhi/Bepari	11.2	3.7	4.2	121.97
Choto Mahajan	12.7	6.6	9.0	22.67
Boro Mahajan	1.5	27.7	36.8	23.31
Aratdar	6.1	40.9	33.5	25.18
Wholesaler	5.1	16.3	8.2	7.51
Retailer	13.7	4.2	5.5	12.67
Total	100.0	100.0	100.0	-

Note: 1 Kaon = 16 Pon, I Pon = 80 pieces.

Aratdars carry out the highest volume of trade (40.9%), followed by Boro Mahajans (27.7%), wholesalers (16.3%), retailers (4.2%) and so on. Obviously, bottom layer actors, that is collectors, deal in the lowest quantity of trade, as low as less than one percent (0.6%). Of all the actors, the Boro Mahajans have the highest proportion of net returns (around 37-39%), followed by Aratdars (around 31-34%), Choto Mahajans (around 8-9%), wholesalers (around 8%), retailers (around 6%) and so on. Obviously, collectors have gross or net returns of only around 3 percent. In absolute terms, the Boro Mahajans and Aratdars have net income 13 to 14 times higher compared to that earned by collectors.

Figure 6.1: Golpata net return (Tk monthly) by actors



6.9.2 Gura Fish

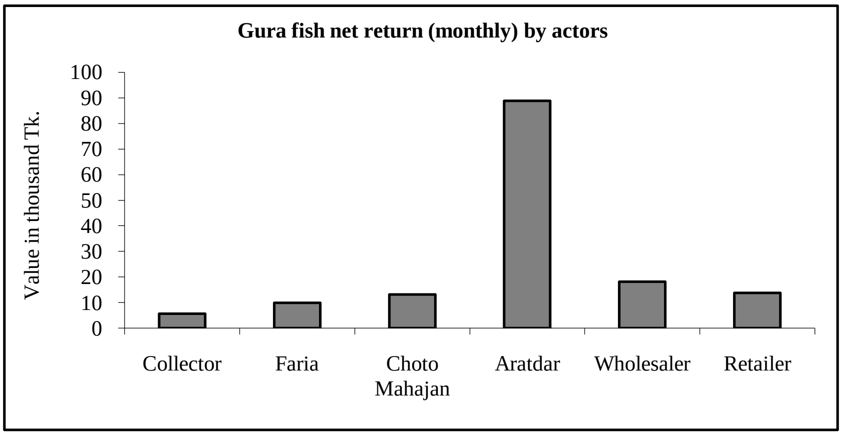
Aratdars carry out the highest volume of trade (72.7%), followed by wholesalers (11.8%), retailers (5.2%) and Choto Mahajans (5.0%) and so on. Obviously, bottom actor types, Farias and collectors, deal in the lowest volume of trade, 4.7 percent and less than one percent (0.6%) respectively.

Table 6.3: Value addition and return for gura fish

	% of value addition & return for gura fish			
	Price Value Addition (%)	Av. volume Per month (Kg)	Net Return (Tk/month)	Net Return as % WC
Collector	64.6	0.6	3.8	72.4
Faria	9.2	4.7	6.6	12.9
Choto Mahajan	1.5	5.0	8.8	10.9
Aratdar	4.6	72.7	59.4	11.1
Wholesaler	7.7	11.8	12.2	9.1
Retailer	12.3	5.2	9.2	78.7
Total	100.0	100.0	100.0	-

Of all the actors, comparatively the Aratdars, again, have the highest gross or net returns (around 59%), followed by wholesalers (around 12-13%), retailers (around 8-9%) and Choto Mahajans (7-8%). Collectors or Beparis have gross or net returns of only around 5 to 6 percent – in absolute terms. The Aratdars have net income 16 times as much compared to that earned by collectors.

Figure 6.2: Gura fish net return (monthly) by actors



6.9.3 Sada (white) Large Fish

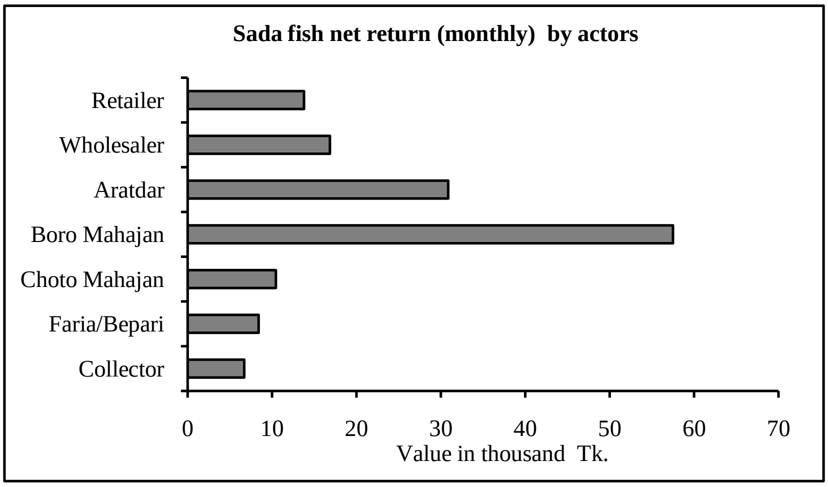
In terms of value additions in prices, collectors, obviously, provide the highest value addition, little less than two-thirds (63%) of the total price. Keeping collectors aside, like in gura fish retailers get the highest value addition (15.5%), followed by Farias (11.5%) (who are also often involved in collection), Aratdars (4.5%), wholesalers (4.0%), and Choto Mahajans (1.0%). As regards traded quantity dealt in by actors, of all the actors, Aratdars carry out the highest volume of trade (41.2%), followed by wholesalers (25.3%) (some of them are Aratdars as well), Boro Mahajans (18.2%), retailers (7.6%), Choto Mahajans (3.8%), and so on. Obviously, bottom actor types, Farias and collectors, deal in lowest quantity of trade, 3.2 percent and less than one percent (0.6%) respectively.

Table 6.4: Value addition and return for sada (large) fish

	% of value addition & return for sada (large) fish			
	Price Value Addition (%)	**Av. volume Per month (Kg)**	**Net Return (Tk/month)**	**Net Return as % of WC**
Collector	62.5	0.63	4.6	239.4
Fariha/Bepari	11.5	3.2	5.8	56.0
Choto Mahajan	1.0	3.8	7.2	66.6
Boro Mahajan	1.0	18.2	39.8	45.4
Aratdar	4.0	41.2	21.4	6.4
Wholesaler	4.5	25.3	11.7	12.0
Retailer	15.5	7.6	9.5	103.4
Total	100.0	100.0	100.0	-

In terms of proportions, the Boro Mahajans, again, have the highest gross or net returns (around 31-39%). For the Aratdars, as usual, the proportions are also high, gross and net returns being in the range of 21 to 23 percent, followed by wholesalers (around 12-15%), retailers (around 9-14%) and Choto Mahajans (6-7%). In proportional terms, collectors or Beparis have gross or net returns of only around 5 to 6 percent. In absolute terms, the Aratdars have net income 16 times as much compared to that earned by collectors.

Figure 6.3: Sada fish net return (monthly) by actors



6.9.4 Hilsha

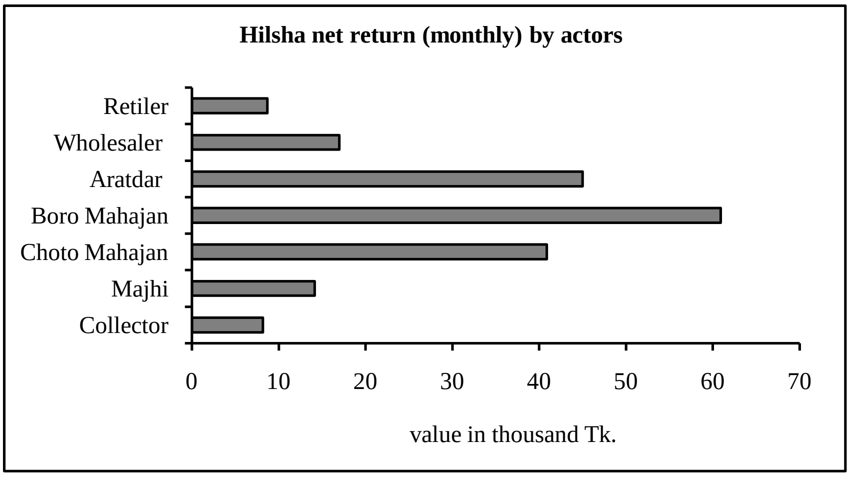
Collectors provide the highest value addition, a little less than two-thirds (63%) of the total price. Retailers create the next highest value addition (12.3%), followed by Majhis/Farias (10.0%), Choto Mahajans (8.3), Aratdars (2.7%), wholesalers (2.3%) and so on. Aratdars trade in highest volume of products (e.g., more than half of total transaction, 50.5%), followed by wholesalers (19.9%), Boro Mahajans (17.0%) and so on. Obviously, bottom actor types, Farias and collectors, deal in lowest quantity of trade, 4.0 percent and less than one percent (0.5%) respectively.

Table 6.5: Value addition and return for hilsha

	% of value addition & return for hilsha			
	Price Value Addition (%)	**Av. volume Per month (Kg)**	**Net Return (Tk/month)**	**Net Return as % of WC**
Collector	63.3	0.47	4.2	-
Majhi	10.0	4.6	7.3	91.2
Choto Mahajan	8.3	5.5	21.0	59.8
Boro Mahajan	1.0	17.0	31.3	21.3
Aratdar	2.7	50.5	23.1	12.3
Wholesaler	2.3	19.9	8.7	NA
Retailer	12.3	2.0	4.5	NA
Total	100.0	(100.0)	(100.0)	-

In terms of proportions, again, Boro Mahajans (28.5%), Aratdars (27.1%) and Choto Mahajans (18.0) are the highest beneficiaries. Collectors or Beparis have net returns of only around 4 to 6 percent.

Figure 6.4: Hilsha net return (monthly) by actors



6.9.5 Shrimp Large (galda)

Value addiction in terms of price shows that collectors as usual provide the highest value addition, about three-fourths (75.0%) of the total price. Keeping collectors aside, retailers create the next highest value addition (8.7%), followed by Majhis/Beparis (5.0%), Choto and Boro Mahajans (both 3.3%), Aratdars (2.5%) and wholesalers (2.2%).

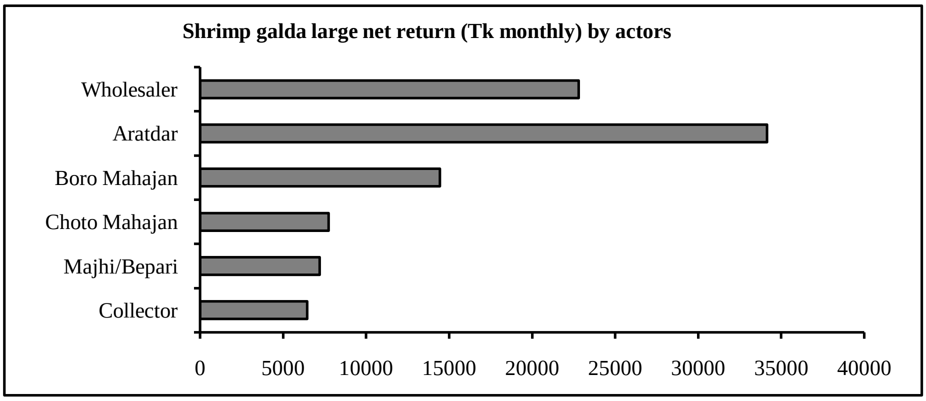
Table 6.6: Value addition and return for shrimp large (galda)

	% of value addition & return for shrimp (galda)		
	Price Value Addition (%)	**Av. volume Per month**	**N. Return**
Collector	75.0	0.31	6.1
Majhi/Bepari	5.0	5.1	6.8
Choto Mahajan	3.3	8.2	7.4
Boro Mahajan	3.3	13.4	13.7
Aratdar	2.5	40.2	32.4
Wholesaler	2.2	28.9	21.7
Retailer	8.7	3.9	11.9
Total	100.0	100.0	100.0

Source : Table 6.5.

Aratdars, again, have the highest proportion of gross or net returns (around 31-32%), followed by wholesalers (around 20-21%), Boro Mahajans (around 14%) and Choto Mahajans (7-8%). As usual, collectors have the lowest proportions of both gross and net returns (6-7%). In absolute terms, the Aratdars have net income more than 5 times as much compared to that earned by collectors.

Figure 6.5: Shrimp galda large net return (TK monthly) by actors



6.9.6 Shrimp Large (bagda)

More than two-thirds of value addition in terms of price is made by collectors. After the collectors, retailers create the next highest value addition (11.1%), followed by Majhis/Beparis (6.7%), Choto and Boro Mahajans (both 4.4%), Aratdars (3.6%) and wholesalers (3.1%).

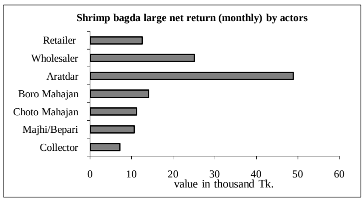
Table 6.7: Value addition and return for shrimp large (bagda)

	% of value addition & return for shrimp (bagda)		
	Price Value Addition (%)	Av. volume Per month	N. Return
Collector	66.7	0.42	5.5
Majhi/Bepari	6.7	5.6	8.2
Choto Mahajan	4.4	8.8	8.6
Boro Mahajan	4.4	11.0	10.9
Aratdar	3.6	44.6	37.8
Wholesaler	3.1	26.1	19.3
Retailer	11.1	3.5	9.7
Total	100.0	100.0	100.0

Source : Table 5.6.

Aratdars, again, have the highest proportion of gross or net returns (around 36-38%), followed by wholesalers (around 19%), Boro Mahajans (around 11%) and Choto Mahajans (9%). As usual, collectors have the least gross or net returns (6%). In absolute terms, the Aratdars have net income more than 7 times as much compared to that earned by collectors.

Figure 6.6: Shrimp bagda (large) net return (monthly) by actors



6.9.7 Shrimp Fry (galda and bagda)

The shrimp value chain is relatively more complex, more than any other products, with a variety of actors and intermediaries at each node of the chain. Although there is said to be a ban on fry catching, fry collectors appear to have continued to operate, however, at the risk of further insecurity and the increased level of unofficial payments that they are required to pay to local officials. Considering value addiction in terms of price, the collectors of shrimp fry (galda and bagda) provide the highest value addition, around 57 to 64 percent of the total price. As regards the traded quantity dealt in by actors, of all the actors, Aratdars of both fry types carry out the highest volume of trade (65-69%), followed by Beparis (around 27-33%). Obviously, bottom actor type, collectors, deals in low quantity of trade, only around 2-4 percent.

Table 6.8: Value addition and return for shrimp fry (galda)

	% of value addition & return for shrimp fry (galda)			
	Price Value Addition (%)	Av. volume Per month (piece)	Net Return (Tk/month)	Net Return as %of WC
Collector	57.1	2.0	6.4	-
Bepari	18.6	32.7	30.0	70.42
Aratdar	24.3	65.3	63.6	31.60
Total	100.0	100.0	100.0	-

Source: Table 5.9.

Table 6.9: Value addition and return for shrimp fry (bagda)

	% of value addition & return for shrimp fry (bagda)			
	Price Value Addition (%)	Av. volume Per month (piece)	Net Return (Tk/month)	Net Return as % WC
Collector	64.1	4.0	16.8	-
Bepari	19.2	26.7	22.1	20.9
Aratdar	16.7	69.3	61.1	3.8
Total	100.0	100.0	100.0	-

Source:Table 5.10.

Aratdars have net income nearly 10 times as much compared to that earned by collectors. In contrast, the income level for bagda fry has been relatively low. For example, monthly net returns for bagda fry estimate as Tk 30,720 and Tk 11,075 for Aratdars and Beparis respectively.

Figure 6.7: Shrimp fry galda net return (monthly) by actors

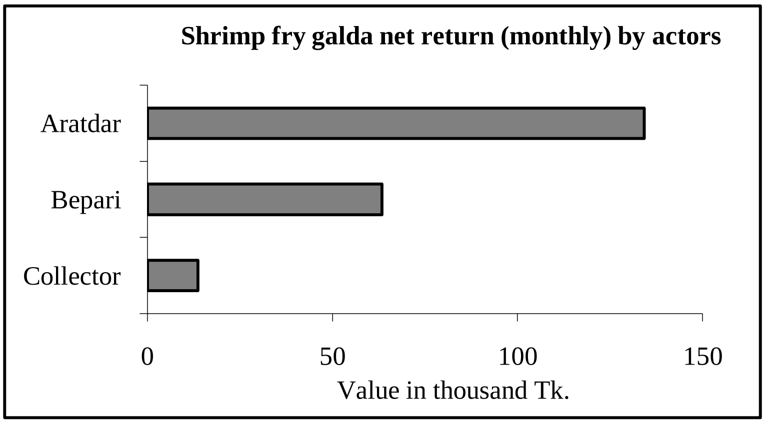
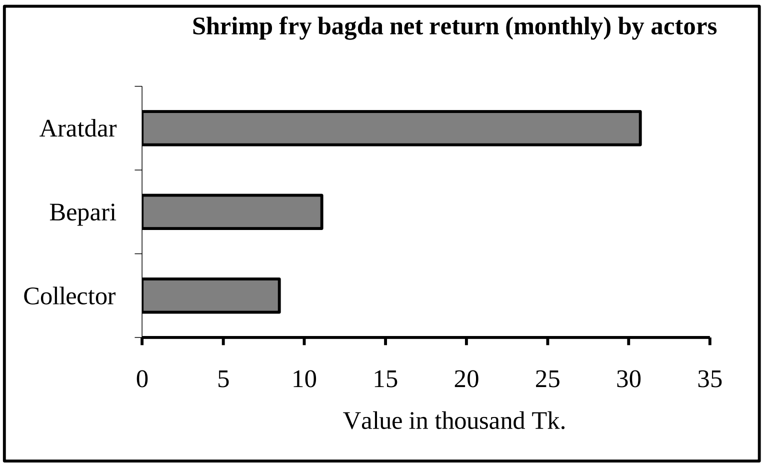


Figure 6.8: Shrimp fry bagda net return (monthly) by actors



6.9.8 Crab

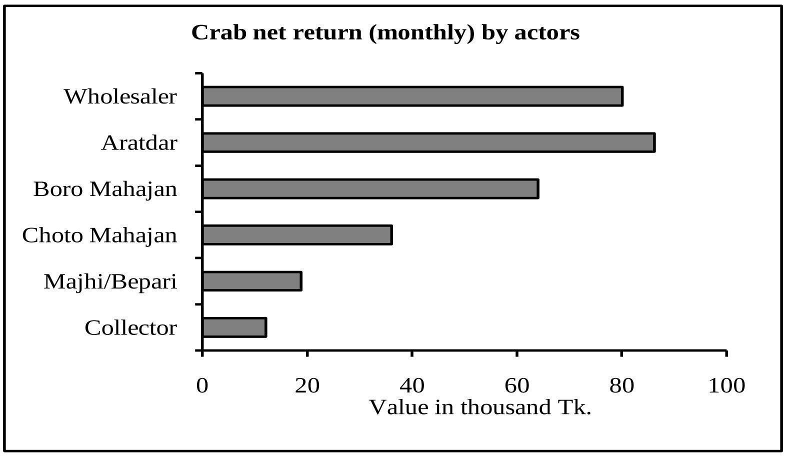
Crab collectors provide the highest value addition, a half (50%) of the total price. Majhi/Farias create the next highest value addition (17.6%), followed by Choto Mahajans (13.8%), Aratdars (8.3%), Boro Mahajans (6.9%), wholesalers (3.4%) and so on. In contrast to relatively lower price value addition, Aratdars, compared to other actors, trade in highest volume of products (37.1%), followed by Boro Mahajans (28.8%), wholesalers (19.3%), Choto Mahajans (10.6%) and so on. Obviously, bottom actor types, Farias and collectors, deal in lowest quantity of trade, 3.5 percent and less than one percent (0.64%) respectively.

Table 6.10: Value addition and return for crab

	% of value addition & return for crab			
	Price Value Addition (%)	Av. volume Per month (Kg)	Net Return (Tk/month)	Net Return as % of WC
Collector	50.0	0.64	4.1	158.2
Majhi/Faria	17.6	3.5	6.3	27.0
Choto Mahajan	13.8	10.6	12.1	17.6
Boro Mahajan	6.9	28.8	21.5	4.6
Aratdar	8.3	37.1	29.0	24.6
Wholesaler	3.4	19.3	26.9	5.3
Total	100.0	100.0	100.0	-

In absolute terms, the Aratdars have net income more than 7 times as much compared to that earned by collectors.

Figure 6.9: Crab net return (monthly) by actors



6.9.9 Honey

Value Addition

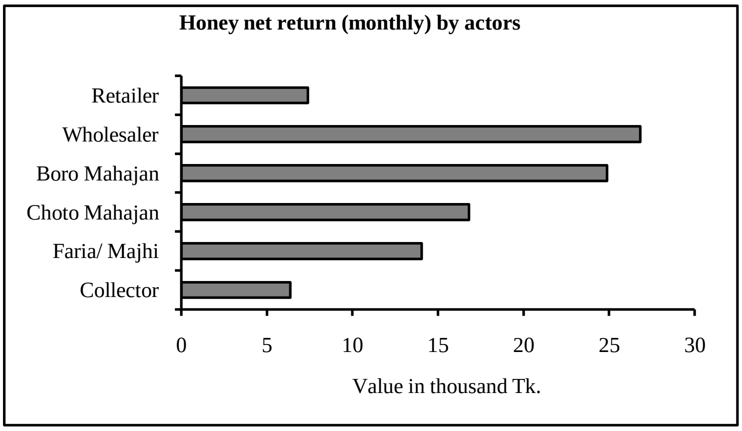
Value addition in terms of price shows that collectors as usual provide the highest value addition, about three-fifths (60.0%) of the total price. Retailers create the next highest value addition (16.7%), followed by Majhis/Beparis (12.0%), Boro Mahajans (6.7%), wholesalers (3.3%) and Choto Mahajans (1.3%). No Aratdars appear to exist in honey value chain but most usually wholesalers act as Aratdars.

Table 6.11: Value addition and return for honey

	% of value addition & return for honey			
	Price Value Addition (%)	Av. Volume (Kg) per month	Net Return (Tk/month)	Net Return as % of WC
Collector	60.0	1.1	6.7	119.35
Faria/Majhi	12.0	7.3	12.9	64.82
Choto Mahajan	1.3	8.7	17.8	29.25
Boro Mahajan	6.7	25.3	26.3	12.44
Wholesaler	3.3	54.4	28.4	8.94
Retailer	16.7	3.2	7.8	18.50
Total	100.0	100.0	100.0	-

Relatively the wholesalers have the highest proportion of gross or net returns (around 27-28%), followed by Boro Mahajans (around 25-26%) and Choto Mahajans (around 17-18%). As usual, collectors have the lowest proportions of both gross and net returns (6-10%).

Figure 6.10: Honey net return (monthly) by actors

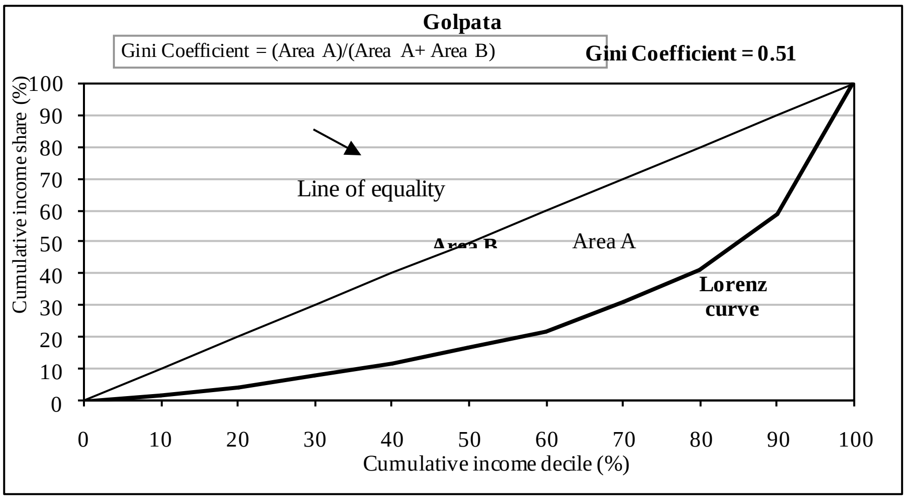


6.10 Distribution of Actors Income – Income Inequality

6.10.1 Golpata

The degree of inequality is quite high in that the average annual income earned by the collector category is found to be more than 16 times as less as earned by an Aratdar. In terms of deciles distribution, the top 10 percent of the actors earn 20.5 times as much income as the bottom 10 per cent (1:21). Gini coefficient, measuring income inequality, for golpata estimates as 0.51, which is quite high.

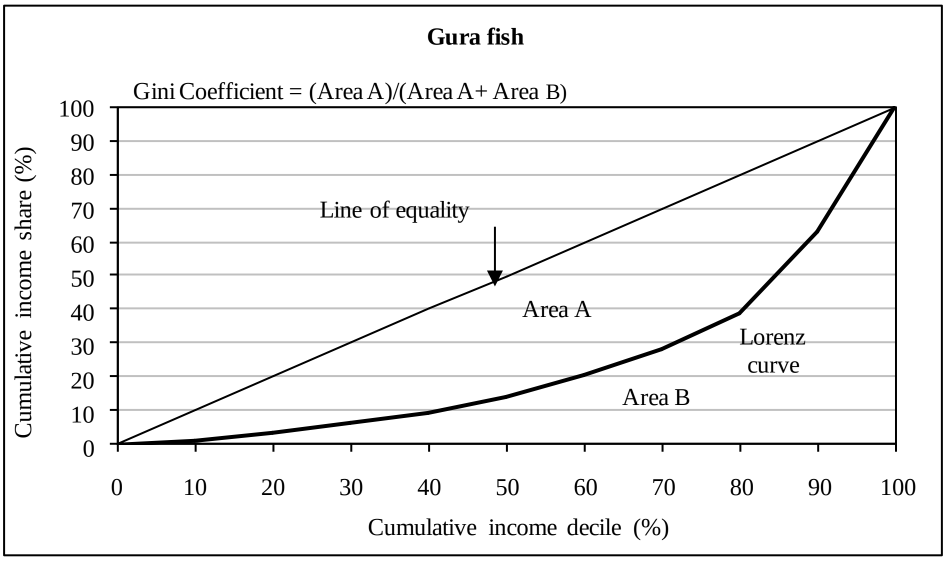
Figure 6.11: Lorenz curve: Golpata



6.10.2 Gura (Small) Fish

The average annual income earned by the collectors, for example, estimates 13 times as less as earned by an Aratdar. In terms of deciles distribution, the top 10 percent of the actors earn as high as 34 times as much income as the bottom 10 percent (i.e.,1:34). Gini coefficient for gura fish estimates as 0.53, which is again quite high.

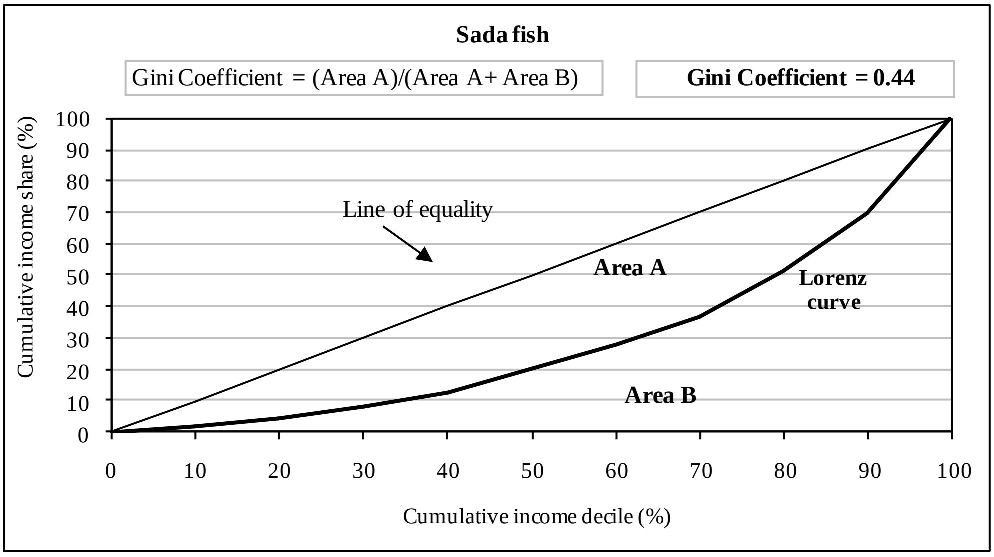
Figure 6.12: Lorenz curve: Gura fish



6.10.3 Sada (large) Fish

The degree of inequality in the value chain appears to be quite high in that the average annual income earned by the collectors, for example, estimates as more than 10 times as less as earned by an Aratdar. In terms of deciles distribution of income, top 10 percent of the actors earn as high as 19 times as much income as the bottom 10 percent (i.e., 1:19) (See Figures 5.61 and 5.62) . Gini coefficient for Sada (large) fish estimates as 0.44, which is a bit lower compared to most other SRF products.

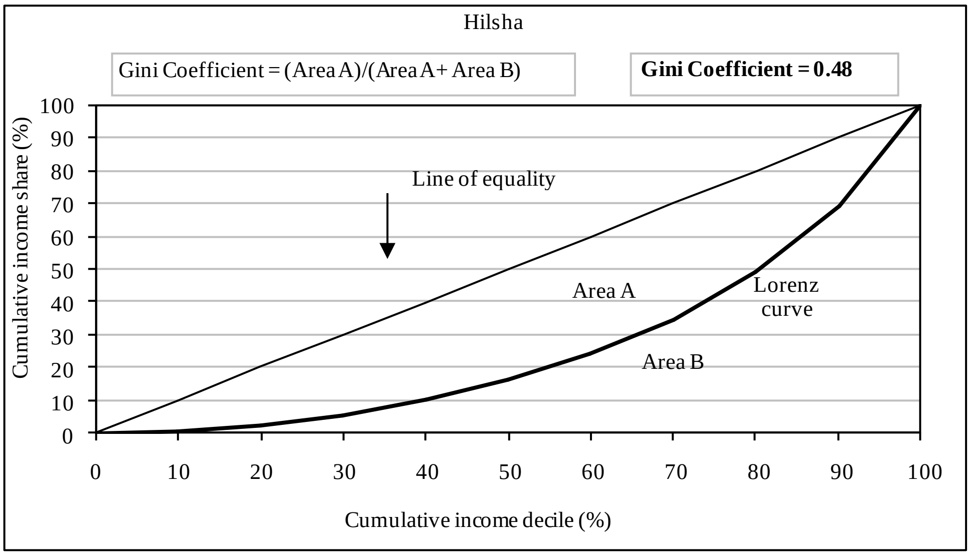
Figure 6.13: Lorenz curve: Sada fish



6.10.4 Hilsha

The average annual income earned by the collectors, for example, estimates as nearly 8 times as less as earned by a Boro Mahajan. Considering two deciles, the top 10 percent of the actors earn as high as 42 times as much income as the bottom 10 percent (i.e.,1:43). Gini coefficient for hilsha fish estimates as 0.48, which is a bit lower compared to gura and sada fish.

Figure 6.14: Lorenz curve: Hilsha



6.10.5 Shrimp Large (galda and bagda)

The degree of inequality in the value chain appears to be quite high in that the average annual income earned by the collectors, for example, estimates as more than 5 to 7 times as less as earned by an Aratdar.

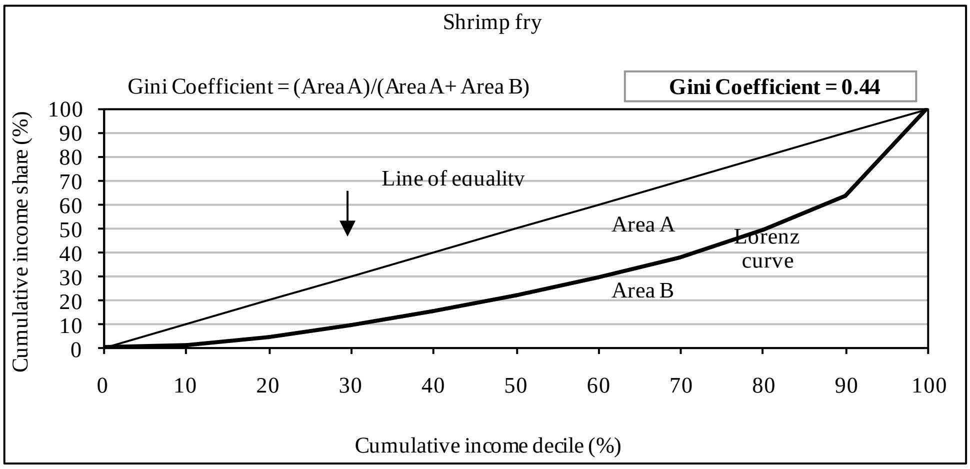
6.10.6 Shrimp Small (galda and bagda)

The degree of inequality in the value chain appears to be quite high in that the average annual income earned by the collectors, for example, estimates as more than 7 to 8 times as less as earned by a Boro Mahajan for galda and bagda shrimp respectively.

6.10.7 Shrimp Fry (galda and bagda)

The degree of inequality in the value chain appears to be quite high in that the average annual income earned by the collectors, for example, estimates as more than 9 times and 2.5 times as less as earned by an Aratdar for galda and bagda respectively. Gini coefficient for shrimp fry estimates as 0.44, which is a bit lower compared to those of most other SRF products.

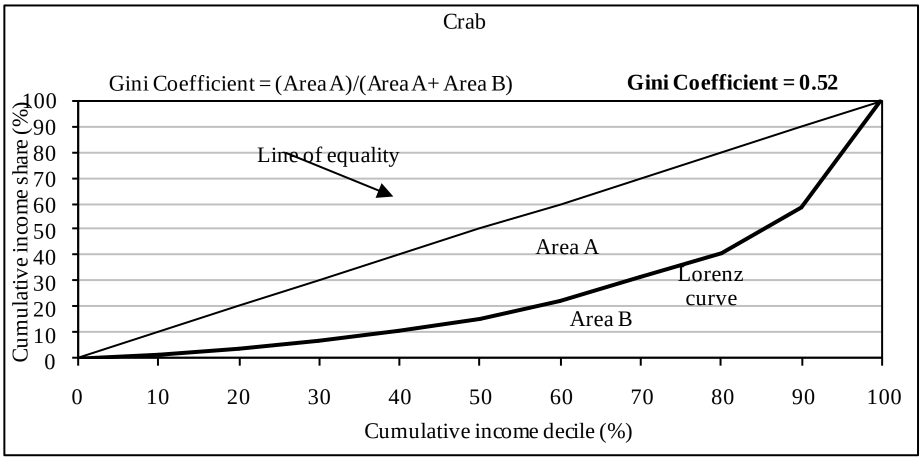
Figure 6.15: Lorenz curve: Shrimp fry



6.10.8 Crab

Like in most other products, Aratdars in this value chain earn the highest amount of income. The degree of inequality appears to be high in that the average annual income earned by the collectors, for example, estimates as more than 9 times as less as earned by an Aratdar. In terms of distribution by deciles, the income distribution appears to be much skewed (Table 5.29). Considering two deciles, Decile 1 for the bottom-ranking actors and Decile 10 for the top-ranking actors, it can be seen that the top 10 percent of the actors earn as high as 35 times as much income as the bottom Decile 1 (i.e., 1 : 35). Gini coefficient for crab estimates as high as 0.52.

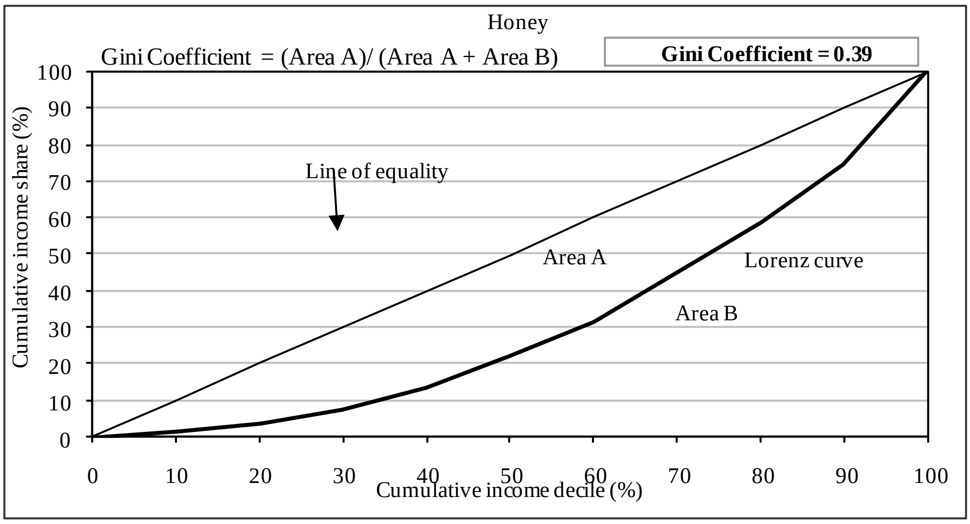
Figure 6.16: Lorenz curve: Crab



6.10.9 Honey

The degree of inequality in the value chain appears to be relatively less in that the average annual income earned by the collectors, for example, estimates 4 times as less as earned by a wholesaler. In terms of distribution by deciles, the top 10 percent of the actors earn as 17 times as much income as the bottom Decile 1 (1 : 17). Gini coefficient estimates as 0.40 among the SRF products, which is a bit lower compared to those of other SRF products.

Figure 6.17: Lorenz curve: Honey



6.10.10 Summary

Ironically, the sample collectors earn net returns in the range of only 3 to 7 percent while they create price value additions by as high as 50 to 75 percent, depending on the products. Intuitively, given the existing economic situation, SRF extraction is deepening poverty levels, which may help widen the income gap between rich and poor. The degree of inequality has been worse in some activities than the others. Taking all SRF products together, the average income earned by an Aratdar or a Mahajan is found to be nearly 5 to 7 times as much as earned by a collector. Inequality is demonstrated in that the income of a collector constitutes, in terms of total income of all actors, only 4.9 percent, followed by Majhis/Beparis (9.5 %), Choto Mahajans (9.2 %), Boro Mahajans (23.9 %), Aratdars (31.9 %), wholesalers (14.5 %) and retailers (6.6 %).

Table 6.12: Annual income level of SRF Actors: All products

Actors	Annual Income (SRF product)	%
Collector	53632	4.90
Majhi/Bepari	98936	9.05
Choto Mahajan	100361	9.18
Boro Mahajan	261664	23.92
Aratdar	349197	31.93
Wholesaler	158195	14.46
Retailer	71813	6.57
Total	1093799	100.00

Note: Non-peak months are standardized with corresponding number of days worked.

Figure 6.18: Annual income level (%) of SRF actors: All products

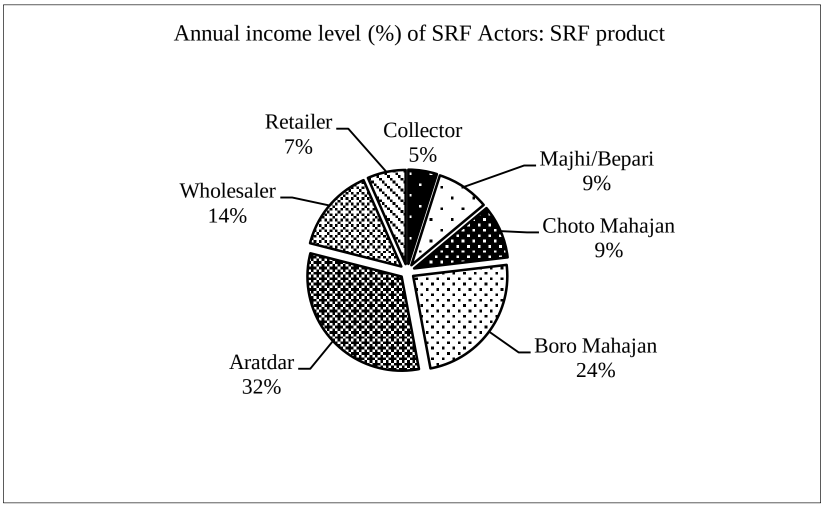
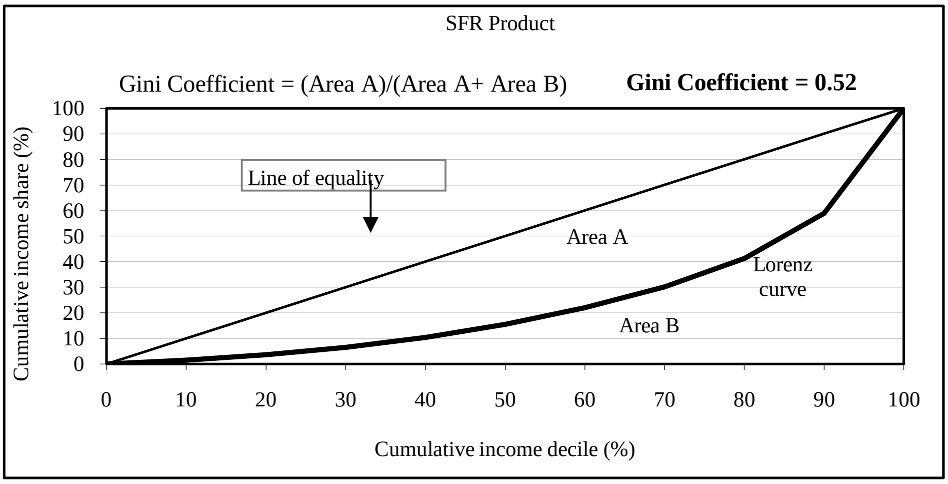


Table 6.13: Income distribution and income inequality in the landscape area

SRF Products	Proportion of income (%) at		Proportion of Deciles 1 to 10	Gini coefficient
	Bottom half (Deciles 1 to 5)	Top half (Deciles 6 to 10)		
Golpata	16.6	83.4	1 : 21	0.51
Gura fish	14.2	85.8	1 : 34	0.53
Sada (white) large fish	20.3	79.7	1 : 19	0.44
Hilsha	16.4	83.6	1 : 43	0.48
Shrimp large (galda)	NA	NA	NA	NA
Shrimp large (bagda)	NA	NA	NA	NA
Shrimp small (Galda)	NA	NA	NA	NA
Shrimp small (bagda)	NA	NA	NA	NA
Shrimp fry (galda and bagda)	21.5	78.5	1 : 41	0.44
Crab	15.5	84.5	1 : 35	0.52
Honey	22.2	77.8	1 : 17.1	0.40
All products	15.5	84.5	1 : 29.3	0.52

The income distribution appears to be highly skewed in the landscape. While the bottom half (Deciles 1 to 5) of the actors have 15.4 percent of the total income, the top half (Deciles 6 to 10) of the actors accounted for as much as 84.5 percent of the total income. The proportion of decile1 to decile10 is as high as 1:29. The Gini coefficient, measuring income inequality, for the landscape as a whole is estimated as 0.52. As was evident from previous section, the Gini coefficients for individual products are estimated in the range of 0.40 to 0.53. One can mention, in this context, findings from a study conducted by BIDS. It was found that in the coastal districts the Gini coefficients vary from 0.19 to 0.36. In no cases, Gini coefficients for any of the coastal districts are higher than or close to that in the landscape area. In fact, the coefficients in the landscape estimate much higher, indicating that so far the SRF actors' income is concerned the landscpae is characterized by severe inequality in income.

Figure 6.19: Lorenz curve: All SRF products



6.11 Policy Implications

The major findings obtained from the previous sections of this chapter can be related to few major issues that are crucial to the improvement of value chains, in terms of return and equity, conservation and co-management, and overall improvement of the quality of life of the people involved with SRF resource collection. The local people, involved as actors in the value chains, gave reflection on the importance of strong and favorable policies necessary to devising a pro-poor value chain and uplifting the income situation of the SRF collectors.

The increased population with few alternative livelihood opportunities poses a serious threat to the Sundarbans, which is one of the main cause of climate change vulnerability of local people. Moreover, dependence of local people on the forest is high (28% of the population in the landscape are dependent on the SRF) and in future this dependence will increase, which is likely to aggravate the existing pressure on the government mechanisms for forest management and protection. There are more than one million people directly involved with the resources extraction from the SRF. The pressure on SRF for resources extraction has increased tremendously as the number of collectors has increased many fold over the last decades, resulting in huge reduction in per capita resource collection from the SRF. With the high increase in living cost added to that scenario, the people and the community, especially that of the bottom layer actors in the value chains, tend to fall in the process of pauperization.

The present analysis demonstrates a very dismal picture on poverty levels in the region. The landscape upazilas have a much higher (extreme) poverty rates (0.42) compared to an average non-landscape upazilas in Bangladesh (0.26). In fact, nine out of ten landscape-upazilas (except in Patharghata and Barguna), have a much higher extreme poverty levels than the corresponding non-landscape upazilas of five landscape districts, in terms of Head Count Ratio (HCR). The average monthly income of the SRF harvesters is in the range of Tk 5,000 to 6000 only during harvest seasons and there are months when they have hardly any income at all. The analysis demonstrates huge income inequality among actors. The empirical evidence also suggests that the top 10 percent of the SRF actors earn as high as up to 43 times as much income as the bottom 10 percent (estimated Gini coefficients for various SRF products range from 0.42 to 0.53, which are on a much higher side in Bangladesh context). Thus, the poverty situations in the landscape appear to be severe, which has immense policy implications. The foremost intervention, therefore, will be to address the poverty of the bottom layer forest resource actors which will effectively help the management and conservation of the SRF. To sum up, as the problem analysis demonstrates, this demands a special attention because of the following:

- The SRF collection quantity has significantly declined. Some of the species are getting rarer. This is more so in fishery sector and that is why the fishery sector demands a special focus as discussed in Chapter 4.
- Number of harvesters (e.g., fishermen or golpata collectors) increased many fold (present study estimates over 0.9 million fish collectors, most of which are fisher laborers; other actors in the fish sector estimates as more than 0.2 million in this sector, most of whom are Farias/Beparis).
- Because of gradual displacement from agriculture due to increased salinity, more number of people are pouring into the landscape as collectors. Most SRF extractions are merely seasonal and consequently there is high pressure on the fishery sector for subsistence and per capita collection has been reduced to a large extent.
- The major income share of the harvesters is taken away by the higher level intermediaries such as the Mahajans or the Aratdars due to dadons. Dadons and poverty operate in a vicious circle.
- Transportation cost, especially for the fishers, is very high and the time needed for the transportation/collection is also long to render the collectors more vulnerable.

6.12 Policy Interventions

Keeping the above policy review and implications in perspective, some of the policy interventions for climate change adaptation are discussed as below. It is pertinent to mention, however, that many of the suggested interventions would, in addition to FD, require a multi-sectoral approach wherein resources would be ploughed in from different sources and integrated implementation responsibility to be shouldered by a project based inter-agency/authority/board constitued under the leadership of Forest Department of the MOEF by drawing experts from the concerned Governemnt Departments such as Department of Fisheries, Department of Environment, Water Development Board, Department of Agriculture Extension, Department of Livestock, etc.

6.12.1 Improving the Value Chains and Poverty Situations of SRF Actors

Micro-Financial Support

Access to capital has been the most crucial issue, especially among the collectors. Although dadon is a source of exploitation for the collectors, hardly they are left with other choices. There are two major reasons for which they take dadons; (1) dadons are easily accessible and available in adequate amounts, and (2) dadons provide immense support during lean periods. Dadons act as physical, social and financial safety. However, the bottom layer SRF actors such as harvesters and Farias are locked into contracts that perpetuate this cycle of debt. A pertinent question is how to break or whether to break the system. Nevertheless, as it is difficult to break the deep-rooted dadon system, the positive and negative sides to this business need to be considered when planning new interventions geared at improving value chains.

Access to Capital - Setting up of Specialized Banks and Specialized Programmes

Government may recognize the Sundarbans as a separate and important economic zone/sector, just as Agriculture or Industries, as the landscape consists of more than 9 million people. Specialized banks or specialized micro-credit organizations are to be set up to save the harvesters of the Sundarbans. Like agriculture loans, share cropper loans and small and medium enterprise (SME) loans programmes, suitable credit programmes need to be launched where SRF actors should be given a special attention. The central bank can take initiatives in this respect.

Service Centers and Financial Support

Pending the establishment of the Specialized Banks, a few selected public and private banks in the landscape should be requested to set up the SRF service centers/cells to channel funds to the SRF sector and to cater the special needs of the SRF actors, especially the harvesters in a better way and on softer terms. Collateral free loans should be considered for the collectors. Even the Mahajans or similar other actors should be encouraged to access credits with boats/nets kept as collaterals, the impacts of which are expected to be trickled down to collectors.

Targeting Programs

The banks should fully consider the issues and realities of the harvesters and set their policy and procedures accordingly. They should target programs to providing social securities and safety-nets to the collectors, along with adequate amount of credits for the collectors on favorable terms. The banks can also help promote the effort of conservation while sanctioning loans. Repayment schedules and horizons should be flexible and reflect the likely cash flow of the activities in question. At the first stage, some priority sectors can be taken up for the purpose on a pilot basis. At the same time, appropriate authority should take safety net programs for the SRF actors, particularly the collectors, and extend support during lean periods or at the time of crisis such as natural hazards. Like what was taken up with SMEs, Bangladesh Bank can take the initiatives in this respect through, for example, launching refinancing schemes.

Improving Terms of Trade and Marketing System

Currently there are many ways of debt repayment in practice - repayment in cash with interest (47.6%) or without interest (4.0%), repayment in goods at market price (16.7%) and repayment at reduced market price (33.3%). The collectors have to sell their collected products at a price reduced by up to 22.5 percent compared to prevailing market price, depending on the products. There can be several ways of improving terms of trade and marketing systems for the SRF products. One important way to minimize transportation costs is to foster and expand spot markets and auctions, which will also ensure offering lower level actors higher prices. Increasing the number of depots and landing places could also minimize the transaction costs and the time for transportation to ensure that the returns are evenly distributed. This would help particularly fishery and crab sectors. The Department of Fisheries needs to identify regions lacking depots and arrange accordingly.

Enhancing Bargaining Power of the Collectors

The harvesters, particularly the fishermen and crab fishers, cannot negotiate prices as the fish products are purchased by th*e* Aratdars through Mahajans or Paikars. Enhancing bargaining power of the harvesters is imperative. Better access to the current market information has to be ensured. Barriers to entry, poor infrastructure, inadequate communications, and high transaction and transport costs make the markets in favor of buyers. In order to safeguard the rights of the collectors and capacity of the collectors to negotiate selling prices, it is important to form collectors’ organizations, similar to that of the higher level intermediaries such as Aratdars.

SRF Actors Groups/Cooperatives/Associations

One way of reducing vulnerability of the lower layer actors of value chains is to organize Groups or Cooperatives. This would help create storage, post-harvest processing, refrigeration facilities, and encourage shared transportation on a collective basis. Not only these cooperatives will prove beneficial in income generation, but they also will contribute to their confidence building, empowerment, awareness and overall sustainable harvest management of the SRF and in coping with natural disasters.

Improving the Socio-economic Conditions of Bottom Layer Actors

Improving the socio-economic conditions of the vast bottom-layer actors should be a major policy concern. A range of options may be available to improving the socio-economic conditions of bottom layer. As a rationing system for foods for collectors will be beneficial, designing and implementing VGD, VGF or Food for Employment during lean seasons may be good initiatives to benefit the marginal collectors. Obviously, this will also facilitate sustainable resource management of the SRF. As the per capita collection quantity from the SRF has tremendously declined, efforts should be made to enable collectors to switch over to other economic activities. Less investment oriented activities may include closed fisheries, handicrafts, closed crab culture, crab fattening, fish feed production, hogla and mat making, bee-keeping, coir industry, tree plantation, horticulture, tailoring, knitting, livestock, small and medium industries and social forestry for the bottom layer actors. Developing a welfare fund for the collectors of various products would be a step forward. In this context, mention may be made of the year's (20109-10) harvest of honey which has fallen by 16 percent as per the BLCs issued this year compared to last year. One of the reasons is that the Mawalis were employed in repair works of Sidr and Aila affected embankments. This gives a clear message that Mawalis or Bawalis would not exert pressure on the SRF, provided they get alternative opportunities for employment and income.

The process, through which the trawling ships undertake catching fishes, needs serious consideration in the light of conservation and reproduction. The exploitation of jatka fish and use of 'current' nets in fishing have no option asserted by fisher collectors themselves as they have little income support during lean periods. Some of them use medicines and poisonous (chemical) substances to catch fishes which kill all the living beings in those leased-out canals. There should be strict regulations to check these types of activities so that the reproduction of the fishes or other species is not hampered.

6.12.2 Conservation of the Sundarbans

The protection and sustainable use of the mangrove forests would yield higher welfare benefits than any other activities towards its development. The effective integration of the interests and priorities of the local people into forests and wetlands management and above all, coordinated efforts appear to be important. More importantly, the stakeholders, particularly the bottom layer actors have to be offered adequate benefits through value chains and livelihoods opportunities. The SRF actors observed that increased population, loss of aquatic and other species, increased pressure on the Sundarbans, demand for fuel woods, climate change and disasters and lack of coordination of the government bodies have made the conservation a very complex job. These need to be taken in perspectives while designing conservation interventions. While more than two-fifths of the populations are in extreme poverty, of all the issues, then the poverty situation needs to be tackled on priority for the success of conservation.

The local government institutions (LGIs) such as Union Parishad and Upazila Parishad need to be strengthened as their role is very crucial both in protecting the forest and improving the situation of the collectors. The SRF actors are in the opinion that politicization and lack of integrity of these institutions are the major bottlenecks to managing and conserving the Sundarbans. Without strong participation of the LGIs, the conservation of the SRF through co-management may not be sustainable. Strong policies are also necessary for the UPs to function independently apart from enhancing their capacities.

The extreme poverty situation is further deteriorated by the incidence of natural calamities. So, addressing the issue of destruction due to natural calamities should also be integrated with forests conservation. It is important to provide allowance or alternative livelihood means (e.g., interest-free micro-finance provision, skill development training) for those engaged in collecting fish fries to reduce dependency on fishing. A provision of special allowance for education of children involved in shrimp fry collection would also be helpful. Issuing permits and licenses to fry catcher would allow only the seasonal capture of fry. The beneficiaries of the social forestry programs should include only those who take part in plantation and nurture them from the time of commencement. The collectors take high financial and life risks during collection of products from the forest as the act of pirates and tigers has been cited by a large number (30%) of SRF collectors as a major problem of extraction. Insurance schemes particularly for the SRF harvesters will be beneficial and will minimize risks in this respect.

6.12.3 Exploitation and Unemployment

The unemployment is getting more and more crucial in the landscape areas, particularly due to the destruction/degradation of agricultural lands. The natural calamities have also contributed much to unemployment. A dismal picture of the harvesters profitability is revealed as they earn net returns at best in the range of 3 to 7 percent while they create value additions (in terms of price) by as high as 50 to 75 percent, depending on the products in question. High interest rate and never ending dadon repayment, the abuse by the Mahajans and lack of working capital are the major reasons that contribute to the exploitations. Almost all actors along the value chain, particularly the collectors and Mahajans, are affected by high transactions costs, which increases their costs of harvests, accounting for 10 to 25 percent of total costs of production, depending on products.

The law and order situation needs improvement to protect the SRF collectors from giving periodical ransoms to the forest and river pirates. The collectors of the SRF should be provided identification cards, which the SRF actors observed, will improve the situation and status of the collectors. In that case, the FD can ensure the total number of collectors and the amount of catch they are allowed per year, apart from providing some useful information on certain species. Once the security is ensured this will have some bearing on the production costs and subsequently some benefits are likely to be trickled down to the harvesters. The FD has to be given more advanced equipment and technology, more speed-boats, and gun-ships as discussed in Chapter 1 of Part II. More trainings and exercises jointly by the FD and the Navy will benefit the effort to fight the pirates. Low cost equipments are to be installed and digital technology will add advantage in conserving the forest. The use of the Information Technology should be further enhanced in protecting the forests and sanctuaries that are crucial to conservation of the Sundarbans.

6.13 Selected Value Chains Implementation

Two priority value chains, Fisheries Value Chain and Tree Nursery Value Chain have been designed as below for their implementation in the Sundarbans landscape:

6.13.1 Fisheries Value Chain Design and Implementation

This value chain design approach is based on breaking down the Sundarbans fisheries market into its key activities, making an assessment of the potential for adding value to fisheries via cost advantage or differentiation, identifying the current activities where the fisheries business appears to be at a competitive advantage, and determining appropriate strategies built around focusing on activities where competitive advantage can be sustained for fisheries. This approach ensures revenue growth by identifying not only the efficient parts, but also discovers the weaklings in the value chain, which may be outsourced for increasing the efficiency of the overall chain. In contrast with the value chain that functions over only a single channel, a sub-sector analysis was done to find out several channels which may compete with each other.

Sarankhola Upzilla was identified as a case study area as it is one of the site where the livelihood of nearly two-third of the population depend on catching fish from open waters, and almost every household possesses a small pond on which they culture fish. Accordingly detailed discussions were held with the sampled households in selected villages where a survey with the potential fishers was conducted to design an appropriate fish value chain. The objective of the assessment was to understand the functioning and dynamics of the value chain, identify key players, and finalize possible initiatives to promote fisheries through micro- entrepreneurs as service providers and local stakeholders as fishers.

6.13.1.1 Value Chain Objectives

The fisheries value chain is designed with the following objectives to be achieved by focusing on the production, marketing, distribution, support services, and all other activities required to be implemented from fisheries production in farms by fishers up to its consumption by local people and for cash sale:

- To produce local variety of fish by employing local resources,
- To meet the local and regional demand of fish,
- To provide sustainable livelihood and alternative income to fishers,
- To introduce fish cultivation in a scientific way by enhancing the technical and managerial skills of fishers and service providers, and
- To build up the required linkages between the producers and consumers, and the fishers and service providers

6.13.1.2 Competitive Advantage of the Fisheries Value Chain

Although the fish farmers face stiff competition due to the import of fish from neighboring countries, it is found as a profitable business because of the following reasons:

- Local availability of fish spawns and fish hatcheries
- Simple and known technical knowledge that fishers have continued from generations
- The increasing market demand at home and abroad
- Attracive returns as the fisheries business has proved profitable
- Potential to increase income and employment of local people

- Positive impacts to the environment
- Special Government support for the fisheries sub-sector.

6.13.1.3 Target Population

Target population for the fisheries value chain will comprise the poor fishers and local people, who have limited land and work opportunities, except going to the SRF for extracting wood, catching fish and honey collection to meet their livelihood. In addition, local people practising fish culture in their own pond will also be targeted for improved fisheries. In all, 26 villages have been initially identified and from each village 3 households will be selected for demonstration of fish culture and subsequently these trained fishers will act as trainers for other people.

6.13.1.4 Target Market

The high-income families from rich and middle classes form the upper segment of consumers. Given their purchasing capabilities, they are often the prime target for buying indigenous, expensive fish in large quantities. The lower and poor consumers tend to buy common, cheap varieties of fish in moderate quantities. Furthermore, another important segment of fish and shrimp buyers are the supermarkets, restaurants and hotels as well as foreign customers. The demand for fish and shrimp is increasing with the growing population, higher purchasing power among the urban consumers and traditional preference for seafood especially fish, as well as increasing demand in overseas markets. The high demand and the availability of raw materials and technical knowledge have resulted in the increased supply of fish. Yet, there is a visible gap in the supply and demand, perhaps mainly due to inadequate fish production.

The demand-pull motivates more and more entrepreneurs to get involved in fishery by converting many unused, dried-up and abandoned ponds for fisheries. This value chain has a high growth potential, as national supply of fish is insufficient to meet the national demand. The good road and communication, and other infrastructure facilities have made it easier and less time consuming for transportation and supply of fish to Khulna and Dhaka and other big cities. This has created a high demand for fish from Khulna, encouraging entrepreneurs and pond owners to engage themselves into fisheries as a high priority value chain in the Sundarbans landscape.

6.13.1.5 Value Chain Mapping

A value chain map is a graphical representation of all the major actors in a fisheries value chain. It presents the linkages between different supply channels that transform raw materials into finished products and then distribute those products to final consumers and different markets. A fisheries value chain in Sarankhola would link the fish producers to fish consumers through a number of intermediaries who add value at each level. For example, fishermen and fish producers access fresh fingerlings that are sold either at local markets or obtained from the wholesalers. A large number of fishers catch fish and fingerlings from the open waters of the Sundarbans and sell it to the local market traders who then sell to the wholesellers. The value chains are different for fresh water fisheries and the shrimp/prawn. Main suppliers for the fisheries value chain are the suppliers of fingerlings, fertilizer, fish feed and lime. Different entrepreneurs collect the fishery materials from the wholesale suppliers for retail selling to fishers. Fish traders or Aratdar play an important role in bulk buying and they sell to the fish vendors or small fish shops. The consumers are the common people, hotels, restaurants, hostels, and hospitals.

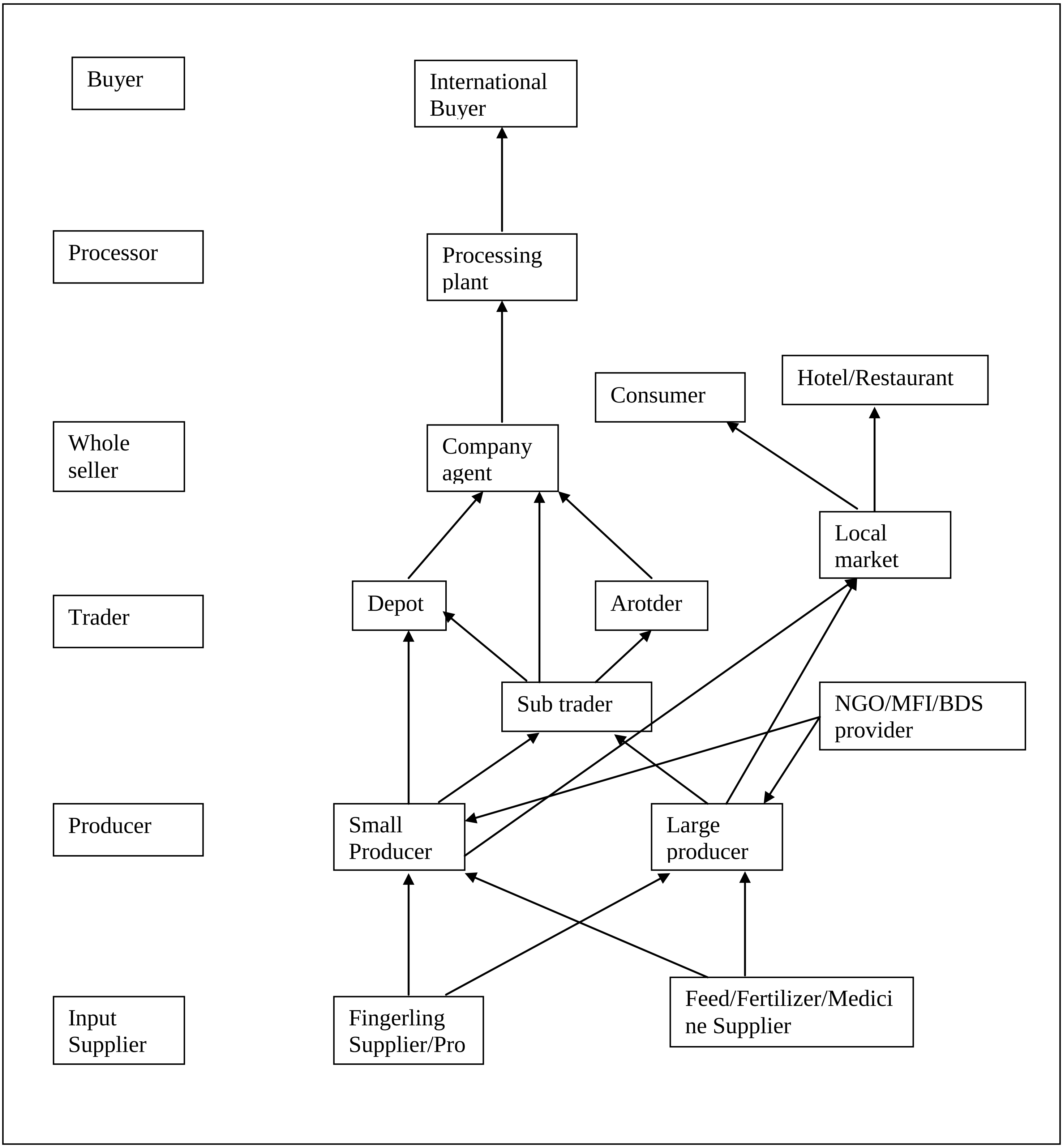
In addition to main suppliers, other actors include entrepreneurs/aratdars as wholesalers, aratdar as retailers, and individual customers and hotels as consumers. These actors have developed their associations to protect their interests. But not all fishers and entrepreneurs are organized, as a result of which they have to sell their products to middlemen, thereby earning less as the profits are shared by the middlemen. However, the entrepreneurs are very few and much organized than the fishers and exercise control over the market. Many have their own distribution chain and capable to supply their products accordingly to the demand of the market. However, the demand fluctuates and price varies depending on market forces. To evade competition and minimize losses, they fix and charge prices through consensus.

Fishermen are able to access fresh fingerlings from local fingerling markets, individual traders, and wholesale fingerling market. The fingerlings are raised keeping in view the varieties of fish that are most demanded by customers. The fingerling breeders are able to purchase brood fish from brood fish farmers, who obtain licensed breeds from government facilities. Brood fish farmers earn a profit by selling brood fish and fingerlings. Farmers receive technical advice at the fingerling markets through fingerling traders and farmers, but on an adhoc basis. Fish traders accordingly adapt to the requirements of fish farmers, who access appropriate fish food through local animal feed distributors.

Input suppliers from two different sectors provide support for fish culture: These are fingerling producers/suppliers and the suppliers of medicine, food and fertilizer. There are two types of producers, small scale producer and large scale producers. Sometimes they receive financial support from the NGOs, micro finance institutions and others for their production and also for establishing a production process. The producers, who culture fish in their ponds twice in a year, sell their fish to the depot, arotdar, subcontractor and the local market. With the scarcity of fish supply and higher demand, fish farming is becoming a profitable industry in the Sundarbans landscape where, in addition to open water capture fisheries, fishes and shrimps are cultivated mainly in ponds. The increasing purchasing power and growing population and their growing preference for shrimps have driven many entrepreneurs to get into shrimp cultivation and business. Furthermore, they are encouraged to increase shrimp production to serve the international market demand. Bangladesh has succeeded in earning substantial foreign exchanges (the second largest after garments industry) by exporting shrimps to Europe, America and Middle East.

Fish Depot owners and arotders in local market get catch fish directly from small or large producers, but sometimes they buy from subcontractors who do not sell fish directly in the local market. In the local market, Forias are involved in buying and selling of fish. Depot owners and arotders buy fish from small or large scale producers and they sell the bulk fish to a company agent. Some times depot or arotder take dadon from company agents and so are bound to sell their bulk fish to them. A company agent taking fish from depot owners and arotders processes the fish through ice covering and at the end of the day he sells it to the market in bulk amount. In Sarankhola there is no fish processing plant nearby and so the producers shift their produce to a nearby processing plant. Some fish processing agents collect fish from depot and arotder to process it for exporting to the international market. The processing plant owner processes their fish according to the buyer preference and export to the European countries, United States and also some Middle East countries. Different components of a fish value chain in Sarakhola are presented in Figure 6.20

Figure 6.20 Pond Fisheries Value Chain at Sarankhola site office



6.13.1.6 Fisheries Opportunities and Interventions

Production of fish is a profitable activity as according to the actors involved, at present, there are different types of fish (Rui, Catla, Mrigal and other) that are profitable to produce: According to an estimate, production of different kinds of fish in a pond (0.50 acres) requires an amount of Taka 27,500 and total sales is estimated at Taka 40,000. Given an investment of Taka 5-7 lakhs, a profit margin of 35-45% can be achieved in a year. The following production technologies were identified in Sarankhola for the fishery sector:

- Rice fish farming
- Fingerling rearing
- Carp polyculture
- Fish culture

Three main types of fishery activities would involve capture fishery, culture fishery and dry fishery activities. The fishery sector is more productive and efficient than the other seafood sectors in the Sunadrabans landscape. Moreover, fish farms have no significant negative impacts on the environment and the business is socially responsible as it generates employment and adds value to society in the form of supplying protein and creating profit. Both men and women get actively involved in the fish cultivation.

The relationships that exist between the market actors of fisheries value chain can be described in terms of "governance" structures. Understanding these structures is important in designing suitable interventions to support the targeted fisheries value chain. Although many customers/suppliers are involved in different transactions, the flow of information is often limited because the suppliers of inputs for fisheries cater to various customers. The following constraints were found to be holding back increased income and employment opportunities for small scale and micro-enterprises participating in a typical fisheries value chain at Sarankhola:

- Lack of sufficient capital.
- Deficiency of marketing management.
- Lack of storage and preservation facilities.
- Smuggling of fish.
- Spoilage and perishable nature of fish.
- Outbreaks of diseases.

In order to resolve these constraints, the following opportunities and interventions are identified:

- Promote sustainable solutions that will be long-lasting.
- Encourage and make use of existing private sector initiatives.
- Leverage farmers’ own capital and land for developing appropriate fisheries value chain.
- Soils, waters and climate are good for developing fisheries value chains in Sarankhola.
- Skilled fishers and cheap labour are available at Sarankhola.
- Fisheries production technology is widely known locally.
- Inputs such as fish feed and storage facilities such as ice factories are available locally.
- Both local and international demand for fish exist.

- Trade fairs for the promotion fish processing and exporting can be arranged at Khulna and Dhaka
- Access to improved training/technical assistance can be possible to help pond fish culture.
- Skills of the line agents of integrators and private sectors in new technologies can be improved for assisting contract pond fish producers to produce bulk amount of fish.
- Cost share and training of line supervisors in the latest techniques appropriate for pond fish producers, and providing financial support to independent producers
- Access to appropriate financial support from financial institutions provided to increase fish production as well as income of independent producers.
- Reliable market information provided by identifying arotaders, who are interested to share market information and provide technical assistance to producers.
- Group marketing for the producers can be formalized by establishing good linkages between markets and the producers

6.13.2 Tree Nursery Value Chain Design and Implementation

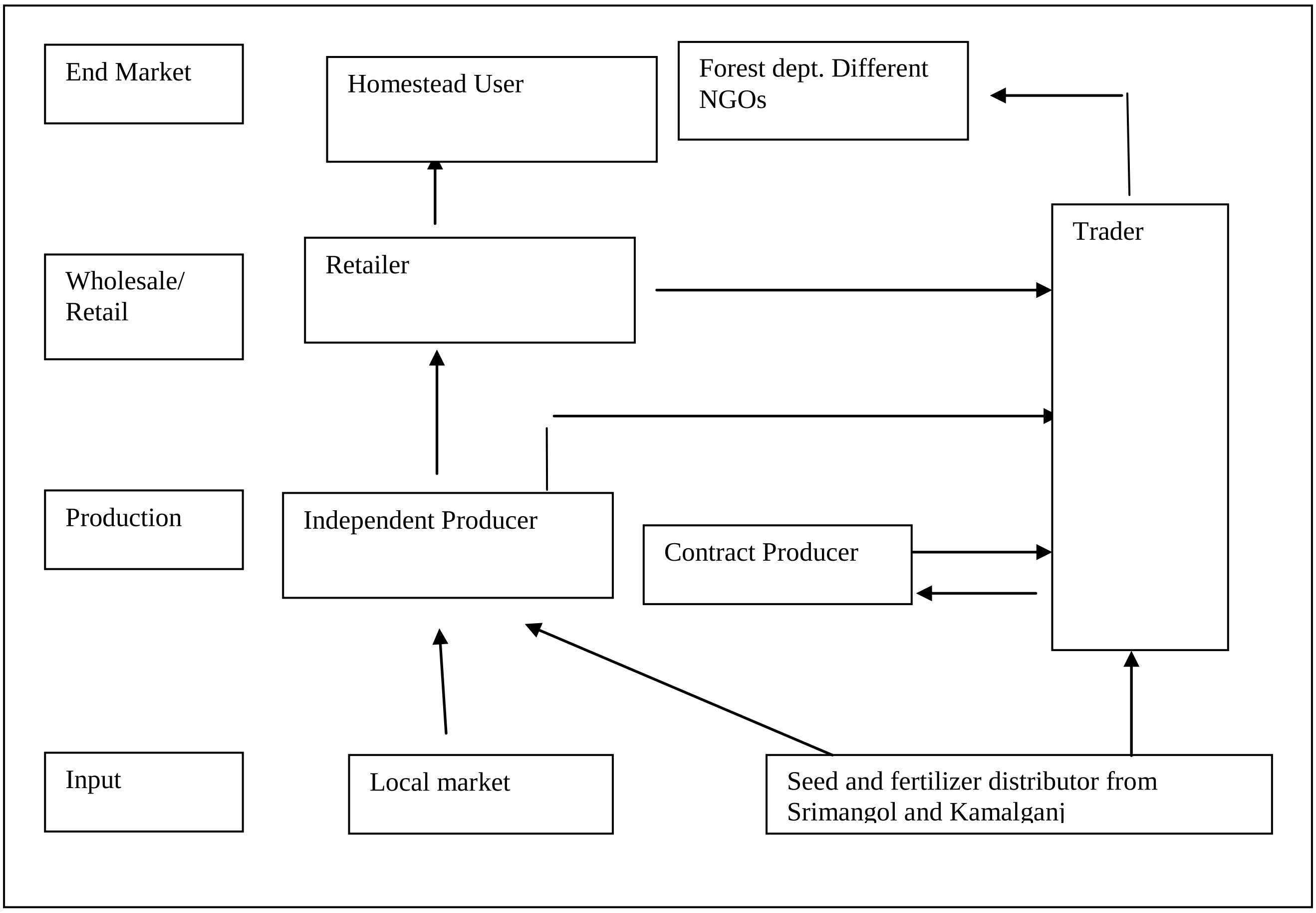
It came out during the field visits that tree nursery development has great potential in the Sundarbans landscape due to huge demand, particularly for homesteads tree plantations. An assessment of the tree nursery development value chain was, therefore, conducted with the objective to understand its functioning, dynamics, key players, and possible initiatives to facilitate promotion of nurseries as conservation enterprises by local forest dependent communities. Forests dependent people including the members of co-management organizations such as community patrollers will be the target population for the interventions. They have limited alternative sources of income and so can devote their surplus labour in develoing nurseries in their homesteads and cultivable lands, thereby increasing their income and employment opportunities with positive impacts to the environment**.**

Many private nurseries have grown up, particularly in the cities and towns of the Sundarbans landscape for meeting the demand for quality seedlings and seeds of horticultural, vegetables and tree species. Village nurseries to be developed by local people having some land will be encouraged to meet the local demand for quality seedlings and seeds. Technical and logistic support will be arranged to prospective farmers. Seedlings to be raised in village nursery will be as per local preferences which may include timber, fruit, vegetable, flower, fuelwood, fodder, medicinal and other NTFPs bearing species. Nursery planning activities will be started at least one year in advance with proper attention on i) collection, processing and storage of seeds, ii) testing, certification and distribution of quality seeds, iii) training and awareness on improved nursery techniques and inputs, iv) seed orchards, v) water source and watering regime, vi) nursery management intensity and technical supervision, vii) culling, root coiling and fibrous root development, viii) standardization of nursery techniques, and ix) improved transportation of seedlings from nursery to planting sites.

6.13.2.1 Tree Nursery Value Chain Mapping

The following map (Figure 6.21) represents a graphical form of all the major actors in a tree nursery value chain in the Sundarbans landscape. It presents different supply channels that transform raw materials into seedlings as finished products and then distribute/sell those seedlings to final consumers and the different markets.

Figure 6.21: Value Chain Map for Tree Nursery



6.13.2.2 Tree Nursery Value Chain Functions and Actors

There are a number of large and small suppliers involved in supply of inputs such as seeds, sticks, manure and fertilizer, mats, sheds, polythene bags, and soil working and watering equipments required for tree nursery development. Independent producers usually procure these inputs from local markets. Sometimes seeds are collected locally either from nearby forests and/or roadside plantations. Independent producers are mainly the small scale producer, who produce the products according to their own specification and on the basis of local market demand. They sell their products directly in local market where local individual consumer buy seedlings mainly for household plantations. Some traders buy seedlings from producers to sell in the pocket markets, whereas contract producers produce seedlings according to the demand of traders who give orders with specifications about the seddlings species and the size. FD generally does not buy seedlings from private growers as they develop their own nurseries every year. But sometimes different NGOs purchase plants for their plantation activities. Local people who plant several types of fruits and timber species in their homesteads are the main buyers and can be approached through co-management organizations including CMC.

The types of relationships that exist between market players in nursery value chain can be described in terms of "governance" structures, the understanding of which is important in designing appropriate interventions. In nursery development value chain in the Sundarbans landscape two types of governance structure exist: Small nursery farmers are in most of the cases free from any type of contract and so they sell their product at local market through competition and hence price is determined by supply and demand relationship. On the other hand small traders or large buyers enter into contracts with small or medium producers to whom they sometimes supply inputs. Hence desired product is produced according to their specification and price is controlled by them in such a directed type of market relationship.

6.13.2.3 Nursery Value Chain Development Constraints, Opportunities and Solutions

Value chain development constraints and opportrunities are identified in Table 6.14 based on group discussions with key stakeholders:

Table 6.14: Tree Nursery Value Chain Constraints, Opportunities and Solutions

Category	Constraints	Possible Market Based Solutions
Seedlings Development	• Inadequate technical skills to produce to buyer specification.	• Provision of training on quality seedlings production technology • Set up quality seed banks • Dissiminate nursery development techniques
Market Access	• Lack of linkages to large buyers (FD and NGOs) • Lack of information on quality seedlings • High transportation cost	• Facilitate mediation between the producers and buyers. • Circulate brochures with technical specifications • Establish nurseries near to plantation sites
Input Supply	• Poor quality of inputs. • Seasonal variation in supply. • Sources of quality inputs are far from producers	• Enhance sources of quality inputs locally • Extension services to small producers • Establsih linkages between input providers and producers
Management and Organization	• Inability of producers to organize of economics scale • Lack of training for various stakeholders in financial management, production skill • Absence of organization of producers and suppliers • lack of communication and cooperation between different stakeholders	• Faciliate tree growers and marketing groups and their federations • Provide training and demonstrations through exchange visits • Develop and disseminate communication matrials
Policy	• Strict forest laws on private tree growing	• Faciliate a dialogue between the producers organizations and FD
Finance	• Lack of supplies credit; • Lack of access to commercial funding;	• Facilitat access to credit by linking to MFIs.
Infrastructure	• Poor road, electricity, etc.	• Improve connectivity by liaisoning with Govt. departments

Focus group discussions with key value chain actors (input suppliers, producers, traders, CMO members, FD field staff) were held to identify facilitation interventions that can promote the targeted market solutions. The main objectives of the focus group discussions were to: (i) validate the assessments of market solutions in the value chain, and (ii) propose interventions that will support the provision and use of the market-based solutions as presented in Table 6.15.

Table 6.15: Tree Nursery Value Chain Solutions and Facilitation

Value Chain Constraint: Lack of technical skills on quality seedlings production techniques
Market based solution: Provision of training and technical assistance in developing quality seedlings.
Proposed Provider: Forest Department and other relevant organizations such as Bangladesh Forest Research Institute
Challenges and Incentives to the provision and use of the Market based Solution • Lack of skilled trainer to provide the training • Difficulties in organizing the small producer • Lack of standardized training materials
Facilitation Activities: • FD may arrange TOT for extension agents • FD may organize small producers through CMCs • FD may develop and implement a training module • FD may help form seedlings producers and marketing groups and their federations • Marketing the products through establishing sustainable market linkage with private sector

In selecting the above-discussed interventions it was kept in mind that new interventions are likely to be identified once implementation begins and so the proposed intervention need to be updated and additional solutions could require new facilitation activities. The following facilitation activities are summarized for implementing a nursery value chain :

- Organized small producers, preferably through CMCs
- Organize training for producers to timely produce quality seedlings
- Ensure buy-back guarantee to buy seedlings through CMCs
- Encourage public private partnerships
- Capacitate existing NGOs to promote the production and marketing of quality seedlings
- Provide necessary inputs and credit support to private tree growers

6.13.3 Homestead-based Livelihood Development

Main objective of livelihood programs for landscape development is to develop linkages with appropriate livelihood programs and other projects/initiatives that will reduce biotic pressure on the Sundarbans by providing alternative livelihood opportunities to poor stakeholders living in the surrounding landscape. Up-scaling of skills will be taken up for generating value additions through capacity building of local people. Revolving fund and entry fee revenue allocated to the CMCs will be used to provide finance for the members of community patrolling groups and co-management committees and they will be encouraged to set up micro-enterprises to generate value additions locally. The following livelihoods activities are proposed to be implemented in the Sundarbans landscape:

- Integrated homestead farming
- Cultivation of high value crops
- Food processing and marketing
- Village tree nursery
- Pond fisheries

Fishries and tree nursery value chain have been discussed in detail and so will not be repeated here. Many villagers on fringes of the Sundarbans landscape practice subsistence farming (low input and low output) on their homesteads (small yard, backyard ditch, etc.). Inter-dependency among the various components of the production technology package can be designed to maximize output, which can be used for household consumption, and surplus being sold for buying non-agricultural daily necessities. This will provide food security and better adaptation to climate change by enhancing their income by creating livelihood assets and self-employment opportunities.

Diversification of production possibilities will help avert production risks and reduce climate change vulnerability. Possible components of such an integrated production technology package may include vegetables (on open fields, machans, dykes and other unutilized places around houses), cash crops, horticultural and tree nursery, poultry rearing, cow rearing (local improved breed with crossing for fattening), fish culture (in micro-ponds), duck-cum-fish culture (in family ponds), pigeon farming (six pairs of pigeon reared as scavengers) and apiculture (domesticated wild bees). Complementary off-farm activities may include food processing (threshing, winnowing, drying, grading, husking, etc.), food preservation, and other cottage and small scale value addition activities.

High value crops have more nutritive value, high price and demand. But this production technology is suitable to those farmers who have cultivable land and can make a minimum investment. Suitable high value crops include tomato, potato, fine rice, papaya, ginger, turmeric, yard long bean, leafy vegetables, aroids, chilly, beetle leaf, maize. guava, banana, jackfruit, pineapple, etc. Some vegetables can be grown all year round and so fetch more prices during off-season. Simple food processing and preservation techniques will be explained to local people for creating value addition locally and providing self-employment opportunities. For example, pickles of mango, lemon and jackfruit can be made locally for households nutrition and cash sale.

Livestock-poultry sub-sector is an important part of food security and cattle rearing with focus on milch cow rearing is particularly suitable for poor people residing within the landscape. The following livestock rearing technologies are found suitable for their implementation in the landscape :

- Beef fattening
- Milch cow rearing
- Broiler/Layer rearing

Beef fattening can be achieved within a short period (3-12 months) by using a local improved breed cow with crossing hybrid. Milk provides a balanced diet by meeting the required demands of nutrition. So at least one milch cow of a locally improved bred, or crossbred cow with average milk production of a liter/day, can be targeted for an identified households. The poultry industry has developed near cities and towns for meeting huge demand within a short time as a supplement of animal protein. Females are particularly suitable for carrying out broiler/layer rearing activities carried out in households.

Non-Timber Forest Products based Livelihoods

Short-term production objectives of NTFPs management will be linked with long-term biodiversity conservation objectives in order to create personal stakes among the members of co-management organizations. Poor forests-dependent communities value a regular flow of NTFPs more than a distant one-time share from final harvests of trees. The flow of benefits from many NTFPs will start from the first year of co-management activities; their volume and composition increasing gradually as the mangrove forests are provided an effective protection against biotic interference. The importance of NTFPs depends on a number of factors including use value, barter (exchange) value, market demand, accessibility to markets, storage and perishibility. It is important to create stakes among local stakeholders for biodiversity conservation by ensuring adequate benefits to them from the Sundarbans and off-PA based income generation activities. This objective can be achieved by facilitating close linkages with the livelihoods of local stakeholders and NTFPs development. The backward and forward linkages of NTFPs based production technologies are substantial.

A long-term NTFPs management policy focusing on the access of co-management committees, liberalization of government restrictions on storage and transport (e.g. transit permit), dissemination of relevant information about marketing is necessary. The development of such a policy will be based on an exhaustive survey of NTFPs (extent, distribution, threatened species, regeneration and enrichment, collection and use-patterns, illicit removals, present and sustainable level of extraction, local needs and community dependence, processing and value addition opportunities, ethnobotany, indigenous knowledge base, local stakeholders, markets and marketing channels, forward and backward linkages, export and trade).

The timing of various agricultural operations and NTFPs management and collection activities are generally complementary. This means that appropriate management practices can be locally adopted in order to provide year-round employment and income to local unemployed villagers, thereby reducing the severity of rural poverty and vulnerability, particularly during the agriculture lean season. For example, the agriculture lean season could best be made use by the members of co-management organizations for the collection, harvesting, processing and marketing of NTFPs. Many NTFPs based activities are more suitable for the rural poor including women and children due to specific characteristics of NTFPs management such as labor-intensive, simple technologies (many times the collection techniques are inherited and handicrafts made by employing family skills), easy accessibility and benefits to poor, seasonal collection, supplementary income to forest dwellers and household activities with low volume. However, a number of NTFP yielding plants and waterbodies (e.g. medicinal plants) are distributed dispersely and the collection of some NTFPs is to be completed within a short period. This may hamper an intensive management and collection, particularly in the absence of a designated organization responsible for the collection and marketing of NTFPs.

NTFPs based forest management in the Sundarbans is ecologically and economically sustainable, provided extraction levels are maintained below the maximum sustainable yield by adopting appropriate silvicultural systems and management practices. Indeed sustainable management of NTFPs demands a sustainable management of forests as mother resource. A sustainable level of harvesting is a pre-requisite for socio-ecological security. This is necessary to meet the needs of the present generation without compromising the ability of future generations to meet their own needs for NTFPs. Planting of NTFPs bearing shrubs and tree species (medicinal plants, etc.) will be taken by members of co-management organizations. Many medicinal shrubs and herbs can be planted and managed as a part of homestead. Additionally, a variety of medicinal plants occur naturally in Sundarbans due mainly to favorable climate conditions. Primary collectors collect medicinal plants as per the requirements of local traders who are the main suppliers to big dealers and drug manufacturers. Drug manufacturing processes have been indigenously developed for a number of species. There is a need for developing similar processes for other medicinal plants. Extensive training on the management of medicinal plants will be imparted to FD field staff and CMCs. Members of CPGs will be encouraged to take up homestead plantations of medicinal species. Potential management practices for NTFPs are presented in Table 6.16.

Table 6.16: Candidate Management Practices for Non-Timber Forest Products

Sl. #	Functions	Potential Management Practices
1	Production/Regeneration	Manage the mangrove forests for sustainable development of NTFPs. Protect forests by associating local stakeholders. Take enrichment planting of NTFPs yielding species in identified blanks.
2	Collection/Harvesting	Harvest/collect NTFPs sustainably by employing members of beneficiary groups. Use better harvesting tools and equipments. Impart training and skill development to beneficiary groups in improved harvesting/collection techniques.
3	Pre-processing	Train the groups in primary processing activities including storing, sorting, cleaning and drying. Help establish primary collection centres for storage after primary processing. Provide better pre-processing tools and equipments to group members.
4	Self-consumption	Awareness training. Basic storage facilities.
5	Marketing of unprocessed NTFPs	Provide useful information on use patterns, market channels, prices, demand, etc.
6	Storage and Processing	Provide relevant technology, training, finance, quality control, etc.
7	Marketing of processed NTFPs	Conduct a market assessment and develop a marketing strategy. Linkages with centres of production and marketing. Financing for storage, transport and marketing.

The collection, processing and marketing practices for NTFPs to be adopted by patrolling groups need to be such as to enable them earn their subsistence living regularly. Development of NTFPs through user groups can be taken up by using revolving funds and entry fee revenue and rural credits. Poor harvesting practices for NTFPs will lead to waste and unsustainable practices. Raw materials (e.g. medicinal plants), which are to be kept after harvesting need to be dried and stored properly in order to prevent any quality deterioration. Some NTFPs including honey, grasses and wax can be processed at local level (i.e. user groups). Federations of user groups may establish processing-cum-marketing units (e.g. handicrafts, mats, broom, honey, etc.) locally by pooling their resources. These will not only help in accessing better harvesting tools and equipments but will also help in marketing of processed NTFPs at remunerative prices. The FD may not put NTFPs into auctions and leases. Instead, the responsibility for primary collection, storage, processing and marketing can be given to user groups and co-management committees. This will help in biodiversity conservation through consumers of NTFPs becoming their primary producers with livelihood opportunities in terms of NTFPs based products, employment and income generation. The share of benefits from NTFPs will be given by FD to CMCs for which the GOB will issue necessary orders.

The parameters for ensuring a good quality for different NTFPs are variable. For example, medicinal and aromatic plants graded based on the contents of principles present in the collected NTFPs. Similarly wax and honey are graded according to the size and colour respectively. Moreover, the technologies for grading, processing and storage depend upon market needs and nature of NTFPs. Factors responsible for quality deterioration (of perishable NTFPs such as honey and fishes) through contamination with air, moisture and dust should be eliminated before storing the collected NTFPs.

A well planned marketing of NTFPs can be a means for employment and income generation by optimizing the values of NTFPs and ensuring the distribution of enhanced benefits among the participants. The role of marketing is in creating better linkages between the NTFPs management, processing and end-use. Proper marketing can reinforce sustainable management of NTFPs by indicating the kind of products and raw materials required. The NTFPs markets, which are essentially local, exhibit seasonal behavioral patterns because NTFPs production is seasonal in character. The local merchants and intermediaries many times deprive poor a fair price for their collected NTFPs. There is a wide gap between the NTFPs prices received by the primary collectors and that of final products. So there is a need for rationalizing the marketing system in order to narrow down the wide price differences. The quality of NTFPs as raw material is influenced by post harvesting handling, processing and storage conditions.

The development of NTFPs based enterprises may be hampered due to a number of factors. Lack of adequate facilities for processing and storage will result in losses, especially for perishable NTFPs. Other constraints include limited availability of finance and uncertain markets. Government restrictions on the transit and movement of some of the collected NTFPs (in terms of transit permits to be issued by FD) discourage the collectors for their collection and sale. If the collected NTFPs are processed at local level then the value added (e.g. broom making, leaf collection for puffed and parched rice, basket making, handicrafts making, etc.) can be retained locally thereby generating forward and backward linkages for socio-economic development. However, poor infrastructure, natural calamities, poor skills, poverty and illiteracy among local people may be hindrance in setting up small enterprises for making finished products in the absence of adequate government support.

The processing of some NTFPs may require an access to secondary processing industries and regular markets. Therefore, there is a need for establishing proper linkages between the primary collectors, processing units and markets. Traditional knowledge about medicinal plants and animals should be documented in view of their contemporary relevance. Revitalization of folk traditions on medicinal plants holds a real potential for self-reliance of rural people on primary health care. In-situ conservation of biodiversity of use in traditional medicine should be encouraged by delineating medicinal plants conservation areas to conserve cross-sections of diverse eco-systems having potential for medicinal plants and animal species, and their genetic diversity.

6.14 Summary of Main Prescriptions

Main prescriptions outlined under the above-developed climate change adaptation programs are summarized in Table 6.17.

Table 6.17: Summary of Main Prescriptions: Climate Change Adaptation Programs

Year	Main Activities	Main Outputs/Success Criteria	Responsibility
1 and 2	-Conducting climate change vulnerability and adaptation assessments	Vulnerability and adaptation assessement report	FD/SEALS/ CMCs
	-Identifying a list of feasible value chains and alternate income technologies	Feasible value chains and production technologies identified	FD/SEALS/ CMCs
	-Holding discussions with local stakeholders on feasible value chains & alternate income generation technologies	-Stakeholders' consultations held	SEALS/FD/ Stakeholders/ CMCs
	-Finalizing a short list of priority interventions	Short list of production technologies	NSP/FD/CMCs Stakeholders
	-Mobilizing capable groups and enterprenuers	Groups identified	SEALS/CMCs
	-Preparing training & publicity material on the finalized value chains & production technologies	Training materials prepared	SEALS
	-Designing demonstration centres and farmers field schools (FFS) for proven value chains & technologies	Design of demonstration centres & FFS completed	SEALS
	-Identifying farmers training schools	Farmers training schools identified	SEALS/FD/ Stakeholders
	-Finalizing preparations for imparting training & demonstrations to local stakeholders	Preparations for training completed	SEALS/FD/ CMCs
	-Finalizing operational guidelines for grants and micro-finance	Operational guidelines and manuals	SEALS
	-Capitilization of groups and entrepreneurs through grants and micro-finance	Capital in the Bank accounts of Groups	SEALS
	-Establishing linkages with service providers and whole sellers/consumers	MOUs signed between producers and sellers/consumers	SEALS
3 and 4	-List of feasible production technologies refined based on the early experiences	List of production technologies refined	FD/SEALS/ Stakeholders
	-Continue holding discussions with local stakeholders on improved implementation of value chains	Improved value chains implemented	SEALS/FD/ Stakeholders
	-Priority production technologies refined	Production technologies	SEALS/

	based on the initial experiences	refined	Stakeholders
	-Revising training material on the finalized production technologies	Training materials finalized	SEALS/FD
	-Expanding demonstration centres for proven technologies and arranging for stakeholders visits	Demonstration centres expanded	SEALS/CMCs
	-Expanding farmers field schools and arranging for stakeholders visits	Farmers field schools expanded	SEALS/CMCs
	-Imparting advance training to local stakeholders	Training to groups imparted	SEALS/FD/ Stakeholders
	-Training in simple storing and processing technologies	Stakeholders trained	SEALS/CMCs/ Stakeholders
	-Expanding community based priority value chains including fisheries and tree nurseries	Expanded value chain activities	SEALS/CMCs/ Stakeholders
	- Expanding training & demonstrations to local stakeholders	Trained Groups	SEALS/CMCs/ Stakeholders
	-Expanding grants and micro-finance for enhanced capitilization of groups and entrepreneurs	Groups with Bank accounts and capital	SEALS/CMCs/ Stakeholders
	-Expanding linkages with service providers and whole sellers/consumers	Services available to producers	SEALS/CMCs/ Stakeholders
5 to 10	As above with a mid-term evaluation in the year 6 after the continueing activities will be adjusted and consolidated		

7. Eco-Tourism Programs

The importance of tourism is emphasized in the Bangladesh National Tourism Policy (1992) as a means of outdoor recreation, and eco-tourism in particular focuses on low-impact nature-based outdoor recreation. The Forest Policy (1994) recognizes eco-tourism as a forestry-related activity, which needs to be promoted taking into consideration the nature's carrying capacity in the SRF. Eco-tourism is distinguished with nature tourism in terms of involving and benefiting local community including co-management organizations. Public support for the Sundarbans conservation can be enhanced by allowing a regulated and low impact nature tourism. Regular participatory monitoring, particularly for tracking negative impacts on both the ecosystem and local community, and putting up a corrective mechanism will be necessary for mitigating negative socio-ecological impacts. However it is important to realize that nature tourism exists for the Sundarbans and not other the way round, and so nature tourism and visitor facilities must be compatible with biodiversity conservation.

In view of huge demand, from wealthy domestic population, it is feasible to rapidly increase visitation to the Sundarbans. But a careful planning is needed about the type of tourists being attracted and the ensuing visitor management and minimum facilities required, building public-private partnerships with FD and private tour operators, providing security to visitors, ensuring flow of benefits to local community, and identifying and promoting flagship attractions such as the Royal Bengal Tigers in the world's largest mangrove forests. Although the revenue generated from nature tourism can be an important source of local community development, maximization of income may not be its main aim.

7.1 Program Objectives

Environmentally sound and socio-economically inclusive eco-tourism will be an important goal to be achieved under this Plan. Regulated eco-tourism in terms of nature education and interpretation tours in and around the SRF, as against commercial tourism, for promoting biodiversity conservation and educating visitors as enlightened nature tourists, will be a main objective of the proposed eco-tourism programs. Nature tourism will help inculcate amongst visitors love for the Sundarbans conservation by providing a communion with nature. Socio-economic benefits of nature tourism accruing to local people will be catalyzed by leveraging forward and backward linkages of eco-tourism, and so enhancing socio-economic benefits accruing to local community in the interface landscape zone will be another important objective.

7.2 Sundarbans Eco-tourism Assessment

On a global basis, tourism frequently reaches and surpasses appropriate limits to growth with little notice, planning, or response from decision makers. In recent years, policy makers have begun to advocate sustainable destination planning for tourism – with a set of management approaches that can help ensure that tourism is not environmentally damaging, contributes to conservation and local community development, and provides opportunities for enhanced conservation and sustainable development. In 2004, the World Tourism Organization, now the United Nations World Tourism Organization (UNWTO), published an important guide to *Indicators of Sustainable Development for Tourism Destinations*. Its intent is to provide a process by which policy makers can use research based indicators to make decisions on guiding the development of sustainable tourism. The tourism industry is frequently referenced as a highly important stakeholder/user group with the potential to provide extensive benefits to the SRF. However, there is no consistent analysis of tourism's impacts on the Sundarbans ecosystem or neighboring communities. Therefore, a SWOT analysis to help develop eco-tourism in the SRF is provided in this Chapter. This SWOT analysis will help FD to assess eco-tourism potential and to decide what type of indicators will be useful in monitoring trends and progress towards achieving goals of an eco-tourism destination. A SWOT analysis should give a succinct analysis of the Sundarbans assets and short comings and reveal the opportunities and challenges it faces.

This SWOT analysis of the Sundarbans has been developed to guide FD on the means to develop tourism in the SRF in a sustainable manner. It reveals opportunities for further research and investigation, and will help FD to review what options exist for improving eco-tourism's benefits while reducing its negative impacts. The SWOT analysis was developed via a questionnaire based on the UNWTO (2004) Indicators for Sustaianble Tourism Development guide. Field data was collected in March 24-31, 2009 by a team of local data gatherers and IPAC field staff who visited Khulna, Mongla, Katka, Burigoalini, and Kolagachia. A SWOT analysis is a qualitative not quantitative program for gathering data. Each day the team collected data in the field and subsequently gathered to interpret and share their results on the following:

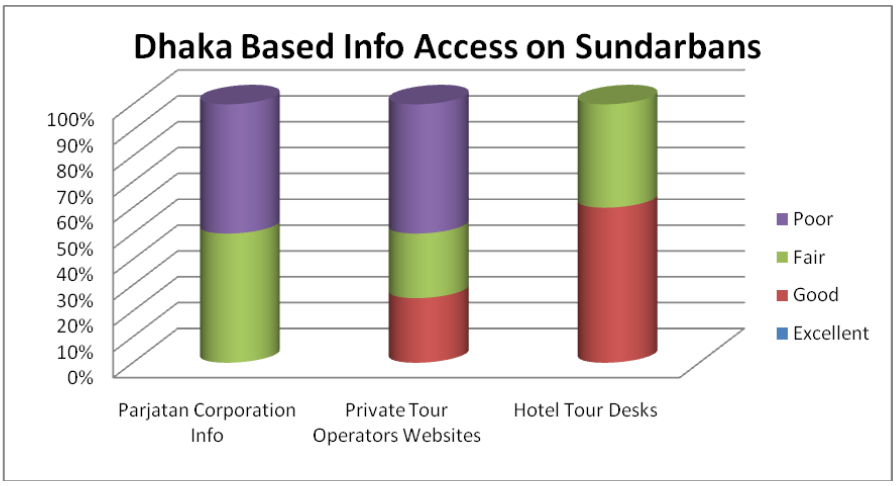
- Information Accessibility on the Sundarbans
- Boat Transportation
- Visitor Management
- Community Benefits
- Cultural Impacts
- Conservation Awareness
- Revenue Generation
- Community Benefits
- Physical Impacts – Entire Sundarbans region
- Unmanaged Tourism- Site Specific
- Socio-cultural impacts in tourism areas

The charts presented are a simple quantification of the number of check marks received in each section of the survey in the categories of Excellent, Good, Fair, Poor, and Not Applicable. These charts are illustrative only and provided to give a simple visual presentation of how the team rated each survey category. The discussions and recommendations provide important background on how these ratings were decided upon. A chart with Strengths and Weaknesses is provided to summarize the discussion in each section. A summary of the opportunities discovered via this research, and threats where relevant, are also summarized. The conclusion provides the master chart for Strengths, Weaknesses, Opportunities and Threats with action points recommended.

7.3 Information Accessibility on the Sundarbans

Eco-tourism information must be provided by the main actors delivering the tourism experience in a way that is accessible and provides the tourist with the information required to make informed decisions on their travel experience. The information presented for the protected areas of the global importance of the SRF, should be rich with content about the ecosystem, wildlife, plants and preferably include information about human resource users and their livelihoods. An important feature of visiting the SRF is not only its natural history, but also the many biodiversity conservation activities transpiring at all times within the SRF. A chain of tourism providers is required to provide this information to eco-tourists. A small selection of each link in the supply chain was surveyed to understand how the SRF is being presented to both international and domestic visitors. In this SWOT, the team looked at information provided on the SRF from information providers in Dhaka, Khulna and Mongla. Dhaka is the capital of Bangladesh and therefore the main departure point for the majority of visitors, domestic and international. Kuhlna is the gateway city to the Sundarbans, where buses, boats and hotels are found for travelers preparing for departure. Khulna is the main departure port for international visitors boarding overnight ships heading to the Sundarbans. Mongla is a small port city where a wide variety of small boats are available for day trips to the most accessible parts of the reserve.

Figure 7.1: Dhaka Based info Access on Sundarbans

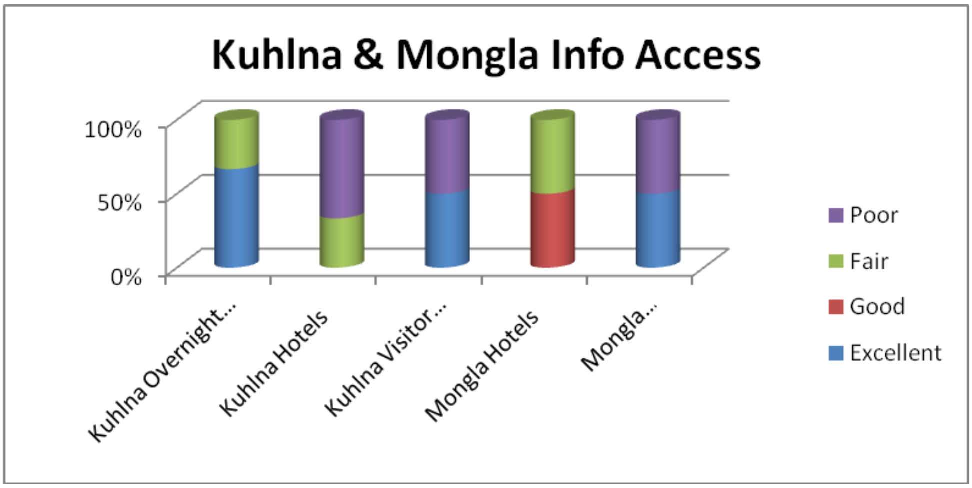


The Parjatan Corporation which is the National Tourism Organization (NTO) of Bangladesh was contacted by telephone, its website was reviewed, the airport desk was evaluated and the Parjatan hotel in Dhaka was contacted. In general there was inadequate information available on the Sundarbans, with their tour division completely unavailable by phone. Their website was acceptable with succinct information provided. The same information found on the website was provided in the airport. Private tour operator websites were helpful, but their websites were judged to be lacking in the type of content rich information that websites can so easily present.

Three tour operators specializing in natural history tours were evaluated for their websites, and one non specialist firm. Hotel tour desks were the most helpful in providing information to our blind callers in the luxury, moderate and budget categories, quickly providing details on the main points necessary for making a decision and connecting visitors to the relevant tour operators on request. None of the information providers queried were rated excellent for information on the Sundarbans. More quality information could be presented on the Sundarbans ecosystem that would attract visitors and help them to learn about this unique ecosystem in advance of arrival. This information should be optimized to reach a broader market more effectively via the worldwide web.

In the gateway city of Khulna, information on the Sundarbans was more available and of higher quality. The leading overnight tour operators are found in Khulna, and the data gatherers found it easy to get quality information from the tour operator offices by just stopping by. Surprisingly the hotels in the city, which clearly catered to international visitors coming to the Sundarbans had little or no information available. This is a clear weakness.

Figure 7.2: Khulna and Mongla Info Access



The Khulna Sundarbans Forest Information and Learning Center found at the FD office was established with funds from the SBCP. There is no promotion, no budget for the center, and no effort to expand or use the center as an educational entry point for the Sundarbans visitors. The projection system, which once offered a film in a charming room set up with a mock Sundarbans boat has become inoperable, simply due to the lack of appropriate lenses for the projection system. The center for information for tours is no longer operating, and the small shop has limited goods which are faded and appear to have remained on the shelves for years. While the team judged the Information Center as excellent for being available with good content and open according to schedule. It was judged poor in terms of its accessibility. None of the hotels or tour operators recommended it to visitors. This is clearly a weaknesses that could be converted into an opportunity.

In Mongla, a much smaller town of more appeal to domestic visitors, the Parjatan Corporation hotel had no information available on the Sundarbans. The hotel manager commented that they had "run out of resources to give the tourist." A small budget hotel in town was much more entrepreneurial, with the owner going out of his way to promote the importance of the Sundarbans ecosystem to the data gatherers, its many wildlife species, discussing the sundari tree species for which the reserve is known, and the fact that it is a protected area. A small private museum in Mongla was also easy to find and open according to schedule. It was rated good as it was easy to locate, and was recommended by a local shop keeper – indicating that visitors were likely to visit it, unlike the Forest and Information and Learning Center in Khulna.

The team also investigated if guides were available in Khulna or Mongla. No guides were located in either location. The only trained guides located during the visit to the Sundarbans worked for the specialist tour operators operating overnight boats out of Khulna. There are no guides for domestic tourists entering the reserve. This is a weaknesses that could be converted into an opportunity. However, the FD is developing 100 Ecoguides with the assistance of IPAC.

A summary of strengths and weaknesses for information accessibility is provided as below:

Strength	**Weakness**
Kuhlna tour operator offices	Parjatan Corporation information in Dhaka & Mongla
Mongla small hotel & private museum	Khulna Sundarbans Forest Information Center
	Khulna Hotel Information on Sundarbans
	Lack of Guides for Domestic Visitors

A summary of opportunities is as below:

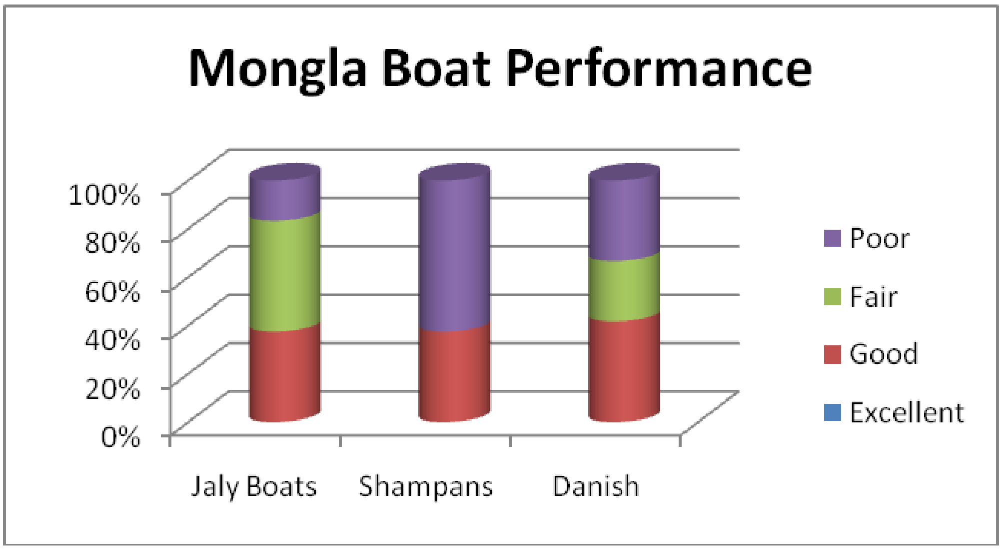
- Improved websites for specialist tour operators with offices in Dhaka
- Improved Visitor Center in Khulna via small investment in Sundarbans Forest Information Center
- Improved guiding services for domestic visitors
- Improved information provision from hotels in Khulna

7.3.1 Boat Transportation

Mongla is a bustling port with thousands of Bengali tourists arriving weekly for short day visits into the Sundarbans. It is easy to find boats for visiting the reserve, as they are found right at the point where the buses park and the Parjatan Hotel is located. No boats departing out of this port are permitted for overnight trips. The team focused its research on the boats available in Mongla for domestic tourists for day trips, as many comments were made by informants in Dhaka about the rapid escalation of day visitation in this area. Eleven day trip boats in total were evaluated, with the captains interviewed regarding their years of experience, emergency procedures, approach to predicting the weather, and cordiality.

Five types of boats were categorized that service tourists. The Jaly Boat is the most popular boat for day trips and they carry 30 people. These former rescue boats have been outfitted for day trips with high decks with chairs or even couches for visitors. The Shampan is a smaller country boat that traditionally ferries local people, which is now available to tourists and can carry 20. The Danish boat is a larger fishing vessel that is carrying as many as 80 tourists. The Launch is a steel boat that carries laborers to ships carrying up to 250 people. These boats are now being deployed for tourism in season. The Launch Line Service carries travelers from Mongla to other locations and its boats are now being deployed for tourism carrying as many as 60.

Figure 7.3: Mongla Boat Performance



Overall the port is chaotic with many different captains promoting their ships. Pricing is highly negotiable, depending on the volume of tourism that day. Overall, the surveyors found that all the captains were cordial without exception. This is an important strength. The Jaly boats had the most experienced captains with the most thorough answers on questions of safety and weather, though none of the boats offer adequate life vests or safety rings as part of their equipment. There is a Jaly boat association that was referenced by several of the captains. This association could provide an opportunity to guide the captains on questions of safety, guiding and customer service.

The Shampans captains were less knowledgeable, with less experience, operating with only the most basic understanding of handling their ships in emergency situations. The Danish boats, which are larger fishing vessels, had one highly experienced captain and two captains with almost no experience. The team attempted to determine if any of these ships carry more passengers than their permitted capacity. Because research did not take place during the highest season, which transpires from December – February, it was impossible to directly observe if the boats were overloading, but according to all local informants in the port this is not a common practice.

The team also traveled for 3 days on an overnight ship owned by Guide Tours. This boat, the first built in its fleet, was being readied to go into port for renovation and upgrade. Its layout was basic and did not include a dining area or chairs for relaxing. The shower and toilet area lacked privacy, located in an area where crew members rested. This is particularly inconvenient for women. Food was excellent and service well coordinated. The team rated the guide provided by our hosts as good. Based on the facilities alone, the boat would be considered to be a budget accommodation. The company focus is clearly on natural history. A great deal of excellent information is available in its lounge on the natural history of the Sundarbans with provisions for the use of computers – a feature which created a good ambience of learning and inquiry. The comment book was filled with rave reviews of the tours, demonstrating that the market Guide Tours attracts for visiting the SRF is strongly interested in natural history and conservation.

A summary of strengths & weaknesses for boat transportation is provided as below:

Strengths	**Weaknesses**
Accessibility of boats in Mongla	Inadequate safety equipment on tourism boats
Cordiality of boat captains	Lack of well presented system for hiring boats
Existence of Jaly boat association	Lack of availability of trained guides

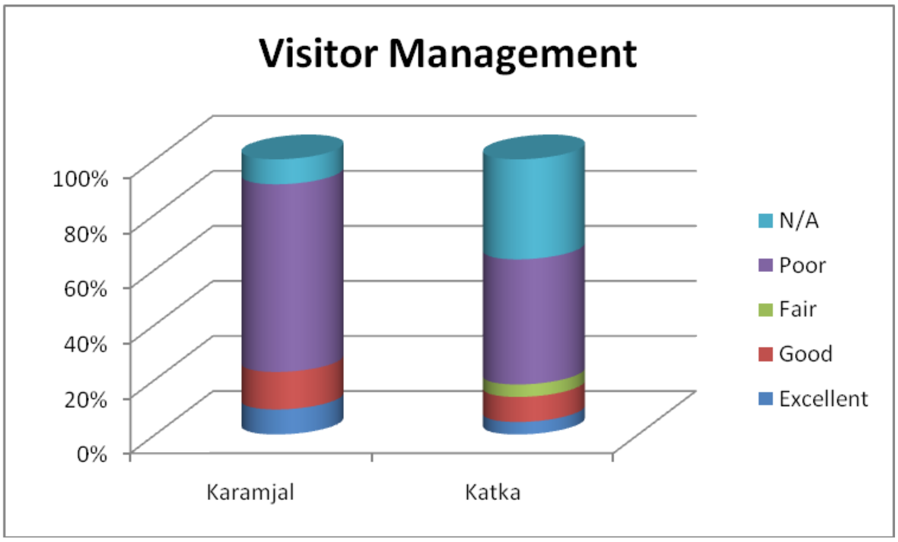
A summary of opportunities and threats is as below:

- Development of program for Jaly Boat operators via the association to develop booking system for boats, guide training, safety procedures, and customer servic
- The potential of a boating accident in Mongla is relatively high. There are inadequate safety procedures, and none of the boats are carrying enough life preservers or safety vests.

7.4 Visitor Management

This part of the data gathering was undertaken via observation and discussion with FD representatives in the Chandpai Range office which oversees, Karamjal – the primary domestic tourism destination in the Sundarbans with a 100,000 visitors annually, and Katka a primary destination for overnight, international and domestic tour boats, with 10,000 visitors. This section of the survey regarded the management steps taken by the FD to protect these tourism visitation sites. Standard and relevant visitor management questions were asked to FD officers in charge of Karamjal and Katka. The interview included questions regarding providing structured areas for visitation, crowd management, public use planning, entry fees, and the collection and return of fees to communities, tourism infrastructure and site protection. Because there are presently no policy provisions to allow the Forest Department to manage tourism as part of its budgetary process in any of the protected areas of Bangladesh, the results of these indicators are poor.

Figure 7.4: Vistor Management



In Karamjal, entry fees are being consistently collected, and the team observed that the ordinances to maintain noise at appropriate levels appear to be respected. There are visible guards and security on the scene and an effort to preserve fragile natural resources. However, there were no picnic grounds, no rain shelter, poor rest rooms, and virtually no waste bins. There was no recreation management plan on file and entry fees are not reinvested into communities, tourism infrastructure, or site protection. In Katka, there is less responsibility for collection of entry and license fees, and therefore more of the questions asked were not applicable. Many of the major concerns with visitor management in Katka, related to its vulnerability to cyclones and recent severe damage to buildings on this site caused by Cyclone Sidr.

The renovation of buildings was underway, and the new Forest Department guest house was virtually complete, though without furniture. The Forest Department officer was well aware that there are inadequate preparations for tourism at the site. A collapsing jetty was being held together with rough boards and twine. Despite the fact that the site was suffering greatly from a lack of investment, it did have a walking path and rain shelter. Noise restrictions are also enforced at this site, and there are guards and security on the scene. Guards check to ensure entry fees have been paid, but there is no reinvestment of entry fees in communities, tourism infrastructure or site protection.

A summary of strengths and weaknesses for visitor management is as below:

Strengths	**Weaknesses**
Guards & security present	No well structured areas for picnics
Noise ordinance enforcement	Poor rest rooms
	Poor waste management
	Dangerous jetties
	No visitor management planning
	No reinvestment of fees into area

A summary of opportunities and threats is as below:

- Review of policies for development of visitor management plans for key visitor sites in Sundarbans, including Katka & Karamjal using expertise of Forest Department officers working on site.
- Cooperation with private sector to develop more appropriate facilities, in public/private management approach – or licensing visitor sites to private sector for development, revenue gathering and reinvestment into sites.

7.5 Eco-tourism Impacts

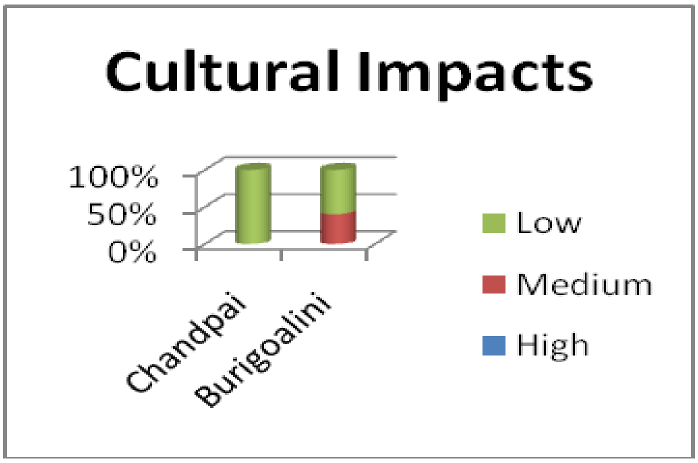
Main adverse impacts of eco-tourism in the SRF could be as below:

- Real possibility of accidents caused by poor visitor facilities, such as dangerous jetties
- Creation of vicious cycle of destruction of visitor sites and poor attitudes from visitors who do not learn to respect the places they are visiting, due to lack of visitor management

In order to assess community benefits the team visited Chandpai in the Eastern Sunderbans and Burigoalini in the Western Sundarbans to observe questions of community benefits from tourism to the SRF. Both communities are located in the landscape zone sites directly adjacent to the reserve. Seven community members were interviewed by the data gathers in Chandpai. All were identified as individuals who have worked with visitors. Chandpai did not have data on the number of visitors to the village, and all agreed the numbers visiting are low. All community members interviewed agreed that their ability to combine tourism income with other sources of local livelihoods is excellent. The individuals contacted were all living at the poverty line, with income roughly at 200-250 Taka daily. In more than one instance the team uncovered severe problems with villagers' ability to feed their families. All villagers were 100% dependent on the harvest of resources from the Sundarbans, and according to the team most were doing so in large part illegally.

To assess cultural impacts the women in Chandpai and Burigoalini were asked if tourism has caused an invasion of privacy, if there have been cases of harassment, any interruption of prime livelihood strategies, increased crime or increased begging. Interviews in Chandpai indicated that women are very poor, surviving on illegal fry and wood collection. Wood collectors are earning just 20-30 Tk per day, and women report the FD seizes wood or restricts illegal fry collection, as both activities are against regulations in the reserve. Tourism is a positive new income source for these women, in desperate circumstances. Women in Burigoalini are more culturally conservative and are less likely to leave home for any purpose. A growing number of female visitors come to their homes to use the toilet. This was judged to be an invasion of their privacy.

Figure 7.5: Cultural Impacts

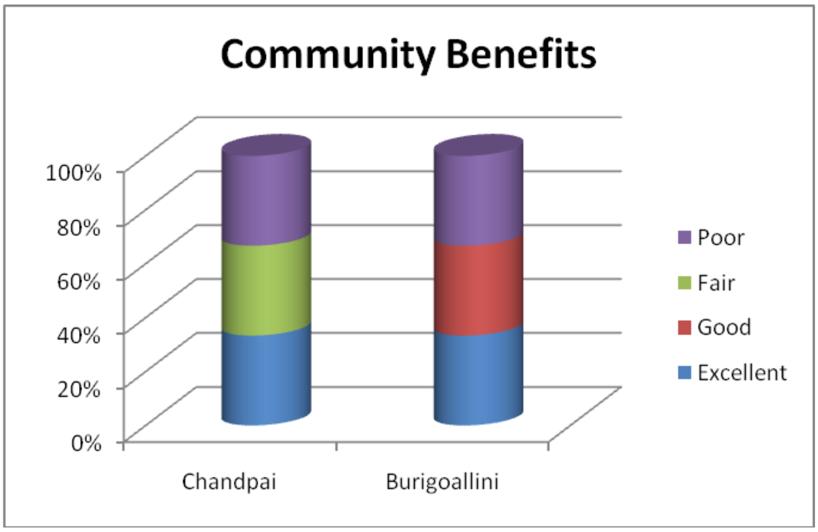


The opportunities and threats are summarized as below:

Opportunities	Threats
Work with women to develop toilet facilities for women visitors at a reasonable price	Growing invasion of privacy due to lack of toilet facilities

The community members interviewed reported that their income was considerably enhanced during the 2-3 month tourism season. The retailers roughly double their monthly earnings in tourism season, as does the van driver. The guide has found he earns more as a guide during the 2-3 month season than as a day laborer for the Forest Department. The team rated the opportunity for community members to combine tourism income with local sources of livelihood as excellent in Chandpai.

Figure 7.6: Community Benefits



There had been no training opportunities made available to the community for tourism related skills according to all those interviewed. This is a missed opportunity and was considered a weakness.

When asked if micro-enterprise linkages had been improved through community sales opportunities to tourists, the team learned that no villager was presently selling tourism related goods. However, the banana retailer, the pharmacist, and food vendor were all increasing sales during tourism season. Microenterprise leakages were rated as fair for Chandpai.

In Burigoalini, 8 community members were interviewed : Once again, the ability of community members to combine tourism with local sources of livelihood was found excellent. The micro-enterprise linkages to tourism were rated as good in Burigoalini. According to FD officials 10,447 visitors came to Burigoalini in the 2007/2008 season and paid the entry fee to visit the SRF. Similar to Karamjal and Katka, the actual visitor numbers could be double, if the figure were to include those who do not pay the entry fee. Burigoalini, is the gateway for the Kalagachia Forest Department rest stop which has tourist facilities, and it is the starting point of the world famous honey collectors, who have attracted global press attention when they depart each year on April 1 to collect honey in the SRF. The baseline average income in Burigoalini appears to be at the poverty line or 150 Taka a day and most of the individuals interviewed were doubling their incomes from November – March annually with tourism sales.

The trawler society member ferries tourists from November to March, doubling his income during tourism season – from 150 to 300 taka a day. The van driver also doubles his income. The local hotel receives more visitors to eat at their restaurant during the winter-pre-monsoon season. There has been some effort on the part of NGOs to increase local livelihoods from tourism and honey sales. This appears to be paying good dividends and should be studied further – with some impressive returns on honey sales in particular. The local women's cooperative renting mud stoves is also a profitable venture that is reaping good rewards. The street vendor appears to be doing poorly considering the number of visitors, but this represents a potential opportunity.

Overall, the team was impressed with how well community members were benefitting from tourism, considering there had been no training and very little effort to improve their livelihoods to date. The types of businesses that are thriving were broad based – as tourism benefits do not have to be generated by tourism businesses alone – such as transport and hospitality – the supply chain for goods extends to food goods, water, pharmaceutical supplies, & specialty items for picnicking, and local honey.

A summary of strengths and weaknesses for community benefits is provided as below:

Strengths	Weaknesses
Entrepreneurial microenterprises in place	Lack of training in communities
Community capacity to combine tourism income with other sources of livelihood	Tourism income only from Nov-March

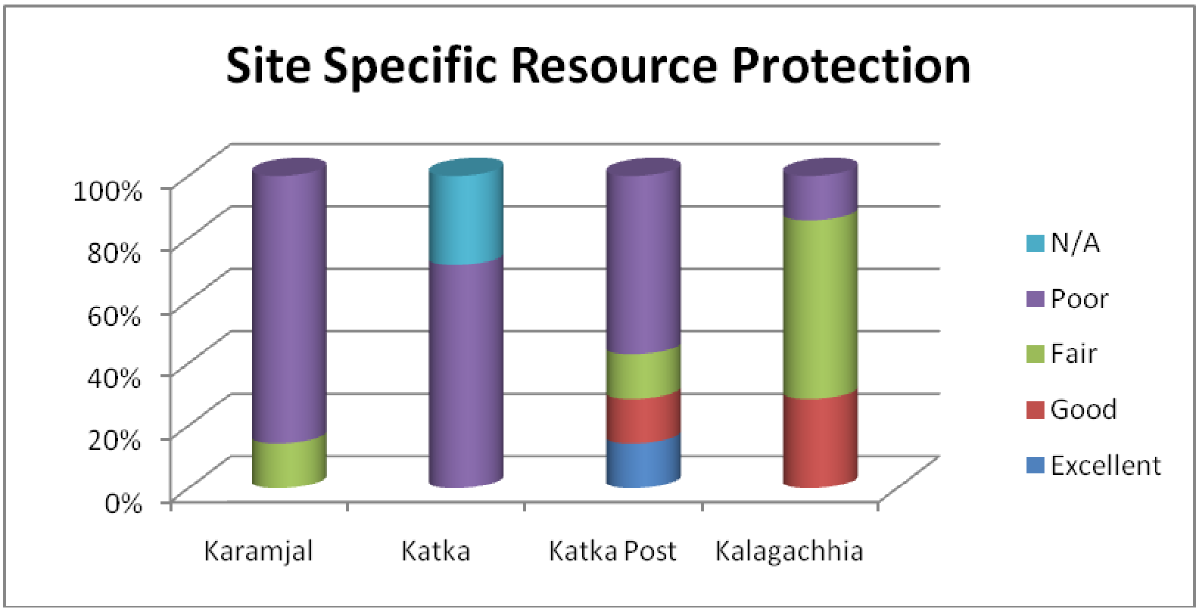
A summary of opportunities is as below:

- Training for community members to develop more effective tourism enterprises
- Guide training for community members to work in SRF
- Microenterprise financing to create more well-financed local microenterprises targeting domestic visitors

7.6 Site Specific Resource Protection

This section looks at specific actions taken by the Forest Department to protect tourism sites from visitor impacts. Important tourists spots in the Sundarbans include : Karamjol, Chandpai, Sarankhola, Harbaria, Katka, Kochikhali, Kalagachia, Nilkomol, Dubla, Alor-Kul, Shekhertek, Mandarbaria, Notabenki, Dobenki, Mirigamari and Jamtala. The review of resource protection was broken down according to the specific visitor sites the team visited. The overall threat of tourism to the SRF was judged to be low. In all sites, the team looked at the prevention of impacts on fauna, erosion, sewage run-off, waste/littering, impacts on flora, impacts on water quality, and excessive noise.

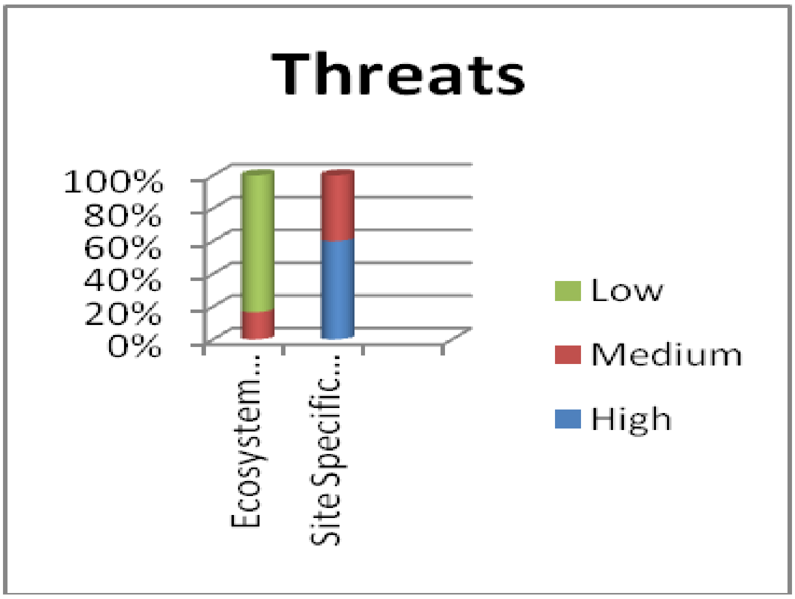
Figure 7.7: Site Specific Resource Protection



The impact of tourism on the Sundarbans ecosystem is currently very limited. Tourists are visiting a very low percentage of the reserve and therefore are not an important threat to the ecosystem. However, the threat of physical impacts on specific tourism sites is high or medium. In Karamjal, the team judged efforts to prevent all of the above impacts to be poor, except for excessive noise. There were clear examples of tourism impacting fauna – wild spotted deer were being fed junk food from the snack food stand. Erosion on the bank where boats land was clearly a problem. The team observed overflowing septic tanks and leakages with drains connected to the river. Litter was abundant, with bottles, packets, cigarettes and other trash on the ground. There was graffiti on trees, and branches were being broken off for tourists to play with. There were no personnel allocated to handle these problems. The visitor center, was a small area with little or no information.

In Katka, where the hike to the beach took place – there was little evidence of the same problems, but neither were there any preventative programs in place. There were no toilet facilities and erosion did not appear to be an issue, making these points not applicable. In Katka Forest Camp, the overall condition of the site is degraded by its vulnerability to cyclones. The team felt the site needs regeneration work and that enrichment planting of keora and gewa seedlings would be beneficial to preserve the area. Unlike Karamjal, there was reasonable sewage treatment and low impacts on water quality. The team also was not able to observe problems with excessive noise, but further observation might be necessary on this subject. In Kalagachia, more efforts to manage the site were evident, such as waste bins, reasonable toilets for visitors with low impact on water quality. The site showed greater consideration of preventing visitor impacts by a small degree and was judged good or fair compared to the other locations.

Figure 7.8: Threats



A summary of strengths and weaknesses for site specific protection is provided as below:

Strengths	Weaknesses
Enforcement of the noise ordinance	Impacts on flora & fauna in Karamjal
	Waste/littering in all sites
	Sewage run-off in Karamjal

Summary of Opportunities

- Creation of appropriate infrastructure for visitors including properly functioning toilets with acceptable septic systems, provision of waste bins and collection of waste

- Improvement of visitor center
- Training of guides in Mongla or Chandpai to accompany visitors in Karamjal
- Education of tourists in visitor center and by guides to protect natural resources
- Training of guards to request the visitors do not feed animals or harm trees

Summary of Threats

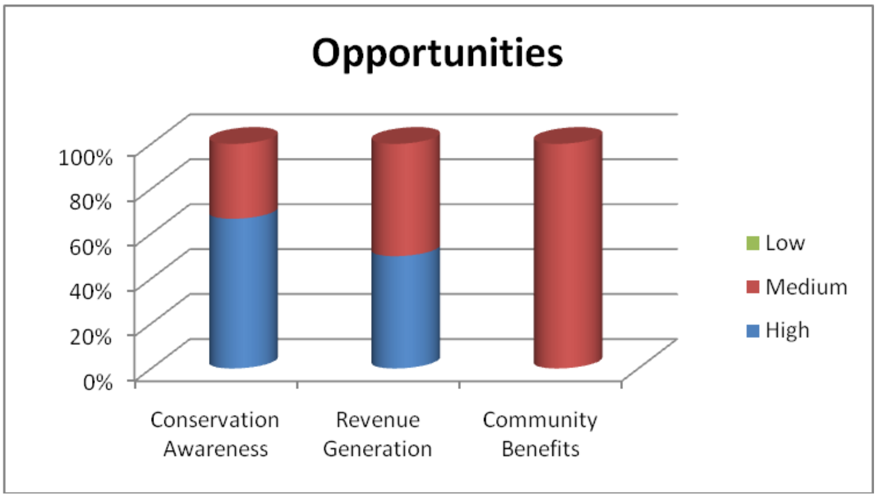
- Escalating damage to Karamjal creating unsanitary, eroded facility without proper provision for rapidly increasing numbers of tourists coming annually

7.7 Main Recommendations for Promoting Eco-tourism

Based on a stakeholders consultation on the opportunities for eco-tourism to improve conservation awareness, generate more revenue, and provide more community benefits in the Sundarbans, the following recommendations are made. The opportunity to raise awareness of domestic travelers is very high and should be pursued as a priority. There are no local guides presently working on the local tourism boats and there has been no guide training in the Mongla region, where the majority of domestic tourism transpires. The existing interpretation centers at Khulna and Mongla need to be improved and better promoted, and the visitor center at Karamjal needs an overhauling. A special section on mangroves and their role in climate change mitigation and adaptation may be added.

The opportunity to raise conservation awareness of international visitors was perceived to be a lower priority, as most arrive already with a high environmental awareness. The publicity of the Sundarbans should be improved for propagating biodiversity conservation, environment and wildlife, and the cause of its habitat by employing both electronic and print media. Schools and colleges will be targeted for conservation education and building an informed constituency. Conducting talks, essays writing and competition will be included in local schools as a part of publicity campaign. Green Brigades (Sabuj Vahinis) and Nishorgo (Youth) Clubs will be formed and trained in nearby schools and madrasas. Professional publicity and communication personnel will be engaged for such tasks. At the community level, conservation awareness has to be tied to revenue generation for local livelihoods. Nature interpretation will, as an educational activity, focus on revealing meaning and relationships of the Sundarbans ecosystems, biodiversity and landscapes.

Figure 7.9: Opportunities



The opportunity to increase revenue for conservation was deemed to be very high, given the entry fees being generated and the number of tourists visiting key tourism sites. The barrier to generating more revenue for conservation is clear, and well-known. The FD presently submits all entry fee revenue to central treasury and the approved entry fee policy has not yet been implemented in the Sundarbans. The entry fee sharing with the CMCs as per the approved guidelines should be immediately implemented. The opportunity to increase revenue generation for border communities was considered to be good, remembering that the tourism season is only 3-4 months a year and cannot become a full-time activity for community members. In addition, the severe problems with resource protection at existing eco-tourism sites would make any large scale efforts to increase revenue generation to communities a problem for the protection of tourism sites already under great threat.

Eco-tourism does not make a serious contribution to the revenue required for the millions of stakeholders dependent on the Sundarbans ecosystem. However, in specific border communities the opportunity to generate more revenue appeared to be good. For example in Mongla, hundreds of buses are arriving and the community remains poorly organized to take full advantage of this economic opportunity. Much more could be done to enhance local revenue generation opportunities in Mongla. Increasing the capacity of the border communities to provide goods to tourists is equally important. The results of the team's community benefits SWOT showed clearly that food vendors and pharmacists are also important recipients of tourism expenditures. It is therefore important to develop a full complement of goods and services, which domestic travelers are seeking in small border villages.

The opportunity to increase community benefits is high, and more can be done to develop border community's rights to undertake activities that can support their families. At present nearly all community members interviewed are willing to have access to resources for protection based on an equitable benefits sharing arrangement. Some gathering and harvesting of natural resources is an integral part of border community's livelihoods for their subsistence consumption. Enhancement of their destitute livelihoods based on appropriate activities via eco-tourism seem to be the appropriate answer to these problems. In addition to limited gathering of some identified NTFPs in the buffer zones where local people can legally harvest what is required to survive, eco-tourism would provide a fine complement to these activities. Without this solution, tourism will only be helping local people engaged in illegal harvest activities in the reserve to survive. In towns like Mongla or Burigoalini, where a broader range of legal activities are taking place, it would be very appropriate to increase activities to improve the full range of community benefits, which can also include access to education, communication technologies, health care, and transportation. A summary of the identified strengtsh, weaknesses, opportunities and threats is given in Table 7.1

Table 7.1: The summary of Strengths, Weaknesses, Opportunities & Threats

Information Accessibility	
Strengths	**Weaknesses**
• Khulna Tour Operators • Mongla small hotels & private museum	• Parjatan Corporation information in Dhaka • Khulna Sundarbans Forest Information Center. Khulna Hotel Information on Sundarbans • Lack of guides for domestic visitors
Opportunities	**Threats**
• Improved websites for specialist tour operators with offices in Dhaka • Improved Visitor Center in Khulna via small investment in Sundarbans Forest Information Center • Improved guiding services for domestic visitors • Improved information provision from hotels in Khulna	Not Applicable
Domestic Tourism Boat Transportation	
Strengths	**Weaknesses**
• Accessibility of boats in Mongla • Cordiality of boat captains in Mongla • Existence of Jaly Boat Association	• Inadequate safety equipment on domestic tourism boats • Lack of well presented system for hiring boats with consistent pricing in Mongla • Lack of available trained guides
Opportunity	**Threats**
• Development of program for Jaly Boat operators to develop booking system for boats, guide training, safety procedures, etc	• Accidents or even deaths caused by a lack of safety procedures & equipment
Visitor Management	
Strengths	**Weaknesses**
• Guards & security present • Noise ordinance enforcement	• No well structured areas for picnics • Poor rest rooms • Poor waste management • No visitor management planning • No reinvestment of fees into area
Opportunities	**Threats**
• Visitor management plans for key visitor sites in Sundarbans, including Katka & Karamjal using expertise of	• Real possibility of accidents caused by poor visitor facilities, such as dangerous jetties

Forest Department officers working on site. • Cooperation with private sector to develop more appropriate facilities, in public/private management approach – or licensing visitor sites to private sector for development, revenue gathering and reinvestment into sites.	• Creation of vicious cycle of destruction of visitor sites and poor attitudes from visitors who do not learn to respect the places they are visiting, due to lack of visitor management
Community Benefits	
Strengths	**Weaknesses**
• Entrepreneurial microenterprises in place • Community capacity to combine tourism income with other sources of livelihood	• Lack of training in communities • Tourism income generated only Nov-March
Opportunities	**Threats**
• Training for community members to develop more effective tourism enterprises • Guide training for community members to work in SRF • Microenterprise financing to create more well-financed local microenterprises targeting domestic visitors	• Revenue generation from tourism may help to support border community livelihoods that are entirely dependent on illegal harvest of resources in SRF, while not replacing these activities due to seasonal nature of tourism business.
Site Specific Resource Protection	
Strengths	**Weaknesses**
• Enforcement of the noise ordinance	• Impacts on flora & fauna in Karamjal • Waste/littering • Sewage run-off Karamjal • Erosion Karamjal
Opportunities	**Threats**
• Creation of appropriate infrastructure for visitors including properly functioning toilets with acceptable septic systems, provision of waste bins and collection of waste • Improvement of visitor center • Training of guides in Mongla or Chandpai • Education of tourists in visitor center and by guides • Training of guards	• Escalating damage to Karamjal creating unsanitary, eroded facility without proper provision for rapidly increasing numbers of tourists

Based on the findings as above it would be wise to focus on creating a more sustainable environment for domestic eco-tourists, with better facilities, guides, and opportunities to purchase goods offered by border communities. In Khulna, the Sundarbans Forest Information Center represents an excellent opportunity, with minimal investment to bring back to life a good interpretation center, at an important gateway. The good maps would attract visitors almost immediately to this underused site. A small investment in the existing projection system would make it possible to once again offer the interpretative video – a simple means of attracting more visitors as well. With these small investments, possibly in cooperation with the Khulna tour operators, it is likely that hotels and tour operators would begin to refer their visitors to the Information Center, a highly important tool to educate visitors.

A nature tourism circuit/region will be identified in and around the Sundarbans by linking with other local and regional attractions including Bagerhat where the Sat Masjid is another World Heritage Site. More hiking trails will be identified and brochures developed by highlighting attractive places for eco-tourists. Guided tourism will be developed by developing a cadre of trained eco-guides by involving local unemployed youth. They will be trained on eco-tourism including identification of animals, birds and plants, local culture, biotic influences, etc. Involvement of co-management organizations will be sought in developing community based nature tourism. Local people will gainfully be involved in the management of eco-tourism including energy conservation, waste disposal, vehicle and visitors control, check posts management and entry fee collection. Relevant brochures, pamphlets, guide maps, handouts, audio-visual aids and display boards will be set up at convenient points. Code of Ethics and Conduct for visitors will be displayed along with information signage. Publication of Sundarbans photographs and books will be taken up along with the production of other promotional materials for eco-tourists.

Systematic efforts to create an appropriate tourism environment must come first. Opportunities to assist border communities, particularly those not entirely engaged in illegal harvest activities, appear to be very good. Suitable linkages will be established with the Parjatan Corporation and tour operators for developing eco-tourism in a way that the benefits accrue to local community. Community revenue generation programs in Mongla and Burigoalini have very good potential. Work with Jaly Boats in Mongla and their association offers the opportunity to generate a safer environment for tourism, better organized, that would generate not only more revenue but greater conservation awareness. Work with local shops and existing micro-enterprises in Burigoalini could help to improve their ability to generate revenue and provide an alternative livelihood to individuals who are suffering from landlessness and loss of opportunity caused by the growth of the shrimp farm industry in the region. Threats to the SRF are largely not caused by eco-tourism. While specific sites for eco-tourism, particularly Karamjal, are under extreme pressure – the overall threats and impacts on the Sundarbans ecosystem from tourism are slight. Nonetheless, the lack of infrastructure is acute in existing tourism sites, leading to threats of accidents, sewage pollution, erosion, and impacts on flora and fauna.

Eco-Tourism has important potential for growth in the Sundarbans, but excellent work by private tour operators has already taken advantage of much of the existing potential. While much more could be done, if more tourism sites were opened by Forest Department by enacting policies that allow for investment in management of eco-tourism with budgets and trained personnel, and appropriate infrastructure. However, tourists management inside the forests should be planned by FD in order to reduce the adverse impacts of tourism on the wirldlife and ecosystems but also ensure that eco-tourists are able to enjoy the wilderness.

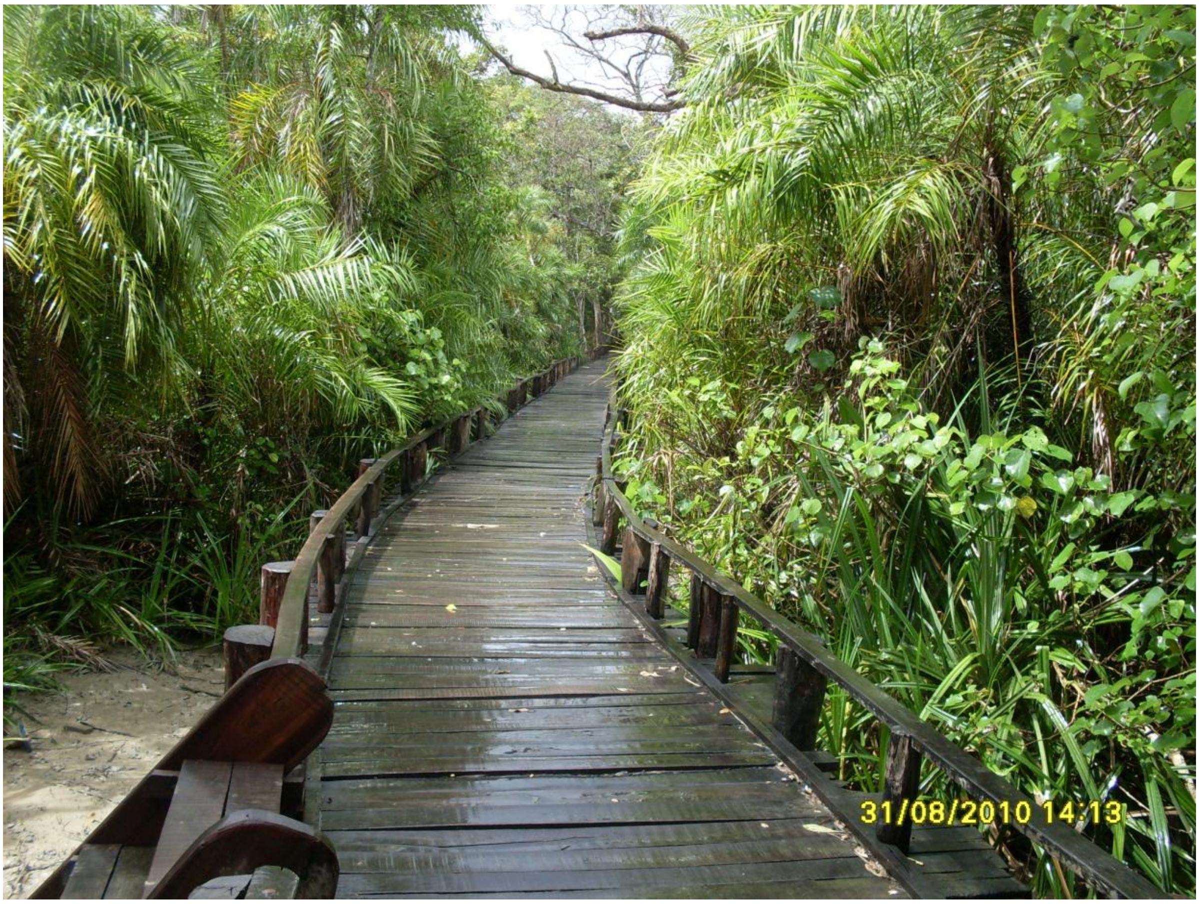
Private investors, if any, should coordinate with the relevant CMC and FD staff. The present system of entry fee collection and community benefits sharing being followed in other PAs such as Lawachara need to be replicated in the Sundarbans. Eco-Cottages and conservation-linked micro-enterprises, including providing services such as food and water to eco-tourists, can be set up by encouraging CMCs and local entrepreneurs who can be technically supported. In efforts to develop more revenue generation for local communities through CMCs, it is recommended that the approved entry fee guidelines should immediately be implemented in the entire SRF by associating the existing 2 CMCs and other 2 CMCs that are under formation. Small interventions in border communities are the best opportunity for gains. Efforts to organize gateways will create a better more informed environment for travelers and community members to begin to make tourism a positive contributor to their local societies, domestic travelers, and provide a more enhanced informational environment for international visitors.

7.6 Hiking Trails

In this section two hiking trails have been identified and described, but many such trails will be identified as part of the implementation of this Plan.

Karamjol Trail

One of the major entry points to the Sundarbans is Karamjol which is located about 5 km (approximately 45 minutes of boat ride from the Mongla sea port). Karamjol is a Forest Station where Forest Department has developed a number of facilities including a dear and crocodile breeding center under the SBCP. Mangrove arboretum, is particularly interesting for visitors as it gives a snapshot of mangroves vegetation. A wooden walkway (see as below) facilitates visitors entry into nearby forests where sometimes tigers come to take water and rest. Dolphins can be spotted in the Passur river on the way to Karamjol.



Under IPAC, trail mapping, brochure development and signage setup have been completed. Karamjol Trail, which starts at VIP Ghat, is about one kilometer. You will get elevated wooden trail here. On the way of wooden trail, visitors will see lot of sundari and bain trees. After walking for ten minutes, they will come across a seating shed, adjacent to a river. Visitors can observe natural scenery of Sundarbans including river, trees and wildlife. If visitors take the right side road with brick soling, they will see huge hental palms which is generally a site for tigers to take rest, and so one should be careful. After ten minutes walking and passing by sundari, bain and hental, visitors can turn right to reach to the crocodile breeding center where visitors can enjoy the crocodiles as well as nature. After a little walk the visitors can see a dear breading center. Within few minute of walk the visitors will reach at the river Ghat which is the end of this trail.

Harbaria Trail

Forest Department intend to develope Harbaria as an Ecotourism center. An elevated wooden trail, watch tower, seating arrangement, a pond, and a rest shed beside the river have been developed. Visitors can watch the tiger's foot prints in the nearby mangrove forests.

IPAC has developed a trail mapping, brochure development and signage setup. The identified trail starts from the river Ghat. Visitors can proceed towards the pond and pass by Forest Sattion office and nearby elevated bridge, and if turn taken right they will reach a watch tower and a brick soling trail. Visitors may like to walk up to the top of watch tower to see scenic beauty of the Sundarbans and upon return take elevated wooden trail to stroll with nature. After a shor walk the visitors will reach a big pond, a turn to left and a walk beside the pond will lead them adjacent to the elevated bridge which is the end of of Harbaria Trail.

7.7 Summary of Main Prescriptions

Main prescriptions outlined under the above-developed eco-tourism programs are summarized in Table 7.2 as below:

Table 7.2: Summary of Main Prescriptions: Eco-Tourism Programs

Yr	Main Activities	Main Outputs/Success Criteria	Responsibility
1 and 2	-Identifying eco-tourism areas within the core zone comprising the three wildlife sanctuaries and regulate visitors movement	Eco-tourism areas identified and regulated	FD/CMCs
	-Identifying eco-tourism areas within the buffer zone and regulate visitors movement	Eco-tourism areas identified and regulated	FD
	-Designing and developing basic eco-tourism facilities for tourists	Minimum tourist facilities are in place	FD/CMCs/ Tour Operators
	-Identify flagship attractions (tiger, dolphin) and their viewing sites	Identified flagship species and sites	FD/CMCs/ Tour Operators
	-Identifying suitable sites for nature camps	Possible sites for 1-2 days nature camps identified	FD/CMCs
	-Designing and preparing publicity materials including pamphlets, bill boards, brochures and maps for raising awarenes	Publicity material developed	FD/CMCs/ Tour Operators
	- Identifying and training eco-guides	Eco-guides identified and trained	FD/CMCs/ Tour Operators
	-Developing and propagating conservation awareness and education, and nature interpretation through electronic and print media	Conservation awareness program developed	FD/CMCs/ Tour Operators
	-Identifying and motivating students and volunteers (Sabuj Vahini) for biodiversity conservation	Number of schools identified and students motivated	FD/CMCs/ Tour Operators
	-Strengthening existing & establishing Nature Interpretation Centres (NICs)	Existing NICs at Karamjol and DFO(W) office strengthened & new ones established	FD/CMCs/ Tour Operators
	-Identifying and mapping existing nature and hiking trails	Existing trails mapped and brochures prepared	FD/CMCs/ Tour Operators
	-Establishing regular contacts with relevant ministries and departments for inter-sectoral eco-tourism planning & promotion	Relevant ministries and departments including Parjatan contacted & coordinated	FD/CMCs/ Tour Operators
	-Developing a policy on public-private conservation partnership	Public-Private partnership policy drafted	FD/MOEF/ Tour Operators
	-Implementing entry fee guidelines through CMCs	Entry fee collection is in operation	CMCs/FD
	-Implementing facility and community	Built facilities and community	CMCs/FD

	development works by using entry fee revenue allocated by FD to CMCs	assets	
	-Developing local stakeholders as service providers (food vendors, transport agents, etc.) to visitors	Food Vendors and other service providers in place	CMCs/Tour Operators
3 & 4	-Eco-Tourism areas shown on maps and brochures developed	Tourism sites and routes publicised	FD/CMCs
	-Regulating eco-tourism within the SRF	Regulated Tourism	FD
	-Expanding basic picnic facilities for tourists	Expanded tourist facilities	FD
	-Expanding suitable sites for nature camps	Expanded sites for 1-2 days nature camps	FD
	-Widely distributing publicity materials including pamphlets, brochures and maps	Publicity material reaches widely	FD/CMCs/ Tour Operators
	- Refresher training imparted to eco-guides	Trained Eco-guides	FD/CMCs/ Tour Operators
	-Expanding conservation awareness and education through electronic and print media	Aware stakeholders	FD/CMCs/ Tour Operators
	-Continue motivating students and volunteers for biodiversity conservation	Number of students motivated	FD/CMCs/ Tour Operators
	-Expanding Nature Interpretation Centre (NIC) network	Expanded NIC network	FD
	-Expanding nature and hiking trails	Expanded trails network	FD/CMCs/ Tour Operators
	-Expanding cooridination with relevant ministries and departments including Parjatan	Relevant ministries and departments pursued and coordinated	FD/CMCs/ Tour Operators
	-Expanding public-private conservation partnerships	Expanded Public-Private partnerships	FD/CMCs/ Tour Operators
	-Continue implementing entry fee guidelines through CMCs	Entry fee collection is in operation	CMCs/FD
	-Continue implementing facility and community development works by using entry fee revenue allocated to CMCs	Built facilities and community assets	CMCs/FD
	-Expanding the network of local stakeholders as service providers (food vendors, transport agents, etc.) to visitors	Expanded network of service providers	CMCs/ Stakeholders
5 To 10	Continue as in case of the years 3 & 4, and evaluate in the year 5 to implement adjusted programs by consolidating gains		

8. Facilities Development Programs

The development and maintenance of facilities is needed to support the long-term administration and management of the SRF. A recommended list of sites that should be considered for future site development and suggested priorities needs to be identified. However, development of new infrastructure will take years of understanding what works and what does not. Wildlife inventories needs to be conducted to orient tourist activities and restrict areas at certain times of the year. A description of each element, feature and component that are needed for a positive eco-friendly experience and their spatial relationships with one another needs to be provided. Also needed for each element, feature, component is a brief set of architectural characteristics that, if followed, will give the SRF a true and unique “sense of place”.

A schematic representation of infrastructure development for destination sites and a generic layout of a typical destination site that could be adapted to other sites is needed. A detailed site plan of important eco-tourism sites including Karamjal site is necessary but inventories and condition surveys must be completed at each site before a detailed site plan can be completed and recommended. In addition to built facilities, this program will also focus on the procurement of transport and other equipments required for the plan implementation.

8.1 Program Objectives

Main objective of this program is to improve the image, aesthetics, function and overall quantity and quality of the infrastructure including eco-tourism facilities in the Sundarbans Reserve Forest. One of the ancillary objectives of the infrastructure development is to minimize the impacts of the activity while maintaining the setting for the staff, visitor and wildlife. This includes litter, water pollution, economic inequity and instability, any long-term social and cultural changes of the population.

8.2 Sundarbans Infrastructure

A brief review of the existing facilities and future development scope is provided in this section but a detailed review of the eco-tourism infrastructure is given in subsequent sections.

8.2.1 Drinking Water and Food Supply

In the Sundarbans the only sources for fresh drinking water are pond water and rainwater. As rain water is safe and easy to collect, there should be facilities for harvesting and storing rain water in each Camp, Station and Range. Depending upon the number of manpower at each post, types of rain water collection systems can be developed. In the past, ponds have served as a main drinking source. However, pond water is contaminated with algae, plankton and diahoreal causing bacteria. Presently there is at least one pond or surface fresh water body at each post (3 to 4 Pond Sand Filter systems in some posts) but most of them need some maintenance or excavation or embankment reinforcement.

It is dangerous to drink directly from the pond water due to impurities and so a simple Pond Sand Filter (PSF) for the Ranges and Stations is suggested as a first solution to clear the turbidity from the water. This filtered water should then be boiled to ensure a bacteria free drinking water supply. A PSF requires regular maintenance and care, and therefore proper training is needed to maintain the systems properly. PSFs are recommended for Station and Range Offices only. For Camp Posts, Chulli Water Purifier is recommended for providing safe water. This locally developed technology, providing up to 25 litres of safe water an hour, is environmentally friendly as it utilizes the heat from the Chulli created while cooking and so no additional energy is required.

Food cost is currently being paid for by the staff in all field Posts. A major constraint for Post staff, particularity the more remote Posts, is their ability to get their food and in most cases, the staff has to abandon his duty for some period to travel to a village market to buy his food. Some type of system should be developed to accommodate the field staff in this regard. This may mean a simple weekly delivery from a FD boat or vehicle, etc. Of course, this may require a slightly higher fuel consumption for the providing transport source, but should be strongly considered in order to relieve this unnecessary burden on the field staff.

8.2.2 Power Needs and Supply

None of the posts has access to mains electricity supply. A limited number of generators in some Range Offices and Stations are available, but most are older models and so require frequent maintenance and repair. The older generators available in some Posts are not able to provide adequate power supply based on their requirement. Though 4 to 5 solar energy systems are existing, most have been heavily damaged by the recent storms and cyclones. There is a need for a generator providing adequate power output for current needs and also anticipating coverage of potential future requirements, for the Range and Station Posts only. The Range and Stations can have a solar energy system, whereas a solar power system can be installed for the Camps. This is the most efficient and cost effective configuration available as all Posts will operate on the low maintenance solar systems for their day to day electrical needs and the generators will only be used when mains power is not available. Moreover, using solar energy as a power source is environmentally friendly

8.2.3 Stoves

All Posts should have their cooking Chulli fitted with the Chulli Water Purifier. This modification will ensure 100% bacteria free, safe water and with no additional energy requirement. Currently, all Posts use Chulli for cooking their food two to three times per day. With a safe water output of 25 litres per hour, this system can provide up to 75 litres of bacteria free drinking water per day.

8.2.4 Medical Support

A "First Aid Kit Box" should be provided for all Posts. A qualified Hospital/Clinic or the International Red Cross/ Red Crescent should be consulted for developing the specifications for each First Aid Kit based on location and remoteness of the Posts. In addition, First Aid training should be provided to some selected FD Field Staff. It is important that a trained person (e.g. Forest Guard) is available at every Post. This training will be available through some NGOs as well as the International Red Cross / Red Crescent. In the event of occurrence of serious injury to Posts Staff, a Special Team will rescue the victim to the mainland for proper medical care.

8.2.5 Accommodation Facilities

Most structures established at different Posts (Table 8.1) are made of wood or bamboo with CI sheet or thatch roofing and so are not suitable for the extreme weather conditions of the Sundarbans. In the last two years, the Sudarbans was devastated by two cyclones and almost all temporary buildings were severely damaged. The existing temporary buildings are in crucial need of maintenance and repair. There are some permanent buildings in some Range and Station Offices. These have not been well maintained and some need complete renovation, whereas others are salvageable through maintenance. There are some permanent structures currently abandoned for last few years but can be renovated to serve as a working facility. New structures to be built in the SRF should be permanent ones, developed on raised platforms swith concrete construction. Properly built concrete buildings, as detailed below, will be structurally sound, to be able to withstand severe weather conditions; they will also be more cost effective and will require less maintenance over a longer period of time:

For Ranges:

Total Staff	Accommodation for 30-38 persons
Space Requirements	Office + Barrack, 2876 Square feet
Type of space	Range office, Assistant’s Room, Wireless operator room, Other office space, rest room, store room, custody room, toilet, common space, staff accommodation, kitchen, dining room.

For Forest Stations:

Total Staff	16-18 persons
Spaces needed	Office + Barrack, 2282 Square feet
Station office	1000 Square feet
Type of space	Station Officer office, Assistant's office, other office space, rest room, store, custody room, toilet, common space, FG bed room, BM bed room, kitchen, dining room.

For Camp:

Total Man power	16-18 person
Spaces needed	Office + Barrack, 2282 Square feet
Camp office	1000 Square feet
Type of space	Camp Officer's office, other office space, rest room, store, custody room, toilet, common space, FG bed room, BM bed room, kitchen, dining room.

8.2.6 Facility Maintenance

Each Range Office will have one existing staff member, (who is mechanically adept and has a good general overall knowledge of mechanics and electrical maintenance) designated as responsible staff for building maintenance. He would follow a regular schedule of visits to the Stations and Camps to conduct preventative maintenance, such as changing the crankcase oil in the generators, changing spark plugs, tunning, etc. This routine, if followed regularly, will dramatically decrease the need for major repairs in the future. However, major repairs, required after warranty, for buildings, fixtures and equipment, must be provisioned in the annual budget.

8.2.7 Renovation of Existing Facilities and Development of New Facilities

Existing facilities including offices and residential building need to be renovated and maintained and the details including inputs and budget have been included in Chapter 11. Similarly a number of new office and residential buildings are proposed to be constructed particularly under the SEALS and such details have been included in Chapter 11 based on the information adaopted from the approved DPP of SEALS. Other facilities including Jetty, PSF, RWHS, Chulli and ponds have been included in Chapter 11.

Table 8.1: Current type, Condition and Number of Buildings

	Concrete															Wood/tin														
	OFF					OFF/ACC					ACC					OFF					OFF/ACC					ACC				
Post	**1**	**2**	**3**	**4**	**T**	**1**	**2**	**3**	**4**	**T**	**1**	**2**	**3**	**4**	**T**	**1**	**2**	**3**	**4**	**T**	**1**	**2**	**3**	**4**	**T**	**1**	**2**	**3**	**4**	**T**
Amurbunia																						1			1					
Andharmanik																							1		1					
Baidyamari																							1		1					
Baraitala																						1			1					
Chandpai range							1			1			1	1	2															
Chandpai station																						1			1			5		5
Charaputia							1			1																				
Dhangmari												2			2			1		1								1		1
Dhanshagor camp																						1			1					
Dhanshagor station								1		1			1		1															
Ghagramari																						1			1					
Gulisakhali																							1		1					
Harbaria		1			1																							1		1
Harintana																							1		1					
Jewdhara																							1		1			2		2
Jongra						1				1																	1	1		2
Khatakhali																							1		1					
Lawdobe																						1			1					
Nandabala																						1			1					
Nangli																							1		1					
Pashur river SP boat																														
Andarmanik																							1		1					
Baniakhali station							1			1		2			2			1		1								2		2
Bhodra							1			1																				
Bhomorkhali																								1	1					
Bojbaja																						1			1					
Hadda							1			1																		1		1
Kalabogi station							1			1			2		2								1	1	2					
Kassiabad station	1				1							3			3													1		1
Khasitana						1				1																		1		1
Khulna range	1				1						1	2			3													1		1
Koyra																							1		1					
Nalian station	1				1							3			3															
Nilkomol												1	8		9													2	2	4
Patkosta							1			1																				
Shibsa																							1		1					
Shibsa SP boat																														
Shorbat khali																			1	1									1	1

Sutarkhali												2			2		1			1										
Alorkel camp																														
Bhola																							1		1					
Bogi station							1			1																	1			1
Chandeshar																							1		1					
Charkhali																							1		1					
Desherbharani							1			1																				
Dubla												1			1													1		1
Dumuria																						1			1					
Gyanpara sp boat																							1		1					
Katka							1			1			5		5															
Kochikhali							1			1			5		5								2		2			2		2
Kokilmoni								1		1																				
Sannyasi sp boat																														
Sarankhola range		1			1							1			1			1		1										
Sarankhola station																		1	1	2			1		1					
Shapla				1	1																		1		1					
Shelar char																														
Supati station						1				1												1			1			1	2	3
Burigoalini station														1	1		1			1								2		2
Chunkuri						1				1																			1	1
Dobeki																							1		1					
Kadamtala station						1				1			2		2														1	1
Kalaghachia												2			2								1		1					
Kobadak station							1			1			1		1													1		1
Koikhali station							1			1		1			1			1		1			1		1					
Morgang																								1	1					
Munshigonj																							1		1				1	1
Notabeki							1			1		3	5		8															
Puspakhati							1			1		1	5		6															
Satkhira range												2			2		1			1							1			1
TOTAL	**3**	**2**	**0**	**1**	**6**	**5**	**15**	**2**	**0**	**22**	**1**	**26**	**35**	**2**	**64**	**0**	**3**	**5**	**2**	**10**	**0**	**10**	**23**	**3**	**36**	**0**	**3**	**25**	**8**	**36**

		functional and not in need of repair	functional and in need of repair	non-functional and in need of repair	non-functional and irreparable.	TOTAL
Concrete building	Office Building	3	2	0	1	**6**
	Office cum accom Building	5	15	2	0	**22**
	Accommodation only	1	26	35	2	**64**
Wood/tin building	Office Building	0	3	5	2	**10**
	Office cum accom Building	0	10	23	3	**36**
	Accommodation only	0	3	25	8	**36**

8.3 Present Status of Eco-Tourism Infrastructure

Almost all the destination sites such as Karamjol, Kochikhali and Katka are experiencing overcrowding and being overrun with tourists and the infrastructure is limited in many such places or non-existent in other places. For instance, Karamjal has reached its carrying capacity and the infrastructure cannot handle current visitor use. Demand for eco-tourism sites is increasing rapidly but a very limited supply of destinations is hindering visitation. Many sites have reached their resource capacity and plants and animals are being affected adversely. Current strength of the FD field staff is unable to control/manage current visitor use as they are not trained to deal with tourists.

Currently the visitation is not dispersed equally and so there is a strong case for visitors redirected to other sites, where possible. The present management strategies (for entrance) are not effective and need to be reconsidered. Most administrative sites in the Sundarbans are currently not set with an infrastructure that will handle the amount of visitation it is currently receiving (not to mention the anticipated future demand) without harmful effects. Forest facilities were not designed or located with tourists in mind. As a result the safety of visitors and effectiveness of staff is compromised. Some of the existing problems (possible solutions listed in brackets) include impacts to flora and fauna (needing paths, hard surfaces); waste/littering (needing an appropriate waste collection system); sewage (provision for toilets); erosion (establishing jetties); noise (information panels/code of conduct); lack of adequate information (provide information panels/code of conduct).

While infrastructure development will help resolve these problems, it will not decrease the number of visitors who want to engage in eco-tourism. In fact, demand will rise as sites are developed for tourists. Forest Department in partnerships with the CMCs will have to address this demand through their entry fee structure and other management tools. Much more is required than the construction of a boardwalk or an observation tower to be able to attract visitors, domestic or international. The important question is not what facilities should be built but rather why should they be built and for whom. The supply of facilities in the Sundarbans currently exceeds the demand for use and that if the appropriate infrastructure is not constructed, visitation will continue to have a detrimental effect on this sensitive environment. There is a delicate balance that must be maintained between facilities and visitation because too much uncontrolled visitation will have a detrimental effect on the environment whereas too much development will change the Sundarbans natural ecosystem.

8.4 Eco-Tourism Infrastructure Development Priorities

Departure sites and destination sites are two different types of sites that will benefit from infrastructure development. The first are the “portal sites” which lie outside the Sundarbans. These are essentially transfer sites where visitors transfer from their land transports to water transports. The portal sites have a limited land base but provide an opportunity for the FD to orient visitors prior to departure. As people are here only for a short time, an information kiosk would be helpful. The other type of sites are the “destination sites” which are located in the Sundarbans at various distances from the portals. Length of stay varies from several hours to overnight boat accommodations. These are the sites where infrastructure will be most beneficial. These sites already have staff housing and offices but lack infrastructure for tourists. Conflicts arise when visitors unknowingly interfere with normal forest opportunities.

Destination sites can be further divided into two different types. “Day-trip destination sites”, that cater to the visitor looking for a part-day adventure and “Overnight destination sites” (usually greater than 25 kilometers), that are further south which require overnight accommodations and take more than one day to visit and return. Day-trip sites are characterized by being less than 25 kilometers from the northern boundary of the SRF and near a population base. Popular day-trip sites include Kalagachia, Karamjal, Harbaria, and Mirigamari, whereas the popular overnight destination sites include Katka, Kochikhali and Nikamal or Hiron Point. Accommodations for tourists visiting these sites require river-based overnight stays as no new land based accommodations will be constructed. Provision of such accommodations will be the responsibility of the tour boat operators.

Since infrastructure development at all sites will take many years to complete, this plan attempts to priorities those sites that will have the greatest initial impact on eco-tourism. Possible criteria for prioritization include:

1. Extent and condition of existing on-site facilities.
2. Existing demand and use.
3. Distance from departure point.
4. Clients served – day use or overnight.
5. Uniqueness.
6. Planned (or existing) Cyclone shelter.

Priority eco-tourism sites including departure and destination sites (Table 8.1 and Figure 8.1) and site-specific possible interventions are identified as below:

Priorities for Departure sites:

1. Mongla – take off for day use sites. Construct and install information board and/or Kiosks.
2. Khulna - Take off for overnight cruises. Construct and install information board and/or Kiosks.
3. Munshigonj - Construct and install information board and/or Kiosks.

Priorities for day-trip destination sites:

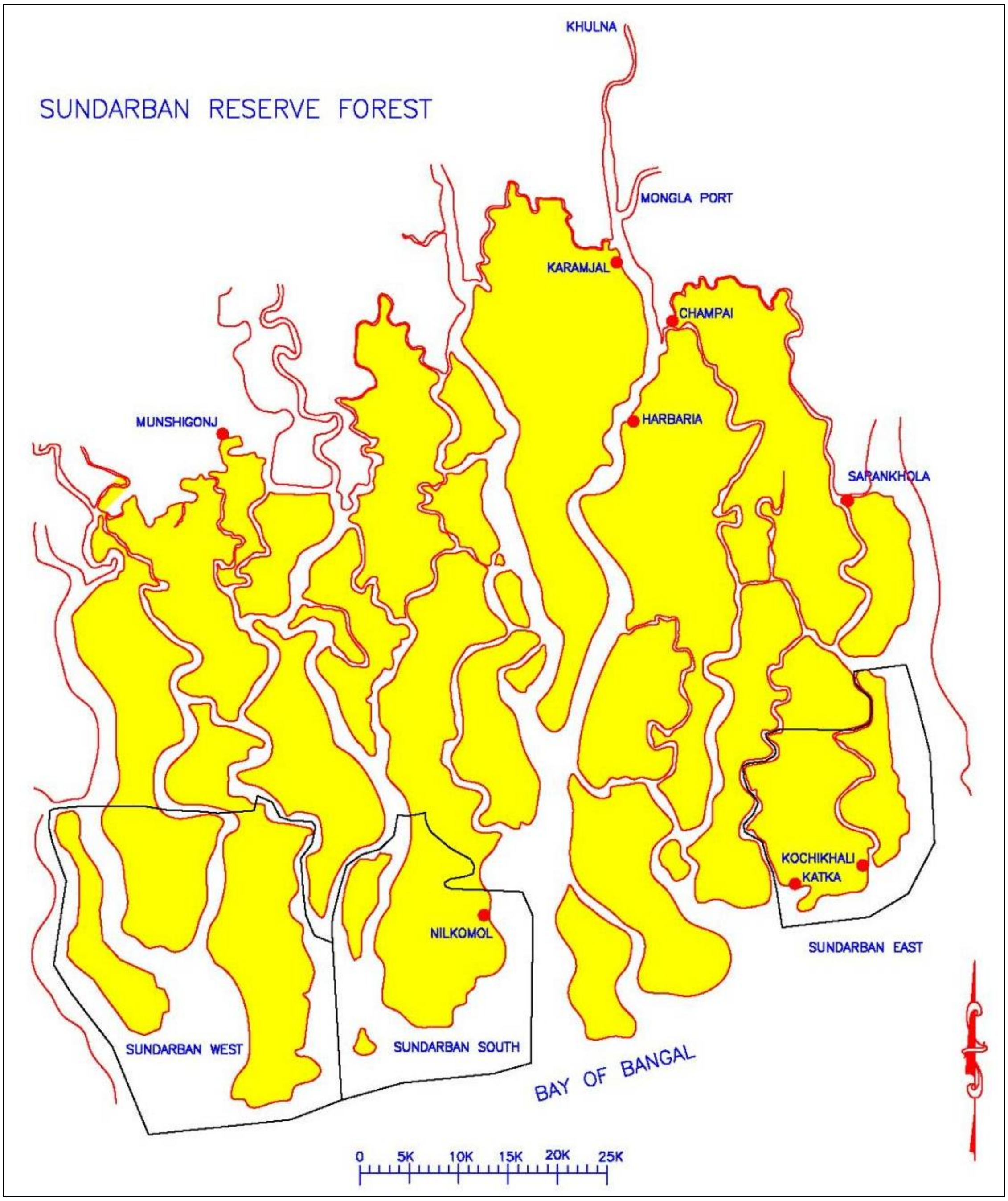
1. Karamjal - Of all the existing day-trip destination sites, Karamjal is the site that rises to the top for needed infrastructure development. Currently it receives 81% of all visitors to the SRF. It is about 5 km from Mongla port and currently experiencing overcrowding on weekends and some weekdays. It has the most developed visitor infrastructure of any site in the SRF including a jetty, trails, huts, concessions, and a captive breeding program for endangered crocodiles. It has a public toilet building but no shade/rain shelters or waste management programs.
2. Harbaria, an adjacent day-trip destination site, will take some of the visitor demand off this site, but Karamjal will always be in high demand because of its proximity to Mongla and the ongoing animal breeding programs.
3. Chandpai and Sarankhola
4. Kalagachia, 5 km from Munshigonj

Priorities for Overnight destination sites:
Katka – Overnight only (including the jetty at Jamatala)
Kochikhali
Nilkamal (Hiran Point)

Table 8.2: Priority Eco-tourism Sites

PRIORITIES	DEPARTURE SITES	DAY-TRIP DESTINATION SITES	OVERNIGHT DESTINATION SITES
PRIORITY #1	MONGLA PORT	KARAMJAL	KATKA
PRIORITY #2	KHULNA	HARBARIA	KOCHIKHALI
PRIORITY #3	MUNSHIGONJ	CHANDPAI SARANKHOLA	NILKOMOL
PRIORITY #4		KALAGACHIA	

Figure 8.1: Priority Eco-tourism Sites



8.5 Eco-Tourism Infrastructure Elements and their Characteristics

The overall character and appearance of infrastructure development should be based on the following principles:

1. Identify and develop places that provide a rich variety of experiences.
2. Design facilities that are subordinate to the landscape.
3. Build only what is necessary and environment-friendly.
4. Locate facilities in suitable places that are buildable, serviceable and maintainable.
5. Concentrate facilities to minimize their environmental impact.
6. Use a simple palette of materials and colors.
7. Use durable materials that have a strong presence and require little maintenance.
8. Conserve resources, especially fresh water.
9. Keep development away from significant natural and cultural resources.
10. Construct facilities that are as accessible as possible.

All facilities should be designed and built with accessibility in mind. The best way to integrate accessibility is to use the principles of universal design which means simply designing programs and facilities to be usable by all people and to the greatest extent possible. Each infrastructure element should be designed in such a way to provide the highest level of accessibility possible for the development level. Trails and paths should be built with a surface that is firm and stable. Accessible ramps should be provided where elevated facilities require stairs and signs should be designed and placed so that they are easily readable. If a program or information is provided inside a building or structure, everyone, including people with disabilities, should be able to enter the facility and participate in the program or receive the information. Some facilities, by their very nature, such as jetties, may not be able to be built fully accessible. If a facility or structure cannot be made accessible, consider an alternative to make the program accessible.

The following is a list of potential infrastructure elements for the Sundarbans, their characteristics and spatial relationships to each other. But no eco-tourism facility should be developed in Tinkona iseland due mainly to ecological reasons.

Information Centers

Construct an Information Center at Karamjal and other major sites and structures should be consistent with the established architectural themes but be bold in appearance.

Entry Stations

Place entry stations at the entrance of each site for collecting fees and monitoring visitors. Entrance stations should be placed along a path or boardwalk and adequate space be provided for occasional crowds.

Toilet Buildings

Public toilets should be provided for all sites that allow visitors. They should be sized to accommodate the current and anticipated future use. Provide separate facilities (generally, 1 toilet for every 35 people) for men and women, and locate them along public paths. If more than one building is required, different locations need to be identified throughout the site. Clean water should be provided in or adjacent to the building and directional signing should be provided so that visitors can easily locate toilets. Buildings should be kept clean and in working order, and regular inspection should be made.

Observation Towers

Observation towers should be developed at sites only when such a tower will enhance the visitor experience. For instance, if sites have adequate views and vistas at ground level, a tower may not be necessary. The tower(s) should be located in such a way that it provides the best view possible. For example, a tower can be located near a pedestrian path or trail so that the visitor can see the desired feature such as a clearing or a unique scenic or geographic feature. The height of the tower should be designed to be appropriate to the surrounding vegetation and not become a focal point. Towers should have the mass to look and feel safe and secure. Each observation tower should be large enough to accommodate 6 tourist plus guards. The structure should be put up by following established architectural guidelines.

Vendor Shops

Shops provide opportunities for private vendors to sell food and craft items. They should be located strategically in such a way that they are convenient, do not block pedestrian flow and do not become the focal point of the site. They can be clustered in groups and shade, liter receptacles and seating areas can be provided nearby. On a site-by-site basis, the number of vendors can be pre-determined to use the site at any one time. Structures should be designed to follow the established architectural theme.

Photo Blinds

Photo blinds should be constructed where wildlife is likely to be observed along paths or trails, but architecture should be minimal.

Shades and Rain Shelters

Shades and rain shelters should be strategically located in such a way that they are convenient, do not block pedestrian flow and do not become the focal point of the site. Where possible, they can be clustered in groups and liter receptacles be provided nearby. On a site-by-site basis, the number of structures to be constructed should be determined but they should be designed to follow the established architectural theme.

Gathering Spaces

Some sites will require an open area for gathering large groups of people where information and orientation to the site can be provided. These areas should be large enough to accommodate anticipated group size, centrally located and on a hard surface near paths and the main entrance area. Nearby sitting areas would also be appropriate.

Trails and Paths

Paths are generally located within the developed area, firm, stable (concrete with rock chip surface or wooden boardwalks) and wide enough to accommodate many people. Avoid surface materials that become slippery when wet (mud and brick patterns). Paths allow visitors to travel safely between facilities within the developed area. Trails, which take visitors outside the compound area, are generally longer, meander and pass by photo opportunities and terminate at points of interest.

Trails are used to direct and control pedestrian traffic and help visitors explore nearby areas. They need to be designed so that animals can pass over or under without interfering with normal behavior. In wet areas, elevated boardwalks can be used. In areas where tigers are a potential problem, trails may need to be enclosed for visitor protection. Trails should be designed as loops with various lengths and benches for resting at wide spots along the trail should be provided. Both paths and trails should be wide enough to allow visitors to walk side by side and to pass comfortably in both directions.

In all cases, the materials used should hold up with little maintenance and also withstand foot traffic and extreme weather. Where possible, construction materials should be such that these are available locally and that can be replaced or repaired with minimum cost and skills. The paths should be located in the most logical places. Trails and paths should be constructed to every location that a visitor is permitted to travel, and paths can be used as a way to control access. Signs should be posted, if necessary, to keep people on established trails and paths. The construction of an elevated boardwalk should be made with Goal Ghars or huts. Goal Ghars should be located as logical resting spots and so that they provide the best views.

Signs

The following four types of signs can be provided, depending upon sites:

1. Site Identification Sign - Welcome sign: The site identification sign is a major sign to be placed near the entrance of the site, usually adjacent the jetty. It should be placed in a wide area along the path that doesn’t block the main pedestrian flow, and also it should be visible so that the site is easily identifiable and becomes a location and opportunity for photos.
2. Kiosk – General Information: A formal display area (kiosk) should be constructed at each destination site near the entrance and departure sites as it gives a sense of arrival and entry. At a minimum, it should have the name of the site, Forest Department and other appropriate logos, rules of acceptable behavior and site etiquette. An overall site map that is easy to understand, showing the major facilities, restroom locations, etc. is also recommended. This kiosk should be posted at a convenient location adjacent to pedestrian ways but not blocking paths. A shade structure could be incorporated into the structure, following the established architectural themes, by using materials, colors, logos and graphics that are consistent with other sites throughout the SRF. Information should be posted in both English and Bengali, and interpretive panels should include both general and specific information about the site including the ecosystem, wildlife, plants, human resource users and their livelihoods and appropriate behavior. Information kiosks at departure sites serve to educate large numbers of visitors. Messages on the importance and sensitivity of the ecosystem, and on appropriate conduct while visiting the site, should be displayed.
3. Site Information Sign: Signs and information panels should be placed adjacent to paths and trails throughout the site to control and manage visitors. Signs, kept to the absolute minimum, should not interfere with views or vistas. Adequate space in front of the signs should be ensured so that people viewing the signs will not interfere with pedestrians passing by. All signs and information panels should be kept in good repair and replaced when needed. Information in both English and Bangla should be posted.
4. Directional Signs: Directional signs are needed to direct visitors to activities and attractions within the site. Signs should be placed at locations where choices are not obvious but their numbers should be kept to the absolute minimum. Signs should not

interfere with views or vistas, and there should be adequate space in front of the signs so that people viewing the sign will not interfere with pedestrians passing by. All signs should be kept in good repair and replaced when needed.

Resting Areas

Resting areas and shades for visitors and guests should be provided. For instance, benches can be provided in conveniently located areas, along paths, adjacent to viewing opportunities, and focal points. They can be clustered together but should be located throughout the site. Benches should be oriented so that the seated observer is orientated outward toward the landscape in order to take advantage of vistas and views. But benches should be designed consistent with the established architectural themes.

Structures

Structures are classified into three types as below:

1. Permanent facilities including Staff Quarters, Offices and Information Centers.
2. Semi-permanent structures including toilet buildings, viewing towers, entrance stations and vendor shops.
3. Minor structures including shade /rain structure and viewing blinds.

Structures should be constructed employing a traditional architecture style and fit lightly on the land where possible. They also need to be durable to withstand extreme weather and the anticipated visitation and vandalism. The following specification and guidelines will be helpful when such structures are designed and established:

Permanent Structures:

Materials: Walls and roof should be colored concrete.
Shape/Size: Staff quarters should be simple in design, primarily rectangular in shape. Locate them in such a way as to be able to survey to site. Size and number shall be determined based on the number of staff. Elevate structures to prevent water damage. Design buildings to be visually interesting but subordinate to the landscape.

Semi-permanent Structures:

Walls: Walls should be permanent, made out of brick and concrete.
Windows and doors: Design openings, both doors and windows, so that direct sunlight in the interior is avoided. This can be accomplished through setbacks, louvers or roof overhangs. Simple windows should be placed in the walls so that cross ventilation is maximized.
Color: Colors should be earth tones.
Materials: Structural elements, such as walls and columns should be colored concrete. Roofs should be natural appearing.
Shape/Size: Keep structures simple and subordinate to the landscape. Structures should be either rectangular or keep size to the maximum needed for the specific purpose.
Roof: Roof should be semi-permanent (corrugated iron sheets) and roof overhangs should be a minimum of one meter.
Windows and doors: Design openings, both doors and windows, so that direct sunlight in the interior is avoided. This can be accomplished through setbacks, louvers or roof overhangs. Simple windows should be placed in the walls so that cross ventilation is maximized.
Color: Colors should be earth tones.

Minor Structures:

Materials: Columns and walls should be colored concrete. Use textures that have the appearance of wood. Use natural materials (bamboo, wood and/or thatch) for roofs, trusses and covering.
Shape/Size: Keep structures simple and subordinate to the landscape. Structures should be either round or octagonal. Keep size to the maximum needed for the specific purpose.
Roof: Roof should be designed so that it can be replaced and repaired with minimum skills. Roof overhangs should be a minimum of one meter.
Windows and doors: Design openings, both doors and windows, so that direct sunlight in the interior is avoided. This can be accomplished through setbacks, louvers or roof overhangs. Simple windows should be placed in the walls so that cross ventilation is maximized.
Color: Colors should be subordinate to the landscape (earth tones).

Utility and Storage structures

Some sites will require storage structures, which should be located, if possible, out of site of visitors. Structures should be consistent with the established architectural themes.

Jetties

Jetties require specialized design and engineering to withstand wave and water action. Design and locate jetties in such a way that boats can tie up safely in both high and low tides. This may require studying river currents to eliminate possible safety hazards. Jetties should be located in suitable places to avoid river bank erosion. Possible safe ways should be provided for visitors to exit the boat and transfer to shore. Where funds are available and visitation warrants, multiple jetties for staff and visitor boats should be constructed.

Waste Receptacles

Waste receptacles should be provided at all sites at convenient locations throughout the site; suitable signs need to be posted so that they are easily located. At a minimum they should be located adjacent to seating areas, restrooms, picnic areas, and food preparation areas. Receptacles should be animal proof and colors that have been established with the architectural theme should be used.

Staff and Guest Housing

Staff quarters and guest houses should be located so that they are separated from visitor areas, out of sight and sound of visitor activities. Structures should be consistent with the established architectural themes.

Emergency Shelters

Emergency shelters should be established (take advantage of locations where shelters are being proposed and will be built) so that they are easily accessible for both staff and visitors and their structures should be consistent with the established architectural themes.

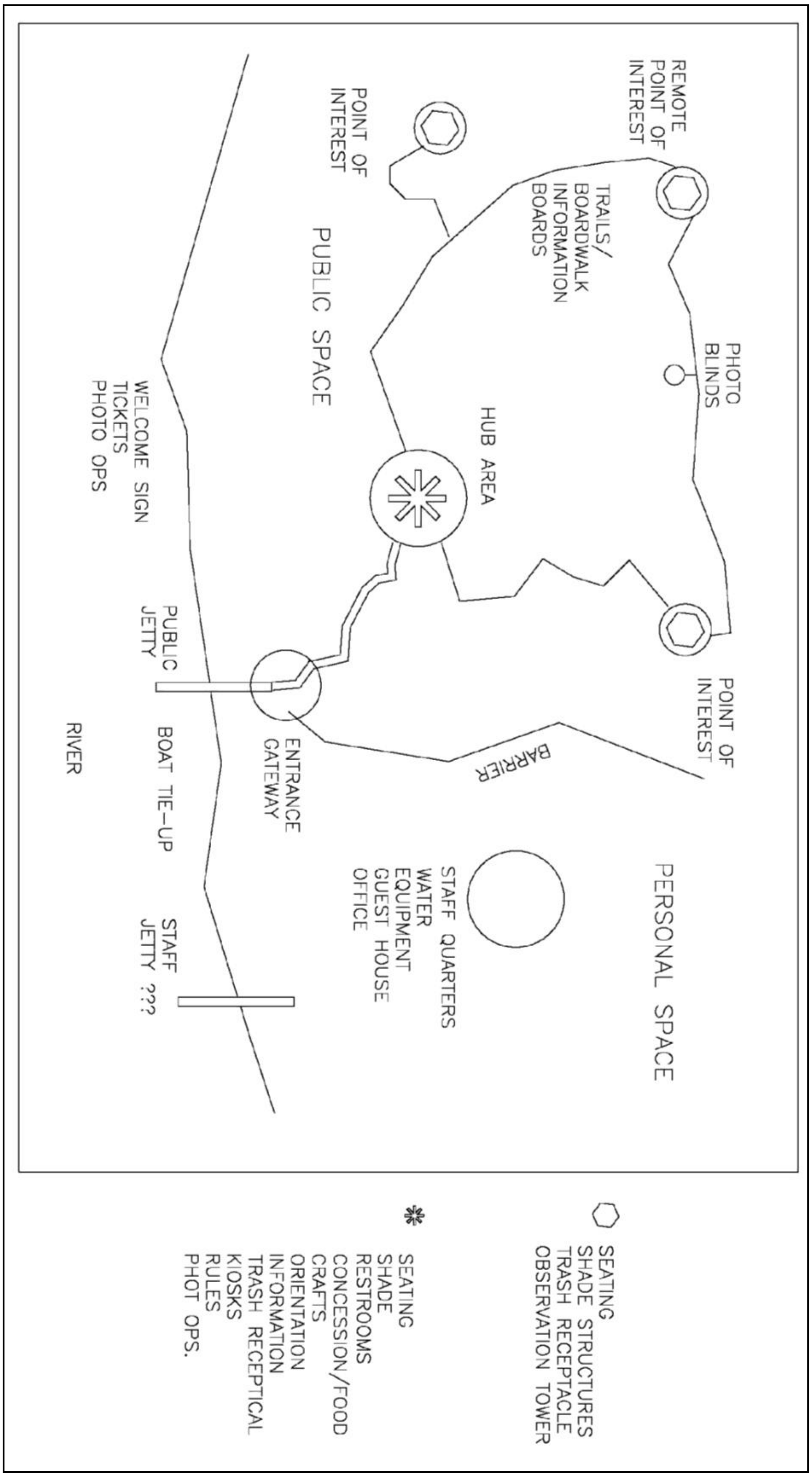
8.6 Schematic Layout for Destination Sites

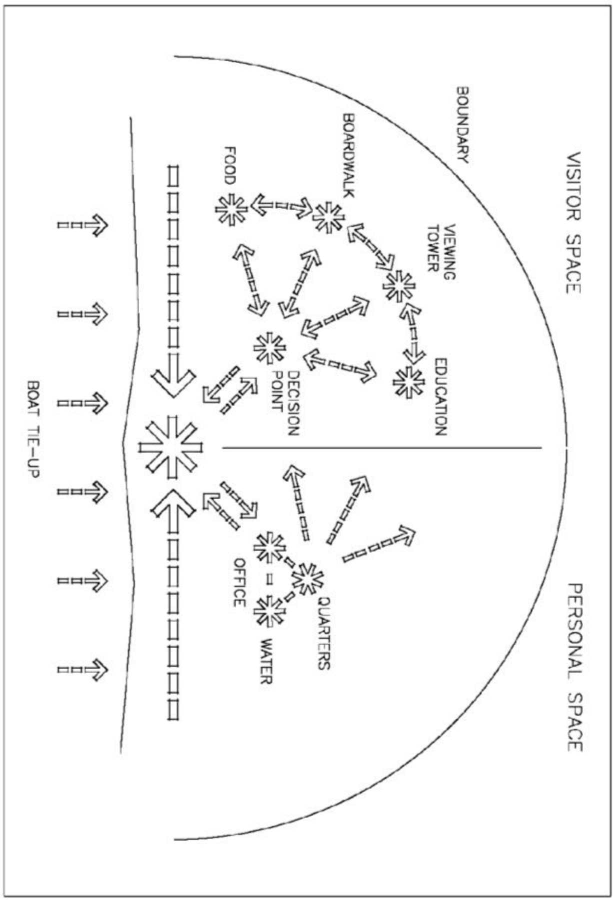
The attached schematic graphic (Figure 8.2) shows the relationship of infrastructure developments with one another. The graphic on the left represents a site with one entrance point and the graphic on the right represents a site with multiple entrance points. Regardless of the site, these relationships are critical. Specific site plans will have to be modified based on the unique features of the site. Determination of what elements should be constructed at each site should be made on a site-by-site basis. Each decision will have to be made based on site features, site goals and objectives, etc.

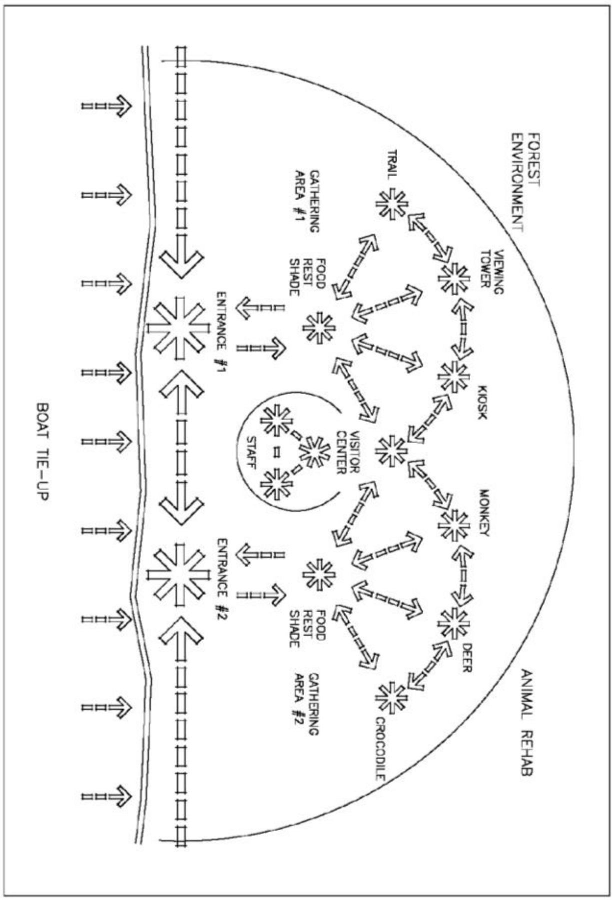
Generic Layout

The attached generic site plan (Figure 8.2) is a representation of where the various infrastructure components could be placed and their relationship to one another. This plan should be used as a starting point for all future developments. Each site will require a thorough survey and analysis to determine which components will fit the unique characteristics of a particular site. Modifications will also have to be considered based on budget, competing sites and other priorities.

Figure 8.2: Schematic Layout for Destination Sites




VISITOR SPACE
PERSONAL SPACE
BOUNDARY
BOARDWALK
FOOD
VIEWING TOWER
EDUCATION
DECISION POINT
QUARTERS
OFFICE
WATER
BOAT TIE-UP


FOREST ENVIRONMENT
ANIMAL REHAB
TRAIL
GATHERING AREA #1
VIEWING TOWER
FOOD REST SHADE
ENTRANCE #1
KIOSK
VISITOR CENTER
STAFF
MONKEY
ENTRANCE #2
FOOD REST SHADE
DEER
GATHERING AREA #2
CROCODILE
BOAT TIE-UP

8.7 Eco-Tourism Infrastructure Development Plan for Karamjal

The Karamjal site receives over 80% of all the visitors to the Sundarbans Reserved Forest. Attendance on a busy day can exceed several thousand people on site at a time. Most come from the adjacent communities and spend 2 to 3 hours on site. However, longer stays can be expected when infrastructure is developed to enhance their experience. The site consists of a core area including animal enclosures, paths, staff quarters, miscelleneous structures and entrance and exit points. Another important part of the site is a series of boardwalks and paths that lead out into the forest.

Because this site is close to local populations, it requires relatively inexpensive travel costs and has the added attraction of the crocodile breeding center, and so it will always be in high demand as a destination site. Other locations will be able to take some of the pressure (demand) off the site, but Karamjal will continue to be a favorite destination for many people.

As a consequence to the overwhelming demand from visitors, no amount of on-site infrastructure will be able to completely address the current and future overcrowded situation. Understanding each infrastructure element and its relationship to each other will greatly help in the control and management of the site. A thoughtful development strategy is, therefore, imperative. Another option that has been considered, is the possibility of expanding the developed area into adjacent land, either contiguous or across the Karamjal Khal. This additional area would allow visitors to spread out into previously undeveloped territory. The decision needs to be considered carefully because though there are many positive things that could come out of expansion, many negatives would come as well when the site is taken for development.

8.7.1 Existing Site Conditions

Two separate areas are considered in evaluating the Karamjal site: the departure area, managed by the Mongla Port Authority, and the site itself, managed by the Forest Department. Both areas would benefit from infrastructure development. Attached at the end of this section are site plans, sketches of proposed structures and a spreadsheet with approximate quantities that will help in generating a cost estimate for future on-site projects.

Departure Area - Mongla Port

This area is used as staging area for people waiting to board boats to Karamjal and other locations. People can wait several minutes to hours before embarking. The area has a toilet and places where people can picnic. Over 100 buses have been reported there on a busy day. Vendors have set up shops where food and water is available for purchase. There are two separate jetties that people use to board boats and sandwiched in between these two jetties is the Forest Department jetty and pontoon. There are no trash receptacles and litter is a big problem. There are no signs or visitor information available. One of the jetties is in disrepair and it would be difficult for many to board. A makeshift bamboo plank has been used to span about a 10 foot gap. Passengers must cross this plank to board. It is unsafe and needs to be corrected as soon as possible.

Site Entrance: The main entry and exit point share the same space at the top of a set of concrete stairs off the Karamjal Khal. Boats tie up adjacent to a set of concrete stairs. On busy days, it can be quite congested. At low tide the canal becomes quite narrow and congested with boats, difficult to turn around and get to the stairs.

The other way to access the site is from the Passur River. Larger boats use this entrance. It has no jetty or stairs and passengers must scramble up the bank. Erosion is evident and continuous.

Paths: Paths within the core area are mud based, raised about 10 inches with a traditional haring-bone brick surface. The crown is excessive and slippery when wet. Paths are quite narrow, making it difficult to pass. There are no wide spots, benches or resting areas at the site at all.

Other paths outside the core area: Other paths are raised mud with no surface treatment that becomes wet and slippery many times during the year. Sections are impassable and under water much of the time. The circulation routes are not continuous and poorly designed.

Boardwalks: Wooden boardwalks that lead into the forest are in disrepair and, in some cases, very dangerous. Many planks are missing or loose. The entire boardwalk is raised about 2 feet above the adjacent forest floor, making it impossible for animals to pass under. They were constructed in nearly straight line. The circulation pattern is an out-and-back rather than a loop or series of loops. The boardwalk is about 4’ wide making it difficult to pass. There are no wide spots for resting and passing. No benches exist along the boardwalk. The wooden railing is too short (about 18”) creating a safety hazard and in some areas it is missing altogether. People use the railing for sitting.

Toilets: The existing toilet building is adequate but will not accommodate the number of visitors at one time. With only one toilet on site, walking distance from some parts of the developed site is excessive.

Staff Quarters and Office:

Quarters are traditional concrete buildings, adequate but not isolated or partitioned off from the public. They are located in such a way to be able to survey much of the core area. The site manager's quarters and office share the same small structure.

Staff Kitchen: The staff kitchen is a wooden structure located far away from the quarters near the Passur river entrance. It is in disrepair and needs to be moved, repaired or replaced.

Food service and eating areas:

Food and food services are housed in a wooden structure and run by a vendor. Food and snacks may be purchased from the vendor. Boardwalks leading up to the structure are made of small logs that are in disrepair and unsafe. The small eating area adjacent to the wooden structure has no shade. Other food can be purchased at various locations throughout the site from walking vendors.

Observation Tower: There is one existing viewing tower on site. It is located in an area that overlooks the animal enclosures. At times, it can get congested.

Animal exhibits: Structures that house animals are functional but no other facility exists. There has been no attempt to use these to create a positive experience.

Shade structures: There are no shade structures on site specifically designed for visitors. But existing vegetation provides some shade.

Information: Information about the site, its function and purpose is lacking. There is neither information at the departure area nor site maps are posted. Similarly neither regulations are posted nor relevant information given in English. FD field staff are not trained to deal with the public.

8.7.2 Proposed Site Plan for Karamjal

Attached is a possible site development plan (Figure 8.3) for the Karamjal site. It attempts to address many of the current site conditions and resolve them by juxtaposition of infrastructure elements. This graphic representation is not the only layout that will work and so a complete set of design documents (plans, cost estimates and specifications) should be commissioned before demolition and construction of new site amenities are started. On site conditions may vary in future and changes to this proposal may be required. Phasing may also be required to complete the site work based on the available funding levels. Possible plans for other facilities are provided in Figures 8.4, 8.5, 8.6, 8.7 and 8.8, covering shade structure, information board, toilet and observation tower.

Departure area: Mongla Port

Kiosks and/or information boards can be constructed for which a concept note given. Fd should work with the Port Authority to find an appropriate location near the Jetties. Install Trash receptacles should be installed and existing jetties and pontoons should be repaired.

Site Entrance:

With the amount of current and future visitors, it will be helpful to have multiple entry points to the Karamjal site. Therefore, entrance to locations should be moved as shown on proposed development plan. The entrance booths should be designed so that FD staff can serve in two lines at the same time.

Paths:

All paths within the core area should be constructed of concrete with stone texture. Where visitors congregate, paths should be designed and constructed sufficiently wide (10') to avoid congestion. Secondary and tertiary paths widths should be reduced, and four feet should be the minimum standard to allow visitors to pass comfortably.

Boardwalks:

Boardwalks should be designed and constructed 6' wide and safety handrails at 42" should be installed along the entire boardwalk. Footings of concrete should be constructed so that no wood comes in contact with the ground. Benches need to be provided at resting areas. The widths of the boardwalk should be increased as needed at congested areas. Height above the ground in some locations should be enough to allow animals (deer) to pass underneath. Boardwalks adjacent to crocodile pens should be raised for easier viewing.

Toilet Buildings:

An additional toilet should be constructed to start with. Other toilet buildings may be be developed as required in the future. Based on an attached concept existing toilet should be developed in order to match new architectural styles.

Animal exhibits:

One of the main reasons visitors are attracted to Karamjal are the animal exhibits. While functional now, plans should be made to increase the animal exhibits to make them more visible and accessible. Possible locations of future exhibits are shown below.

Staff Quarters and Office:

The existing paths should be realigned so that they will not lead the public directly passed Staff quarters. Staff quarters should be off limits to the general public and gates should be installed to discourage public from entering this space. If the office is required for public interface, it should be placed in or adjacent to the "Public Space". The paths should be relocated as shown on the proposed site plan.

Staff Kitchen:

Existing staff kitchen should be replaced by putting a new structure near the staff quarters.
Ample spaces should be provided for food vendors to sell food to visitors in designated areas.

Information Board:

Information boards should be placed near each entrance (see concept) and relevant information including appropriate regulations, rules of behavior, site maps, special events, etc. be posted.

Observation Tower:

Additional viewing towers can be constructed after determining suitable locations.

Shade Structures:

Construct 11 shade / rain structures as per the enclosed concept and by following architectural guidelines; exact location of each structure to be determined in the field.

Directional Signs:

Directional signs should be installed at all intersections.

Site Identification Sign:

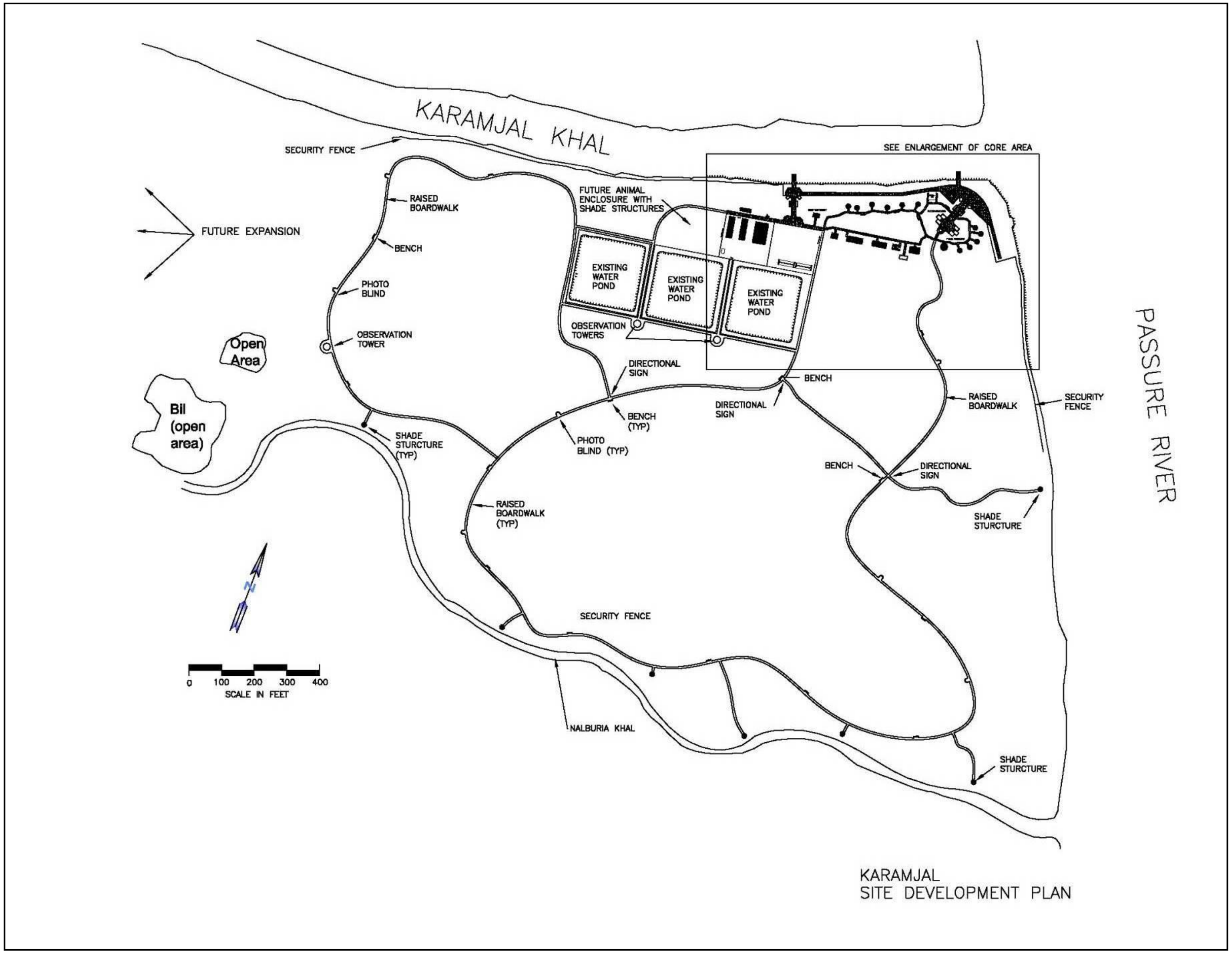
A site ID sign should be designed and installed as per the concept.

Photo Blinds:

Photo blinds should be placed along the paths and boardwalks but the exact location of each structure is to be determined in the field.

Finally, relevant guidelines as provided in NSP (2003) and FSP (2001) for developing facilities in protected areas should be referred to while implementing the recommendations made in this Chapter.

Figure 8.3: Site Plan for Karamjal



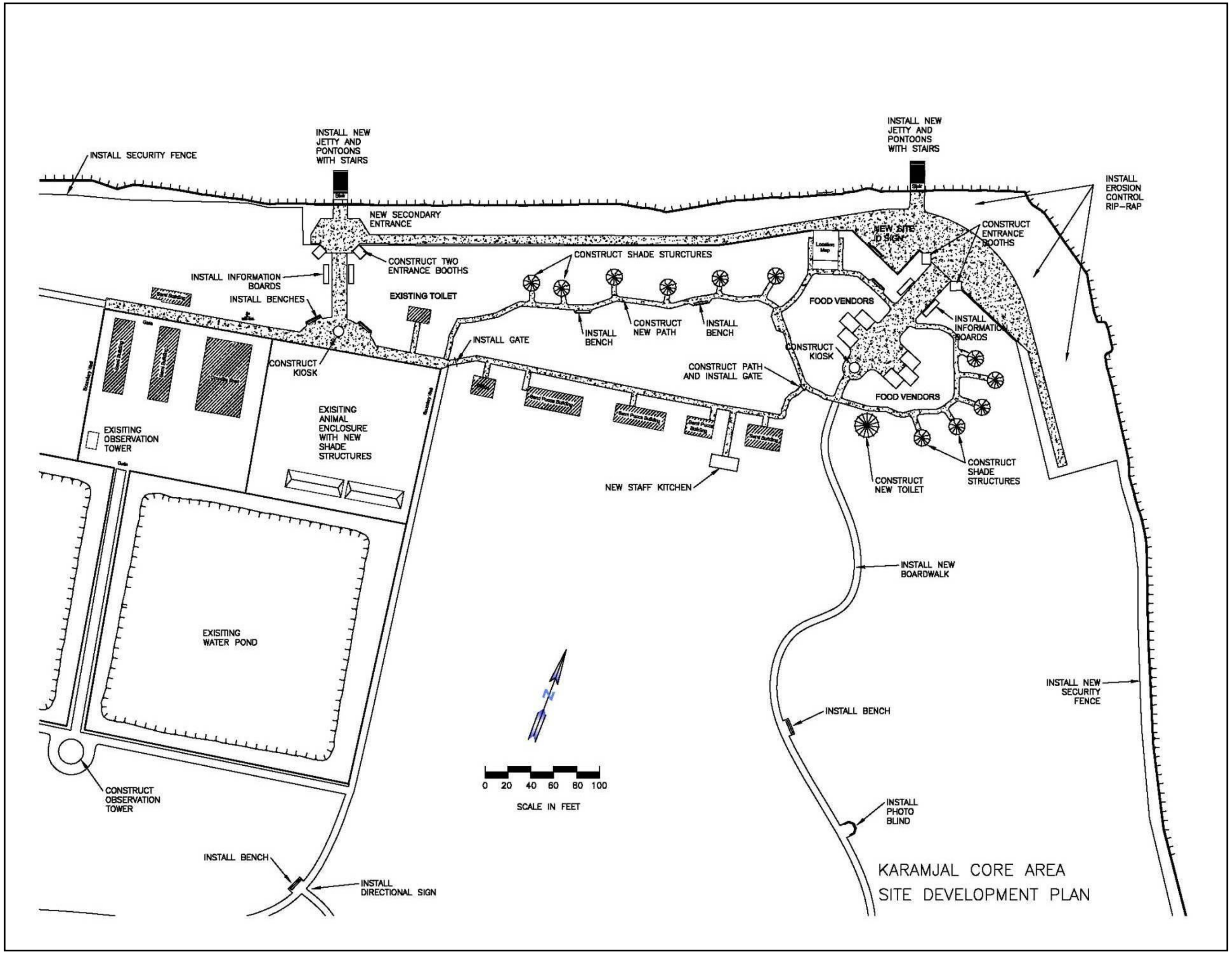

INSTALL SECURITY FENCE
INSTALL NEW JETTY AND PONTOONS WITH STAIRS
NEW SECONDARY ENTRANCE
CONSTRUCT TWO ENTRANCE BOOTHS
INSTALL INFORMATION BOARDS
INSTALL BENCHES
EXISTING TOILET
CONSTRUCT KIOSK
CONSTRUCT SHADE STURCTURES
INSTALL GATE
INSTALL BENCH
CONSTRUCT NEW PATH
INSTALL BENCH
NEW SITE ID SIGN
CONSTRUCT ENTRANCE BOOTHS
INSTALL NEW JETTY AND PONTOONS WITH STAIRS
INSTALL EROSION CONTROL RIP-RAP
FOOD VENDORS
INSTALL INFORMATION BOARDS
CONSTRUCT KIOSK
CONSTRUCT PATH AND INSTALL GATE
FOOD VENDORS
EXISITING OBSERVATION TOWER
EXISITING ANIMAL ENCLOSURE WITH NEW SHADE STRUCTURES
NEW STAFF KITCHEN
CONSTRUCT NEW TOILET
CONSTRUCT SHADE STRUCTURES
INSTALL NEW BOARDWALK
EXISITING WATER POND
INSTALL NEW SECURITY FENCE
INSTALL BENCH
0 20 40 60 80 100
SCALE IN FEET
CONSTRUCT OBSERVATION TOWER
INSTALL PHOTO BLIND
INSTALL BENCH
INSTALL DIRECTIONAL SIGN
KARAMJAL CORE AREA
SITE DEVELOPMENT PLAN

Figure 8.4: Kiosk Structure

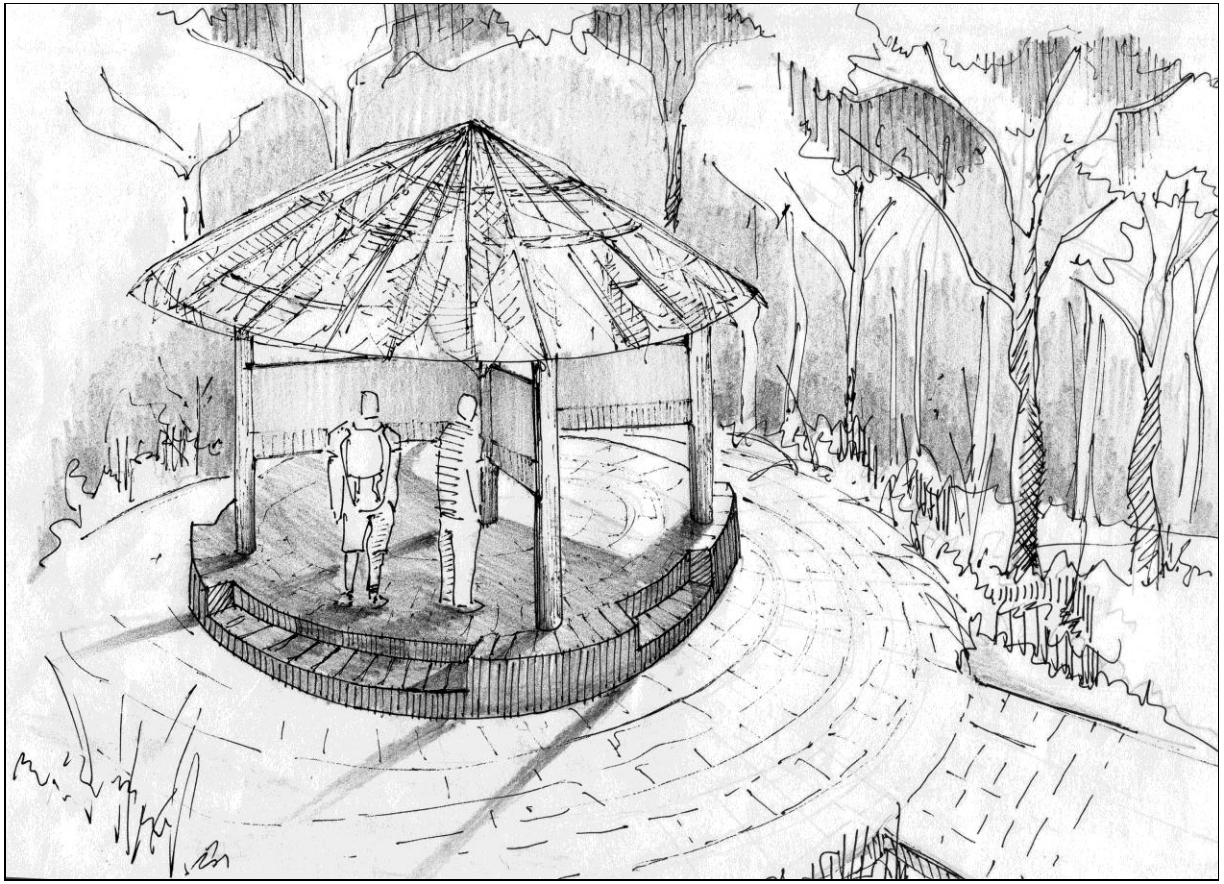


Figure 8.5: Shade Structure

Figure 8.6: Information Board

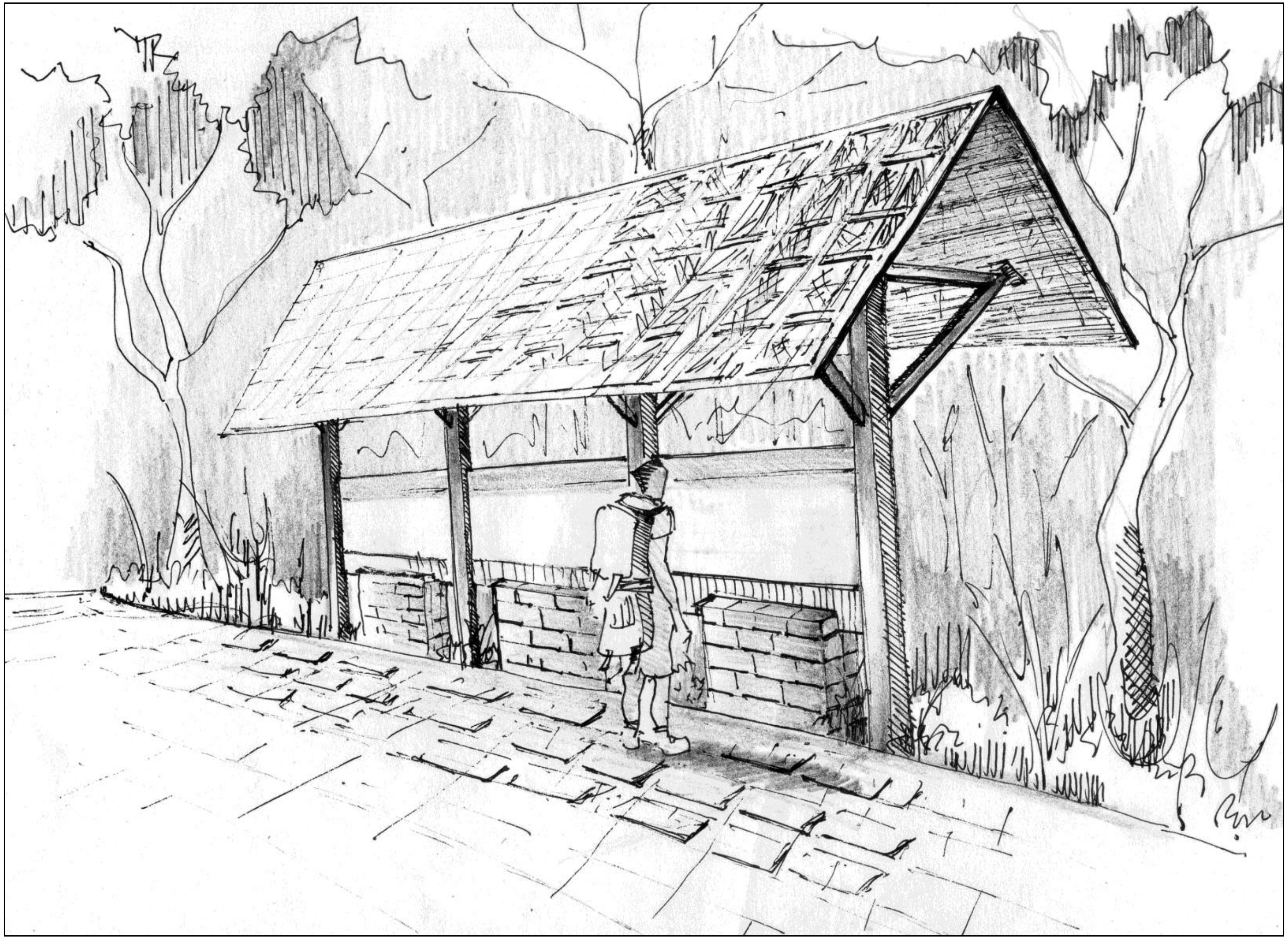


Figure 8.7: Toilet Building

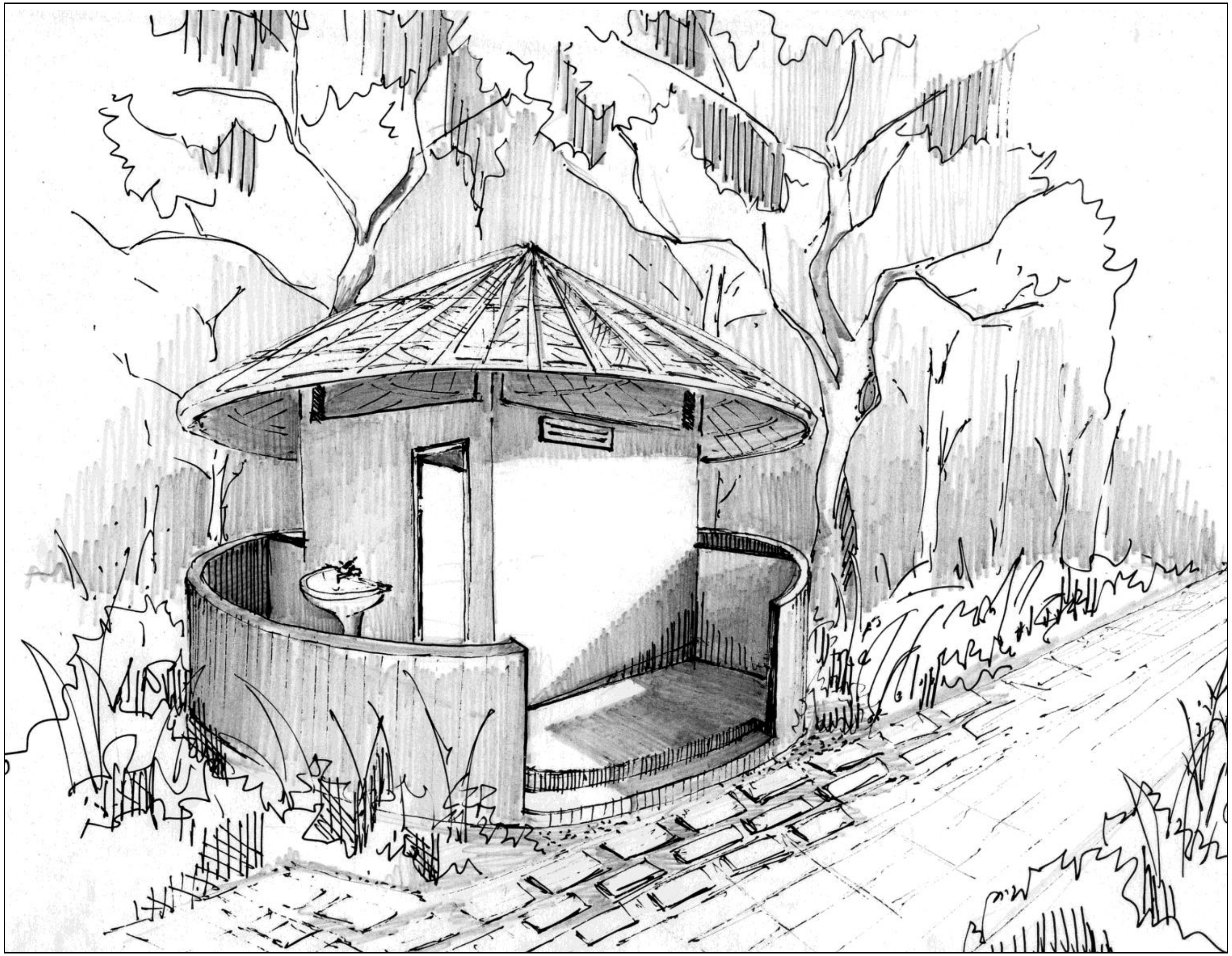
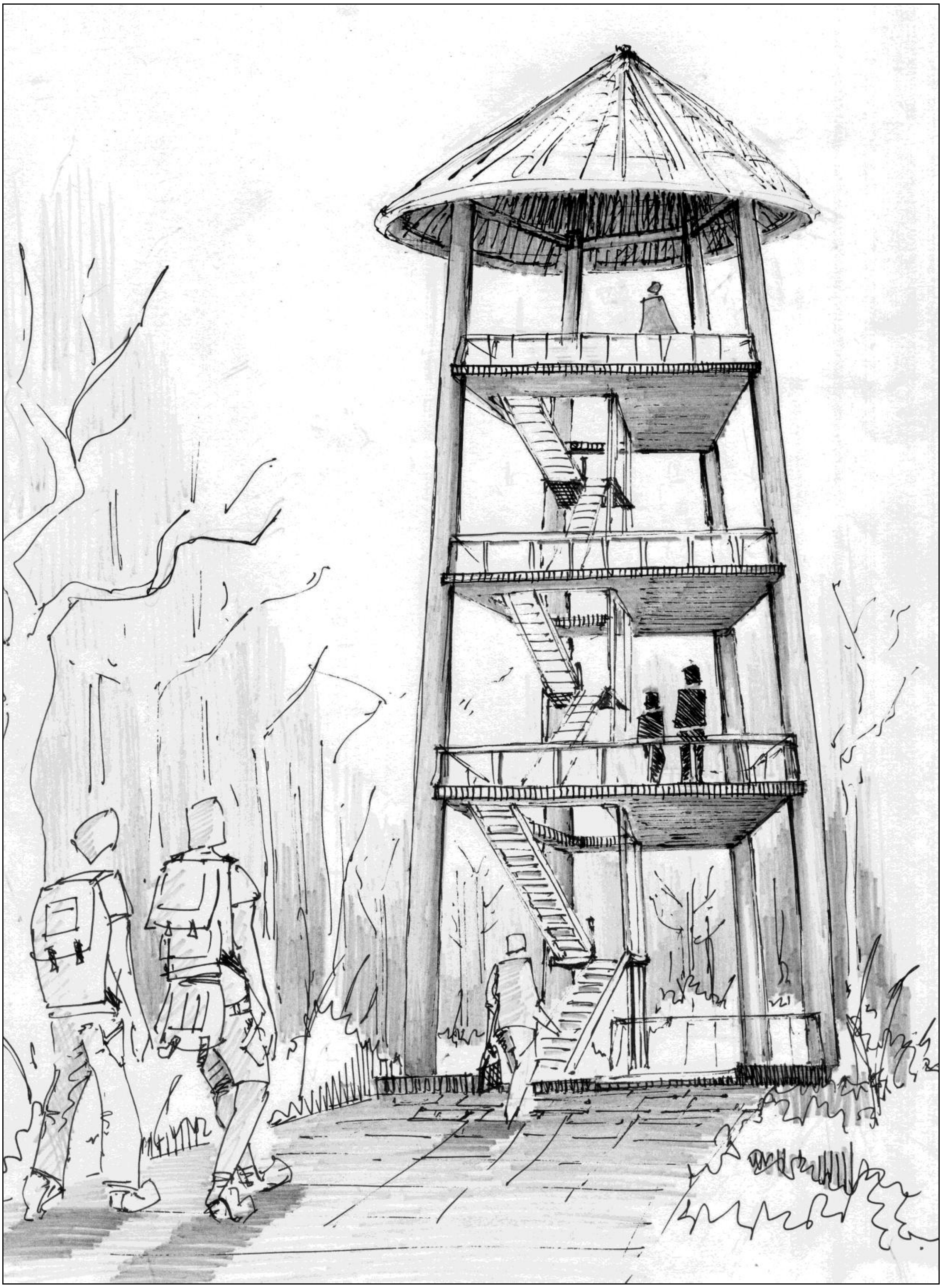


Figure 8.8: Observation Tower



8.8 Field and Office Equipments

Field and office equipments will be needed to support the Sundarbans management programs. In addition to providing appropriate boats to the field staff, double-cab pickups and 125 cc motor cycles will be provided to the field staff. Existing walkie-talkie system will be maintained and mobile telephones will be provided in those areas where the network is available. Desktops, laptops with internet access will be provided to each of the four Ranges and Forest Stations, wherever needed. Compasses, binoculars, GP units, and other field equipments will be provided as needed. Other office equipments including telephone, desk tops, furniture and supplies will be provided. Reevant details along with the budget have been included in Chapter 11 based on the approved DPP of the SEALS.

8.9 Summary of Main Prescriptions

Main prescriptions outlines under the above-designed facilities development programs are summarized in the Table 8.2 as below:

Table 8.3: Summary of Main Prescriptions: Facilities Development Programs

Year	Main Activities	Main Outputs/Success Criteria	Responsibility
1 and 2	-Assessing present drinking water facilities in all FD offices and developing at least one PSF facility	FD offices have atleast one PSF facility for drinking water	FD/SEALS
	-Weekly supply of ration to FD staff on payment	FD staff have food available at their duty posts	FD
	-Installing solar power units in FD offices	FD camps and posts operate on solar systems	SEALS/FD
	-Installing at least one Chulli in FD offices and residences for cooking food	Basic cooking facilities	SEALS/FD
	-Existing staff offices and quarters are repaired and maintained	Minimum office and residencial facilities	SEALS/FD
	-A detailed assessment is done for new offices and quarters construction	Minimum office/residence requirement complted	SEALS/FD
	-Plans, estimates and budget are developed for required buildings	Plans, estimates and budgets	FD/SEALS
	-Finalizing tenders and issuing work orders	Contractors are in place	FD
	-Finalizing eco-tourism sites	List of eco-toruism sites	FD/CMCs
	-Developing site plans, estimates and budgets for each identified sites	Site Plans for each site	SEALS/FD
	-Developing tenders and finalizing contarctors	Contractors are in place	FD
	-Identifying field and office equipments	List of field and office	FD

	requirements	equipments	
	-Assessing existing field and office equipments	List of existing field and office equipments	FD/SEALS
	-Purchasing field and office equipments as detailed in Chapter 11	Field and office equipments are distributed	FD/SEALS
	-Developing PSF facilities as detailed in Chapter 11	Staff have drinking water facilities	FD/SEALS
	-Developing Chulli as detailed in Chapter 11	Chulli facilities are in place	FD/SEALS
	- Repairing and/or replacing jetties	Repairted jetties	FD/SEALS
	-Developing RWHS	RWHS	FD/SEALS
3 and 4	-Continue constructing the identified facilities including staff offices and reseidences and eco-tourism infrastructure	Facilities in place	FD/SEALS
	-Maintaining the identified facilities including staff offices and reseidences and eco-tourism infrastructure	Maintained facilities	FD/SEALS
	-Maintraining office and field equipments	Maintained field and office equipments	FD/SEALS
5 to 10	Continue the activities as listed for the years 3 & 4, and consolidate gains after making mid-plan period adjustments		

9. Conservation Outreach, Conservation Research, Participatory Monitoring and Capacity Building Programs

Conservation outreach, conservation research, participatory monitoring and capacity building are tools/mechanisms for a better understanding of the Sundarbans and its functions in order to sustainably manage its biodiversity comprising forests and wetlands.

9.1 Program Objectives

Main objectives of this program are i) to better understand and communicate the Sundrabans's biodiversity resources, ecosystems and landscape environment, ii) to identify priority research themes, iii) to establish a participatory monitoring mechanism to help guide the Sundrabans development, and vi) to build capacity of key stakeholders including co-management organizations and the staff of the relevant Government agencies.

9.2 Conservation Outreach

A sound communication and outreach strategy for the Sundarbans will promote and foster sustainable behavior patterns required for the conservation of the Sundarbans through co-management by focusing on the change in behavior of all the stakeholders with respect to their knowledge, attitude and practice. This will require identification of the stakeholders and stakeholders analyses for assessment of their present state of knowledge, attitude and practice by mounting local consultations and households surveys in the surrounding landscape. Under IPAC such a survey was done (see IPAC, 2010 for detailed findings) Expected behavior patterns need to be inculcated among the stakeholders for which a range of communication can be used: TV advertisements/spots; newspaper articles/ inserts/advertisements; radiom programs including talk shows; documentaries (TV airing); field tours for journalists and students; essay writing/art/wall painting competition for children; awards; publicity events; radio programs; newsletters; campaigns and advocacy networks; fairs/melas; eco-tourists shows; communication materials such as brochures and pamphalets; slide shows; websites; seminars; CDs and DVDs, etc. An appropriate branding framework comprising a brand name, logo, messages, communication briefs and guidelines will be developed.

Specifically, the publicity of the Sundarbans management activities will be conducted for propagating the biodiversity conservation, wetlands, environment, and wildlife and the cause of its habitat. Electronic and print media (TV, Radio, Videos, newspaper, magazines, brochures, etc.) will be employed for this purpose. Schools and colleges will be targeted for conservation education and building an informed forests, wetlands and wildlife constituency. Talk shows, essays writing and competitiosn will be included in neighbouring schools as a part of publicity campaign. Sabuja Vahinis (Green Brigades) will be formed and trained in nearby schools and madarsas. Professional publicity and communication personnel will be invited for such tasks. Communication strategies as developed under NSP (2002) and IPAC (2009) will be implemented. Efforts will be undertaken to improve relations and communications between the FD field staff and the media.

Nature interpretation will, as an educational activity, focus on revealing meaning and relationships of the Sundarbans complex ecosystems and landscapes. Public awareness of the laws related to wildlife will be enhanced and prosecutions under the laws will be publicized. Landscape features of the Sundarbans will be depicted in pictorial forms including topographical and biodiversity patterns. Depending upon the availability of resources a sound and light program can be added for explaining to visitors. Local exhibits, murals, dioramas, specimen of plants and wildlife, trophies and photographs will be added. Socio-cultural traditions/features (handicrafts, uniforms, dances, tools, furniture, ornaments, carvings, etc.) of local people will be added with proper leveling and description.

Appropriate signages will be used for the benefits of tourists in finding their ways without any enquiry. These signages may be i) directional signages showing the way to different places, ii) cautional signages indicating about prohibitory acts, iii) orientational signages helping in tourists orientation and iv) interpretive signages kept at conspicuous places to help interpret strategic themes and issues. Nature Interpretation Centre (NIC) will be set up and its design and development will be assigned to a professional organization. It will consist of walk-through displays, audio-visuals, explainatory printed materials, items of historical and conservation significance, computer interactive media, etc. A video film on wildlife and its habitat and cultural aspects may be developed for showing to visitors at NIC. Other relevant topics may include ecological processes at work in the Sundarbans, wildlife behavioural ecology, wetlands management, conservation history, role of local people in conservation, man-wildlife conflicts, etc. A library will be developed at NIC with books, magazines and journals relating to biodiversity, wildlife, environment and forestry.

Other sectors, particularly fisheries and coastal navy and BDR, have profound effects on the management of Sundarbans. Therefore, the FD needs to establish clear linkages and programs for collaborative conservation planning with other relevant agencies/institutions. A collaborative conservation strategy should be developed to provide mechanisms for improving inter-sectoral coordination and information sharing to maximize biodiversity conservation efforts. The concept of public-private partnership will be applied in soliciting the inputs/contributions from private sector particularly for the facilities development in the SRF. It has been shown in many countries that nature conservation progresses rapidly when leading members of the private sector perceive nature conservation as good for the economic well being of the country.

Nature conservation partnerships can be designed to offer interested businesses a vehicle for contributing to long-term forest conservation in a way that is transparent with low transaction costs, generates beneficial public image for the contributor and makes a long-term difference in forest conservation. It will help improve livelihoods by building a strong and mutually self-interested relationship with the local communities. Such a relationship may be formalized by signing co-management agreements under which community representatives maintain joint responsibility for protection with FD, and in return receive benefits that can support community needs for improved health and sanitation, womens' empowerment and livelihoods improvements. Contributors can help create visitor facilities including educational exhibits, public utilities, sitting areas and other visitor amenities by making donations in lieu of recognition on appropriate plaques.

Coordination with related organizations in Asia and elsewhere will be developed. Cross-country exchange visits and training will be arranged to learn from relevant experiences from similar projects being implemented in different Asian countries including India where the

World Bank supported biodiversity project is being imeplemented in coastal areas including the Sundarbans in West Bengal. A working group may be supported for preparing disseminating co-management best practices and lessons learned. Potential organizations for maintaining professional contacts include regional FAO office (Bangkok), RECOFTC (Bangkok), Wildlife Institute of India (Dehra Dun), ICIMOD (Kathmandu), CIFOR (Bogor, Indonesia), etc.

Many times other sectors, particularly land-based sectors, have profound effects (both negative and positive) on the management of forests, wetlands and PAs. Therefore, FD needs to establish clear linkages and programs for collaborative conservation planning and management with other relevant agencies and organizations both within and outside the country. A collaborative conservation strategy will be developed to provide appropriate mechanisms for improving inter-sectoral and inter-country coordination and information sharing to maximize biodiversity conseration. The Sundarbans mangrove forests and the rivers encompass transnational issues as nearly 40% of the ecosystem is in India which is also origin of international rivers that flow in the SRF. The present Memorandum of Understanding between Bangladesh and India on collobarion on the Sundarbans tigers should should be expanded to include enhanced cooperation on the sustainable ecosystems management including equitable sharing of waters for ensuring adequate freshwaters flow through the SRF.

9.3 Conservation Research

Presently conservation research is not being undertaken by FD and there is no funding source earmarked for carrying out such research. It is, therefore, necessary to establish linkages with related research organization such as FRI, BARC and relevant Universities and NGOs. In view of scarcity of funding for conservation research, adequate collaboration and networking with other relevant research organizations is necessary. The appilicability and implantation of relevant international conventions will be examined for the Sundarbans. Conservation research may include aspects such as diverse types of flora and fauna, status of endangered species, wildlife behavior, wetlands management based on an ecosystem approach, sustainable fisheries management, tiger management, resolution of man-animal conflicts, socio-economic issues, silvicultural aspects, man-animal conflicts, impact of anthropogenic pressures on natural systems, etc. Applied research relating to management aspects of the SRF will be given priority by FD over academic studies, which may be conducted by Universities and research institutes. A number of research themes on fisheries management have been identified in Chapter 4. The research suggestions in the following sections, therefore, focus more on forestry related issues

9.3.1 Applied Socio-economic Research

Management driven studies for conservation research will be taken up on priority basis. In the absence of research laboratories, pure research will be not be taken by FD (and so would be left to other research institutes). Possible topics of investigation may include the institutional development and financial sustainability of co-management committees to be formed at different levels and their federations, impacts and dependence of local people, ethnic knowledge on local biodiversity, impacts of human activities on natural habitats, forward and backward linkages of eco-tourism, sustainable collection, harvesting, storage and processing and marketing of NTFPs (means of multiplication), impacts of NTFPs on local economy, collection of NTFPs by the members of co-management committees. Many of these studies will be carried out through action research and by associating the stakeholders. Prioritization of research topics will be decided in a Workshop in which key persons from FD and other stakeholders will participate. A computerized data base and retrieval system will be established.

9.3.2 Applied Biological Research

Suitable benchmarks are needed for measuring diversity and to monitor the status of indicator/flagship/threatened species of flora and fauna. Some relevant topics of biological research may include wildlife-population viability analyses, population dynamics and feeding behaviour, wildlife habitat/niche use behabiour, prey-predator balance, wildlife distribution patterns, wildlife seasonal variability and movements, tiger habitat and management, tiger tranqualizing and its effects, deer management guidelines, sundari die-back, impacts of increased salinity on vegetation composition, impacts of climate change, and wildlife health and diseases. Population viability analyses will be taken up to ensure that considerations of minimum population size and population dynamics are taken into account while formulating appropriate habitat management strategy. The needs of species that are dependent on specific habitats (e.g. streamside areas) or specific components (e.g. standing and fallen dead trees) will also be studied for site-specific habitat management. Poaching and illegal wildlife trade will be studied.

9.3.3 Silvicultural Research

Main topics of silvicultural research may include canopy manipulation for improvement of habitat through natural regeneration, habitat improvement, and monitoring of floristic composition and structure. Main research findings from different silvicultural studies carried out by BFRI will be reviewed in order to draw relevant inferences and frame appropriate recommendations for managing forests in ecosystem zones and habitat management zones. Further research will be required on the effects of selected silvicultural and forest management practices on forest growth, structure and species composition, regeneration of NTFPs bearing plant species, sustainable collection and harvesting of NTFPs,

9.3.4 Ecological Research

The conservation of the Sundarbans mangrove ecosystem demands an in-depth understanding of the ecological processes, ecological niche of key organisms includinf tiger and sundari, development of appropriate technology, forests-waters and human-forests interactions. Additional topics of ecological research will include identification of fragile habitats and ecosystems, environmental impact studies, impact of reduced fresh water flows, effectiveness of water sanctuaries in the identified 18 khals, breeding time and spots of fish, forests-wetalnds interactions, ecological succession, water bodies studies, assess the contribution of PAs in water yield and conservation, and impacts of habitat changes and eco-tourism on wildlife.

9.3.5 Baseline Surveys

Existing literature on resources surveys and research will be reviewed before taking up further studies on additional assessments. The inputs from baseline surveys (for example, current population levels, distribution and habitat use) will be used in refinement and application of habitat management and monitoring.

9.3.6 Conservation Research Dissemination and Utilization

Adequate dissemination and utilization of the results/findings of research studies are very important. Pure research done for academic purposes will find less acceptability by FD and so poor dissemination among the field staff. Research dissemination and use methods may be standardized and circulated among FD staff. Useful research outputs will be included in annual development plans of FD for their implementation.

9.4 Participatory Monitoring

A well developed technique for conservation monitoring in multi-species management scenario is to select one or more key or representative species, and to ensure that habitat suitability for this species or a group of species is retained. Main species considered for purposes of macro-level habitat management while implementing this Management Plan in Sundarbans is tiger as umbrella species. The long-term aim will be to maximize gains in quantity and quality of habitat, and quality for these and associated species.

A survey of natural regeneration (density of seedlings and saplings per ha) in the forests will be taken. This will be complemented by photo monitoring technique, focusing on changes in plant height as a visual evidence of success of the interventions. Forest dwelling bird species will be used for assessing biodiversity status. A simple procedure of sighting and counting (either population or nests) the indicator bird species using the forests as their habitat will be employed by associating local stakeholders in identified transect walks. Benchmark measurements will be taken to establish initial set of values which will act as reference for future comparison with subsequent measurements taken periodically for assessing impacts of project interventions. A critical review of the long-term habitat management strategy based on a detailed inventory of biodiversity will be taken up during the final year of implementation of this Plan. The SRF management practices will accordingly be adjusted.

9.5 Conservation and Co-Management Capacity Building

In view of a conservation and co-management approach adopted in this Plan, enhanced focus is required on capacity building of all the stakeholders including the communities and CMCs, the leaders and staff of the MOEF and FD, and the representatives of the local NGOs and private sector engaged in activities related to the Sundarbans. This will help in strengthening and empowerment of stakeholders, and widespread adoption of conservation and co-management approach with communities and technical department. Capacity building will thus expand to include a much wider range of key groups of stakeholders, and at the same time the following activities will be implemented:

- Strengthening the capacity of existing training and education centres
- Developing and implementing integrated foundation and orientation courses, encompassing conservation and co-management themes

- Developing and implementing in-country and overseas short-term training programs
- Developing and implementing training of trainers to co-management organizations incluing local community such as village conservation fora and peoples' fora to become extension agents for peer-to-peer training of other members/villagers

9.5.1 Capacity Building Strategy

Main elements of an appropriate capacity building strategy are discussed as below:

1. Identifying the skills and capabilities: There is great necessity of imparting conservation and co-management training to the FD field staff responsible for managing the Sundarbans. FD does not have any specialized capacity for imparting PA management training. Of the many forestry subjects only one paper relates to wildlife management being taught to cadre officers at Forest Academy, Chittagong. Other subordinate staff do not receive any significant training on PA management, although wildlife management is one of the many taught subjects. There is a lack of permanent faculty on *in-situ* conservation at ecosystem and landscape levels by involving local communities. However, some forest officers have undergone overseas training on wildlife and PA management. Other stakeholders including the beneficiaries and NGO staff also need conservation training. An exhaustive conservation training plan, covering both in-country and overseas training, will be developed. A training strategy dealing with both quality and quantity of training including refresher and orientation training courses will form part of the training plan.

Skills needed can be categorized as technical skills - those related to actual technical management of the Sundarbans, and community skills – those related to dealing with people in a co-management and conservation setting. Conservation of the Sundarbans would include application of socio-economic and management principles with the desired outcome focusing on modification of human behavior to ensure protection and sustainable use of the forests and wetlands. Possible themes under community skills category would include:

- Communication skills, essential for sharing views and responsibilities for improved governance
- Extension and outreach skills to facilitate interactions with a large of local stakeholders
- Organizational development skills required for organizing and motivating co-management organizations
- Inter-sectoral coordination skills for facilitating an integrated approach among different government agencies, local stakeholders, and the members of relevant NGOs and private sector
- Natural resources economics and business management skills to be applied particularly in ensuring sustainable and equitable flow of benefits to local community
- Eco-tourism and visitors management skills to promote economic growth and entry fee benefits locally
- Conflict resolution skills to deal with inevitable conflicts that may arise as enhanced benefits are shared among key stakeholders

Technical skills in the area of the Sundarbans conservation and sustainable management would include as below:

- Sustainable management of the Sundarbans forests and wetlands with focus on habitat restoration and natural regeneration for enhancing both terrestrial and aquatic biodiversity
- Wetland and fisheries management
- Protected area management and planning
- Ecotourism and outdoor recreation with focus on visitor management and PA planning and implementation
- Community-based natural resources management skills in forestry, wetlands and fisheries
- Innovative technologies including alternative energy such as improved cooking stoves, sand filter devices for dringing water, solar energy devices, etc.
- Climate change mitigation and adaptation

2. Imparting new skills and capabilities: Obtaining and imparting the above-identified skills and capabilities can be accomplished either in-house by FD at training institutions such as Forest Academy at Chittagong by mobilizing suitable resource persons nationally, or this may require either outsourcing and/or establishing partnerships (intra-agency arrangements including DOF-FD collaboration and public-private partnerships) with universities and other relevant institutions. Professional cadre staff starting from ACF onwards can be trained/oriented in higher technical and managerial subjects whereas suboridinate staff from Forest Gaurds to Range Officers can be trained more on field oriented themes with more focus on people skills. A similar categorization may also be needed when imparting training to the members of co-management organizations and NGOs.

Adequate training infrastructure has been developed within FD under different donor funded projects including the FRMP and FSP, funded respectively by the World Bank and the Asian Development Bank. Given the present cumbersome appointment procedures it may not be possible to recruit permanent staff in FD training institutes. So networking with other training and research institutes such as BFRI and IFESCU will be necessary. And as both of these organizations are located at Chittagong, it makes sense to organize such training at Forest Academy, Chittagong.

3. Using new skills and capabilities: Field implementation of the acquired skills and capabilities will be done by regularly interacting with local stakeholders and visiting forests/wetlands. Listening to local community and instilling a sense of belongingness will go a long way in generating a trust that will help bridge the present trust deficit that has historically developed in view of erstwhile custodial and regulatory approach. Basic facilities, particularly better communication, would help re-establish link with local community. Trained FD staff should be given postings so that can use their expertise. A tenure of atleast 3 years should be allowed to thestaff at their respective place of posting. A human resources development plan and a cadre management plan with appropriate provisions for recruitment, training, posting, performance evaluation and promotion will be developed and implemented.

9.5.2 Capacity Building for Management Information System

The SEALS DPP suggests to develop a comprehensive management information system (MIST) that will require technical support to the FD field staff for its field implementation. Details of the proposed MIST and the training requirements can be seen in the approved DPP of the SEALS

9.6 Summary of Main Prescriptions

Main prescriptions outlined under the above-developed Conservation Outreach, Conservation Research, Participatory Monitoring and Capacity Building programs are summarized in Table 9.1 as below:

Table 9.1: Summary of Main Prescriptions: Conservation Outreach, Conservation Research, Participatory Monitoring and Capacity Building Programs

Year	Main Activities	Main Outputs/Success Criteria	Responsibility
1 and 2	-Understanding knowledge, attitude and practices of local stakeholders on the SRF	Local knowledge and aptitude used ind designing and implementing campaign	FD/SEALS/CMCs
	-Campeigning on biodiversity conservation and nature interpretation through electronic and print media	Aware stakeholders	FD/SEALS/CMCs
	-Developing and implementing a branding framework	SRF and Nishorgo brand a household name	FD/CMCs
	-Designing and putting up bill boards and at select places	Bill Boards	FD/CMCs
	-Developing and spreading key biodiversity messages in the landscape	Key messages widely adopted in the landscape	FD/CMCs
	-Identifying possible conservation topics for taking up applied research studies	Research topics documented	FD/CMCs
	-Holding key stakeholders consultations on the proposed list of identified research topics	A short list prepared after stakeholders consultations	FD/CMCs Stakeholders
	-Identifying and networking with interested national organizations for conducting selected research studies	Interested research organizations contacted	FD
	-Developing a set of indicators for conservation monitoring (tiger, birds)	A set of indicators selected after consultations	FD/CMCs
	-Collecting and developing benchmark data/information base with respect to core indicators	Benchmark surveys completed	NSP
	-Identifying regional and international organizations for networking and cross-learning	Relevant regional organizations contacted	NSP/FD
	-Identifying required technical and community skills	List of technical and communication skills	FD/CMCs
	-Preparing an overseas and in-country training plan for imparting training to all stakeholders	Conservation training plan finalized	FD

	-Imparting conservation education to students in the landscape schools an madrasas -Develop and implement MIST	Educated students MIST is in operation	FD/CMCs FD/SEALS
3 and 4	-Expand and continue conservation outreach and communication activities as started in theyears 1 & 2 -Prioritizing the identified research topics -Developing ToRs for expanded research and arranging budget for priority studies -Contracting interested national organizations for conducting selected research studies -Collecting and developing follow up data/information base with respect to core indicators -Maintaining regular contacts with regional and international organizations for networking and cross-learning -Implementing overseas and in-country training plan for imparting training to all stakeholders -Continue other activities as listed for the years 1 & 2	Aware and motivated stakeholders Priority list finalized after stakeholders consultations ToRs ready with required budget Interested research organizations contracted Follow up surveys completed Contacts with regional organizations maintained Training plan implemented	FD/CMCs FD/CMCs FD FD FD/CMCs FD NSP/FD
5 to 10	Continue the activities as listed for the years 3 & 4, and consolidate gains after making mid-plan period adjustments		

10. Administrative and Budget Programs

10.1 Objectives

Main objective of this program are to ensure that technical and administrative staff required to manage the Sundarbans are effectively developed, posted and their performance reviewed, and improvements in financial organizational systems are implemented aiming at the financial sustainability of the Sundarbans.

10.2 Administrative Set Up

The approved organogram (Table 10.1) will be implemented in both the Sundarbans divisions by filling existing vacancies.

Table 10.1: Approved Organoorgram for the Sundarbans FD staff

Sl. No.	Position	Circle	West Division	East Division
1.	Conservator of Forests	1	0	0
2.	Deputy Conservator of Forests	1	1	1
	Subdivisional Forests Officer	0	1	1
3.	Assistant Conservator of Forests	1	3	3
4.	Forest Ranger	1	17	12
5.	Deputy Ranger	0	28	17
6.	Forester	0	60	45
7.	Forest Guard	0	103	88
8.	Boatman	0	299	241
9.	Laskar/Khalasi	0	27	16
10.	Speed Boat Driver/Trawler Driver	0	7	7
11.	Engine Driver/Man	0	15	16
12.	MLSS	5	11	11
13.	Sareng	0	11	6
14.	Office Assistant	4	5	5
15.	Mali/Head Mali	0	5	5
16.	Radio Operator	1	2	3
17.	Sukani	0	3	3
18.	Greezer/Fire Greezer	0	3	3
19.	Driver	1	2	2
20.	Tendol	0	2	3
21.	Head Assistant	1	1	1
22.	Accountant	1	1	1
23.	Cashier	0	2	1
24.	Upper Division Clerk	1	1	1
25.	Carpenter	0	1	2
26.	Night Guard	1	1	1
27.	Sweeper	1	1	1
28.	Deck Keshob	0	2	1
29.	Oilman	0	1	2
30.	Foreman	0	1	1
31.	Draftsman	0	1	1
32.	Data Entry Operator	1	0	1
33.	Turner	0	1	1

34.	Blacksmith	0	1	1
35.	Despatch Rider	0	1	1
36.	Engine Room Keshob	0	1	1
37.	Tendol Strocker	0	1	1
38.	Electric Strocker	0	1	1
39.	Helper	0	1	1
40.	Cook	0	1	1
41.	Mechanical Supervisor	0	0	1
42.	Stenographer	1	0	0
43.	Stenotypist	1	0	0
44.	Fitter	0	1	0
45.	Cash Sarker	0	1	0
46.	Water Carrier Helper	0	1	0
47	TOTAL	23	629	511

It is recommended to implement the approved organogram by creating a third functional Divisions by merging the existing wildlife division and redeploying the approved staff of this division. Presently the sanctuaries are managed under the existing territorial Ranges of Sundarbans East and West forest divisions. Each of the three wildlife sanctuaries will be an independent operational unit with greater decentralized authority for decision-making with an assigned ACF as in-charge. Each of the three sanctuaries will be an independent management and administrative unit, headed by an ACF who will have all the administrative and financial powers.

The year-wise budget including the salary, allowances and other expenditures required for conducting official business for the above staff of FD is provided in the recently approved SEALS DPP and can be referred to.

10.3 Duties and Responsibilities

The present practice of managing each Range under an ACF (under the overall charge of DFO who will be work under the guidance of Conservator of Forest) will continue. However, each of the three wildlife sanctuaries will, as separate management and administrative unit, have an ACF as incharge, supported by adequate field staff. Main responsibilities (as per the approved organogram) of CF will, i) be responsible for overall administration of the Sundarbans Circle; ii) supervise and coordinate all the matters related to the Sundarbans including wildlife protection and management of PAs, ecological critical areas, critical watersheds, wetlands of international importance, and environmental management under Wildlife Preservation Act and other Ordinance, Rules and Regulations and Directives issued by the government from time to time; iii) be responsible to take necessary measures and efforts to fulfill national obligations towards wildlife, biodiversity and other forestry and environmental related international treaties, protocols and conventions endorsed by the government; iv) be responsible for completion of all works within the budget provision of the Circle and distribution of funds within his budget grant among the Divisions under him; v) be responsible for all correspondences relating to wildlife management from time to time; vi) identify and draw up plans and programme for ex-situ and in-situ conservation for the Sundarbans; vii) be responsible for taking programme related to conservation and management of the three PAs, supervision of environmental management and nature conservation functions outside the PAs; viii) be responsible for drawing up programme for monitoring, survey and research in the PAs in relation to wildlife and biological diversity; ix) ensure the preservation of biodiversity, conservation of gene pool, germ plasm and the natural heritage of the nation; x) be responsible for preparation of budget and revised budget of his circle; xi) be responsible for appointment, promoting, disciplinary action, disposal of appeal cases, writing of ACRs of staff falling within his administrative powers; xii) be responsible for administration and ensuring execution of all functions in the forest division under him as per Policy, Acts, Ordinance, Rules and Regulations and Directives issued by the government from time to time; xiii) be responsible for providing proper executive and operational guidelines to the field staff. Exercise control and supervision on the Divisions under his jurisdiction; ivx) be responsible for preparation of development/annual programme related to conservation of biodiversity and eco-tourism; vx) be responsible for preparation and annual inspection of divisional offices within his jurisdiction; vix) be responsible for proper execution of all development programmes within his circle; viix) be responsible for auditing of Divisional accounts and according financial and technical sanctions within his powers; viiix) be responsible for drawing and disbursing in respective offices as well as submission of accounts to the Accountant General; ixx) be responsible for inter-Divisional transfer and posting of Class III and IV staff within the Circle except the staff of his own office; and xx) be responsible for the preparation of preliminary management plan report of the Forest Divisions under his jurisdiction.

As per the approved organogram the DFOs of the Sundarbans East and West Divisions (and the DFO, Nature Conservation & Wildlife Management will, i) be responsible for overall administration, management and protection of the resources of the Division and supervise, manage and control over the matters related to forests biodiversity, wildlife, wetlands and environmental management. Strict and effective enforcement of laws, rules and regulations related to protection of forests, wetlands and wildlife including migratory birds and other amphibians and reptiles; ii) be responsible for drawing and disbursing of fund within the divisions; iii) be responsible for conservation and management of PAs, ecologically critical areas, critical watersheds and wetlands under his jurisdiction with the use of participatory resource management and conservation principles; iv) be responsible for appointment of employees of the Division falling within his powers and dealing with all matters relating to establishment including writing of ACRs of subordinate officers/staff; v) be responsible for transferring and posting of all subordinate staff within the Division except the staff of his own staff; vi) be responsible for preparation of annual budget and revised budget of the Division; vii) be responsible for exercise of powers given under Forest Act (Amendment), Bangladesh Wildlife (Preservation) (Amendment) Act and various Acts and Rules thereunder; viii) be responsible for annual and initiation of programs/activities for habitat improvement within his jurisdiction; ix) be responsible for annual and periodical inspection of forets and PAs and other offices (Range, Beats) under him; x) be responsible for management and in-situ conservation of forets and PAs and execution of all development programme within the jurisdiction of his Division; xi) be Principal Accounting Officer of his Division; xii) be responsible for all types of construction within his jurisdiction; xiii) be responsible for motivational/contact/public relation and publicity functions within the Division; and xiv) any other responsibility assigned by the CCF/DCCF/CF.

The ACF as officer in-charge for Ranges will directly report to the DFO. He will be responsible for administration, budget, planning, protection, coordination and implementation of management plan and co-management activities for Ranges and/or PAs. He will maintain liaison with other related government departments and local NGOs for smooth implementation of co-management activities. He will maintain a close liaison with the territorial staff of Sylhet division particularly in protection of forests, wetlands and wildlife of the Range/PA. The following responsibilities for ACF as officer in Charge are as per the approved organogram; he/she will i) be responsible for over all administration of the PAs, Range Office and Beat Offices within his jurisdiction; ii) be responsible for exercise of powers given under various Acts and Rules thereunder; iii) help DFO in conducting smooth administration of the Division in which they are posted; iv) help DFO in the matter of all types of construction in the Division; v) help DFO in the matter of maintenance of discipline of the Division; vi) help DFO in the matter of raising plantation and nursery for habitat improvement within his jurisdiction; vii) help DFO in the matter of execution of development programme related to protected area management and wildlife conservation within his jurisdiction; viii) help DFO in the matter of checking theft and pilferage of forest produces, fish and other NTFPs, and wildlife; ix) help DFO in the matter of checking encroachment of forestland and wetland; x) facilitating and catalyzing linkages for value chains and livelihood programs in the identified landscape zones; xi) maintain close liaison with FD staff responsible for the management of neighbouring forests and social forestry plantations; and x) any other duties assigned by the CF/DFO.

He will be assisted by a Deputy Range Officer (in discharging his duties effectively), who will be responsible for the management of field staff, budget, protection, etc. The Deputy Ranger and Forester in Charge of a Station/Camp will be responsible for all the field management activities under his jurisdiction and will be assisted by a FG/Boatman in discharging his duties satisfactorily. Adequate support staff will be provided for budgetary and administrative management. The present regulatory management systems will gradually be changed to collaborative management systems. Under the co-management approach the participants and resource management organizations will have defined functions in the management.

10.5 Financial Systems

The existing financial organization systems are adequate and appropriate in most areas but needs a detailed review in order to identify specific areas of financial strengthening in future. For example, under the existing budget codes neither there is any specific budget code for PA head nor separate budget is allocated for PA management. In many countries separate allocations are made for operational funds exclusively for the management of PAs and wildlife. This system needs to be implemented in the Sundarbans in order to ensure a certain required level of annual financial stability for *in-situ* biodiversity conservation in the PAs. The recently approved entry fee guidelines will be implemented in the Sundarbans as eco-tourism activities and entry fees for the co-managed PAs will be a good source of revenue in future.

11. The Budget

The indicative budget requirements for the implementation of the main activities of the Sundarbans IRMP are projected based on the information gathered from the approved SEALS DPP, FD field offices and official documents, and field experience and discussions. While preparing ADPs based on this IRMP it is recommended to update the costs by referring to the latest approved cost norms of the GoB including FD.

11.1 Input Requirements and Indicative Cost Estimates

This proposed schedule of inputs and costs is based on the major input requirements identified in Part II of this Plan. It is intended as both a summary of the major inputs required during the first five year life of the Plan, and as a guide to further detailed costing by FD staff charged with its implementation based on ADPs to be prepared each year. Indicative costs need revision based on learning during the mid-term Plan implementeation period and so a summary of the inputs and costs for the second five year life of the Plan are not provided.

Table 11.1: Input Requirements and Indicative Cost Estimates for the Strategic Programs

		Quantity/ Year						Unit Cost '000	Total Cost '000	
Strategic Programs	**Unit**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total**	**Taka**	**Taka**	**Notes**
1. Habitat Protection Programs										
1.1 Procurement of imageries & Udating of Land Use/Forest Cover Map for the SRF and its interface landscape	Km^2	8000					8000		1500	
1.2 Management Zones Boundary Marking										
1.2.1 signboards	nos	20	25	25	20	10	100	5	500	
1.2.2 outer and zonal boundary markers and/or posts	km	50	100	100	50	50	350	6	2100	Note 1
1.3 Formation and motivation of CMOs including mainly CPGs	CPGs (@20 partici-pants/ group)	20	30	40	10		100	3	300	
1.4 Co-management Councils and Committees formation, orientaion and regular meetings	lump sum	14	14	14	14	14	14		100	
1.5 Control of illicit felling & fishing and poaching by CPGs and CMCs	lump sum								1000	
1.6 Communication networks : maintainance of walki talkies, mobile telephones, etc.	lump sum								1000	
1.7 Provision of arms and ammunition for control of organized smugglers	lump sum								1000	Note 2

		Quantity/ Year						Unit Cost '000	Total Cost '000	
Strategic Programs	**Unit**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total**	**Taka**	**Taka**	**Notes**
1.8 Rewards/Incentives for wildlife protection efforts	lump sum								200	
1.9 Resolution of man-tiger conflicts	no. of meet-ings	50	50	50	30	20	200	2	400	
2. Wildlife Sanctuaries Management Programs										
2.1 Awareness about the 3 wildlife sanctuaries as core zone and tiger conservation & associated provisions	lump sum								200	
2.2 Core Zones Management										
2.2.1 Protecting wetlands and aquatic resources	lump sum								500	
2.2.2 Protecting forests and other biodiversity	lump sum								1000	
2.2.3 Inventory of existing wetlands as habitat for wildlife	lump sum								100	
2.2.4 Habitat Management & restoration	lump sum								500	
2.2.5 Proposal for the declaration of 4th wildlife sanctuary	lump sum								200	
2.2.6 Proposal for the declaration of a marine protected area after field assessment	lump sum								500	Note 3
2.2.7 Tiger census and threat assessments	lump sum								500	
2.2.8 Collaboration with national and international agencies	lump sum								500	
3. Sustainable Forests Management Programs										
3.1 Protection of buffer zone comprising both forests and wetlands	lump sum								1000	
3.2 Forests restoration activities for improved tiger habitat	Km^2	100	100 0	100 0	500	50 0	2500	5	12500	
3.3 Tiger census and threat assessments	lump sum								500	
3.4 Tiger conservation activities by employing response teams	lump sum								500	
3.5 Coupe demarcation and marking of trees in case felling ban is lifted	lump sum								10000	
3.6 Involving CMOs and floating villagers in biodiversity protection and in resolution of man-tiger conflicts	lump sum								200	
3.7 Planning for harvesting of NTFPs including honey	lump sum								200	
4. Food Security and Wetlands Management Programs										

		Quantity/ Year						Unit Cost '000	Total Cost '000	
Strategic Programs	**Unit**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total**	**Taka**	**Taka**	**Notes**
4.1 Protection of wetlands both in the core zone and buffer zone by involving floating fishers and CMCs										As part of 1, 2 & 3
4.2 Inventory of all the existing wetlands	lump sum								300	
4.3 Wetlands habitat restoration through excavation of silted khals	lump sum								1000	
4.4 Habitat restoration by establishing connectivity of existing khals and rivers	lump sum								1000	
4.5 Declare and maintain fish sanctuaries both in the core zone and the buffer zone	lump sum								500	
4.6 Conduct fisheries studies for estimating maximum sustained yield compartment-wise	lump sum								500	
4.7 Develop dry fish management practices for Dubla char	lump sum								100	
4.8 Implement the listed fisheries resources management and conservation measures	lump sum								8000	
4.9 Implement the listed fisheries resources improvement measures	lump sum								9000	
5. Climate Change Mitigation Programs										
5.1 Assessing drivers of deforestation and forests degradation for REDD+ proposal	Stakeholders consultations	10						5	50	
5.2 Climate change vulnerability, risks and adaptation assessments	Stakeholders consultations	5						5	25	note 16
5.3 Developing a list of possible mitigation options	Stakeholders consultations	10						5	50	
5.4 Orientation of FD staff and members of CMCs on carbon project proposal development methodologies	Session	10	10				20	10	200	
5.5 Designing and developing demonstration REDD+ and A/R project proposals	Lump sum								1000	
6. Climate Change Adaptation Programs										
6.1 Collecting secondary information on the households in the interface landscape villages	Stakeholders consultations								200	

		Quantity/ Year						Unit Cost '000	Total Cost '000	
Strategic Programs	**Unit**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total**	**Taka**	**Taka**	**Notes**
6.2 Conducting reconnaissance surveys and livelihood and value chain assessments	Stakeholders consultations								100	
6.3 Identifying a list of feasible value chains including production technologies	Stakeholders consultations								5	
6.4 Stakeholders' Consultations on the proposed Value chains ands livelihood technologies	Lump sum								10	
6.5 Agreeing on priority livelihood technologies	Lump sum								5	
6.6 Developing demonstration centers	Lump sum								500	
6.7 Identifying farmers' field	Lump sum								5	
6.8 Developing identified fields as demonstration centers	Lump sum	100	100	200	200	200		2	1600	
6.9 Imparting skill development training								1		
6.9 Finalizing operational guidelines for grants and micro-credits	Lump sum								10	
6.10 Capitatlization of groups including CPGs	Lump sum								5000	
6.11 Establishing linkages for marketing and service providers	Lump sum								50	
7. Eco-Toursim Programs										
7.1 Identifying suitable areas for eco-tourism in both core zone and buffer	Consultations and field visits	5	3				8	5	40	Note 17
7.2 Identifying existing nature trails and flagship viewing sites	No.	5	2	2	1		10	5	50	
Identifying suitable sites for Nature Camps	No.	2	4	4	1	1	12	2	24	
7.3 Toilets/Restrooms	no.	5	5	2	2	1	15	5	75	
7.4 Resting Facility	no.	2	1	1	1	1	6	20	120	
7.5 Trash cans	no.	10	10	5	5	5	35	1	35	
7.6 Identifying & training eco-guides	no.	70	20	10			100	5	500	
7.7 Preparing publicity materials	no.	15000	5000	2000	2000	1000	25000	0.015	375	
7.7 Motivating youth	no.	500	400	300	200	100	15000	0.025	375	
7.8 Film making (audio-visuals)	no.	1					1	300	300	
7.9 Developing public-private conservation partnership policy	Lump sum								100	

		Quantity/ Year						Unit Cost '000	Total Cost '000	
Strategic Programs	**Unit**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total**	**Taka**	**Taka**	**Notes**
7.10 Implementing entry fee guidelines and orientations of FD field staff	Lump sum								50	
7.11 Orienting CMCs for implementing community development activities by using entry fee revenue	No.	50	50				100	1	100	
7.12 Developing local stakeholders as service providers	No.	15	15	10	10	10	50	1	50	
7.13 Renovating existing NIC at DFO (W) office	No.	1					1	500	500	
7.14 Contacting relevant ministries and other govt. organizations including Parjatan Corporation	No.	5	5	5	2	2	19	1	19	
8. Facilities Development Programs										
8.1 Assessment of existing drinking water facilities	Ranges	2	2				4	5	20	
8.2 Development of PSF facilities	No.	5	5	5	5	5	25	50	1250	
8.3 Installing solar power units in Range Offices	No.	2	2				4	50	200	
8.4 Maintenance of existing offices and residences	No.	20	20	10	10	10	70	40	2800	
8.5 Plan, estimates and budgets developed for proposed building	Lump sum								2000	
8.6 Construction of new offices, station offices, camps, office-cum-barrack, etc	sqm						5600		12697 4	
8.7 Residiantial building : Barracks for camps, etc.	sqm						320		6974	
8.8 Residiantial building : Barracks for Security Guards, officials residences renovation etc.	No.	7					7		2585	
8.7 Renovation Ban Bhaban at Khulna and DFO WL Office	Lump sum								1000	
8.8 Renovation Ban Bhaban and DFO office boundary wall at Khulna	No.	1					1		1051	
8.8 Pond excavation	Cum	6500	300 0				9500		1450	
8.9 PSF for field offices	No.	10	5				15		1733	
8.10 RWHS for field offices	No.	50	23				73		5426	
8.11 Improved Chulli	No.	50	23				73		193	
8.12 Pontoon with Gangway (Steel)	No.	50	23				73		40000	
8.13 Wooden jetty repair and replacement	No.	20	10	10			40		26000	
8.14 5 KV Generators for field offices	66	40	26				66		4713	

		Quantity/ Year						Unit Cost '000	Total Cost '000	
Strategic Programs	**Unit**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total**	**Taka**	**Taka**	**Notes**
8.15 Repairing of existing FD boats and vessels	Lump sum								2000	
8.16 Double cab 4 WD pick ups	No.	2	1				3	2500	7500	
8.17 125 cc motor cycles	No.	4	2				6	150	900	
8.18 Bicycle	No.	6	4				10	18	180	
8.19 DFO Boat	No.	1	1				2	10000	20000	
8.20 42 ft wooden trawler (China Engine) (NPB)	No.	15	5	5	5		30	550	16500	
8.13 30 ft wooden trawler (China Engine) (NPB)	No.	5	5	5	5		20	400	8000	
8.14 Repairing of existing vessels of FD	Lump sum								30000	
8.15 Outboat Engine (75 HP)	No.	3	2				5	100	500	
8.16 Camera (Still)	No.	1	1	1			3	35	105	
8.17 Photocpier	No.	2	2				5	300	1500	
8.18 Scanner	No.	1					1	60	60	
8.19 Multimedia projector	No.	1					1	80	80	
8.20 Laptop	No	1					1	80	80	
8.21 Desktop	No.	10	5	5			20	50	1000	
8.22 External HD (data storage)	No	10	5	5			20	4	80	
8.23 Printers (Laser)	No.	4	2				6	35	210	
8.24 Printer (Color)	No.	1					1	100	100	
8.25 UPS	No.	10	5	5			20	8.5	170	
8.26 Telefax	No.	5	3				8	25	200	
8.27 Air Conditioner (2 tons)	No.	4	2				6	60	360	
8.28 Office Furniture	Lump sum								350	
8.29 Electricity Generator	No	1	1				2	250	500	
8.30 Othe office equipments	Lump sum	40%	60%				100%	600	600	
8.31 Other field equipments	Lump sum	50%	50%				100%	800	800	
9. Conservation Outreach, Research, Monitoring and Capacity Building Programs										
9.1 Conservation Outreach										
9.1.1 Understanding knowledge, attitude and practices of local stakeholders	Lump sum								100	
9.1.2 Campeigning through electronic & print media	Lump sum								1000	
9.1.3 Designing and establishing bill boards	No.	10	5	5	3	2	25	10	250	
9.1.4 Developing & spreading key messages	Lump sum								100	
9.1.5 Conservation Research										
9.1.6 Floral and faunal inventories	m-m	8	4				12	40	120	
9.1.7 Research studies	m-m	8	5	4	3		20	75	1500	
9.2 Conservation Monitoring										
9.2.1 Biodiversity health monitoring	m-m	10	5	5	5	5	30	20	600	

		Quantity/ Year						Unit Cost '000	Total Cost '000	
Strategic Programs	**Unit**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total**	**Taka**	**Taka**	**Notes**
9.2.2 Socio-economic monitoring	m-m	8	4	3	2	1	21	25	552	
9.3 Conservation Capacity Building										
9.3.1 Overseas study tours (2 DFO, 5 ACF, 10 Forest Rangers)	Person	5	5	5			15	120	1800	
9.3.2 Overseas training (Certificate Course in Wildlife Management)	Person	5	4	3			12	100	1200	note 18
9.3.3 In-country training (ACF (5), Forest Ranger (8), Deputy Forest Ranger (15), Foresters (20), Forest Guards (100), NGO staff (20)	Persons	50	30	20			100	10	1000	note 19
9.3.4 In-country training of members of user groups and co-management committees	no.	100	100	50	50	50	350	2	700	
9.3.5 Overseas tour of CMOs & FD field staff at lower level	No.	30	30	30	20	20	130	108	14040	note 20
9.3.6 MIST training	Person	50	80	70	20		200	10	2000	
9.3.7 Biodiversity management training	Person	50	40	20			110	10	1100	
9.3.8 Ecosytem management training	Person	80	50	27			157	10	1570	
9.3.8 Sustainable forest management training	Person	100	150	80	70		400	7	2800	
10. Administration and Budget Programs										**Note**
7.1 Staffing	Tk.	17546	18248	18786	18786	18786				
CF	m-m									
DCF	m-m									
ACF	m-m									
Forest Ranger/Deputy Forest Ranger	m-m									
Foresters	m-m									
Forest Guards/Boatman	m-m									
Other staff	Tk.									
7.2 Allowances	Tk.	6496	6496	6496	6496	6496				
Supply, utilities, vehicle fuel and upkeep, etc.	Tk.	60080	60080	60080	60080	60080				

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