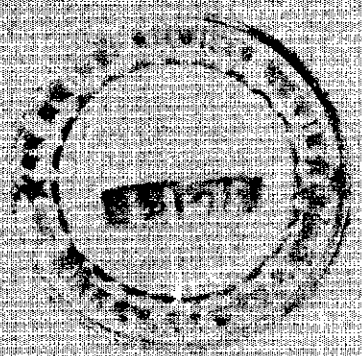
FO:DP/BGD/84/056

INTEGRATED RESOURCE DEVELOPMENT OF THE SUNDARBANS RESERVED FOREST

BANGLADESH

SUMMARY OF THE INTEGRATED RESOURCE MANAGEMENT PLAN OF THE SUNDARBANS RESERVED FOREST

PROJECT BGD/84/056



UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Dhaka, The Peoples Republic of Bangladesh, February 1998

This technical report is one of a series of reports prepared during the course of the project BGD/84/056. The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequently.

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1. INTRODUCTION

This report is a summary of the Integrated Resources Management Plan of the Sundarbans Reserved Forest (IRMP). The IRMP is a detailed document (volume 1, the Main report, is 358 pages; volume 2, the Appendices amounts to 365 pages; the third volume comprises 42 maps). In preparation of this summary it has been necessary to omit some sections entirely. On other occasions new text has been added to improve the readability and flow. It is recommended that the unabridged IRMP should be referred to for further information.

The IRMP is an advisory document for decision makers and managers. The plan provides a thorough holistic assessment of resource statuses of the whole ecosystem for the first time. The findings (1992-95) were based on the best available information and is the major output of the Forest Department (FD) and United Nations Development Programme (UNDP) project "Integrated Resource Development of the Sundarbans Reserve Forest". The project was implemented jointly by the FD and the Food and Agriculture Organization of The United Nations (FAO). Details of the terms of reference for the project can be found in the Project Document (PRODOC) (UNDP/FAO, 1990). The outputs of the project, measured, against the terms of reference, are discussed in the Terminal Report. They are not relevant to a forward looking management plan.

This summary synthesises the major findings and analyses; it records the recommendations and summarises the plan for future management of the Sundarbans Reserved Forest (SRF). In an attempt to make this summary concise, descriptions of how the fieldwork was undertaken and in some cases how the results were analysed are omitted. References to the main text of IRMP and other documents are made so that further clarification can be accessed. The background and description of the area are included, to put the report in context for those not familiar with the Sundarbans and Bangladesh.

One major point is emphasised. The IRMP is not, and was never intended to be, an operational management plan in the form of traditional working plans. It does not prescribe which compartments should be cut and when, and it does not estimate the yield and returns from these operations. It does not prescribe the number and types of fishing gear that should be allowed or the allowable off-take of other non-wood resources. The necessary inventories and stock assessments were not available when the plan was prepared. The IRMP does however, identify the main stakeholders and it describes various strategies and methodologies that can be adopted so that composite operational plans and development programmes can be prepared in the future. The plan identifies gaps in information and describes how proposed reforms in management could achieve objectives set out in the National agenda. However, before implementation, important decisions should be addressed by the Government of Bangladesh, regarding the future institutional arrangements for management of the resource. Scientifically sound options for the multisectoral approach to integrated management are given together with the likely outcomes of each.

This summary is divided into 3 main sections: the first section describes the current situation; the second evaluates the problems that arise from the first and the last describes a series of options for future development and management including some indicative investment profiles.

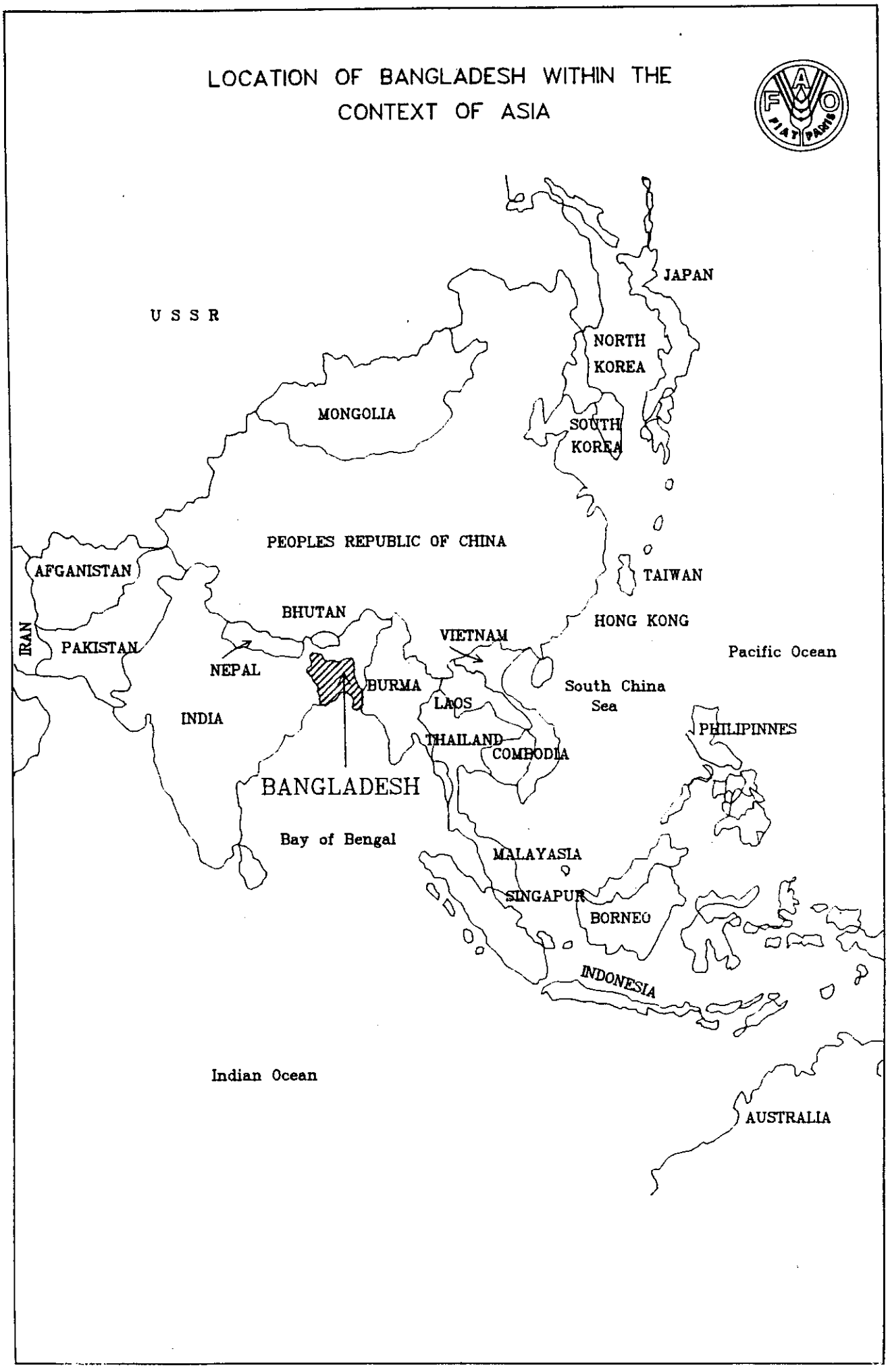
2. CURRENT SITUATION

2.1 Background

The Sundarbans Reserved Forest (SRF), set astride the river deltas of south-west Bangladesh forming the largest contiguous mangrove forest in the world. It constitutes 51% of the Nantion's Reserved Forests and together with its associated intertidal and marine waters represents a rich and diverse ecosystem with great potential for sustainable use management (UNDP/FAO, 1990).

Whilst the physical boundary of the SRF has hardly changed since it was first demarcated in 1875, the Sundarbans today is wholly surrounded on the land ward side by human communities and their farms. The energy flux of the system is governed by tides, the intensity of the annual floods, the sediments they bring with them and differing levels of salinity.

Map 1 Location Map of the Sundarbans Reserved Forest in Bangladesh



Combined, this dynamic amalgam of physical factors influences the distribution of plants and animals and leads to development of fascinating physiological adaptations. Pollution from Mongla Port and the expansion of industries in the Khulna region and those located on the Hoogly and Padma river systems pose a serious threat to the ecosystem.

2.1.1 Location and Area

The Sundarbans Reserved Forest is located in south-west Bangladesh (map 1). It is situated within Khulna administrative division and includes parts of Khulna, Satkhira and Bagerhat districts. The western boundary follows the Harinbhanga-Raimangal-Kalindi rivers and abuts with the Indian Sundarbans. To the south the Forest meets the Bay of Bengal. At the present time there is no legally tenable definition of the southern boundary line. For the purposes of the IRMP two boundary lines (the approximate Curtis (1933) line and the national marine boundary line) have been used. To the east it is bordered by the Baleswar river and to the north there is a sharp interface with intensively cultivated land.

The areas of the Sundarbans Reserved Forest are given in Table 1.

Table 1 Table Showing the Area of Sundarbans Reserved Forest

Area Type	Area (km^2)
Total area inside SRF boundary	6 017
Total land area	4 143
Exposed sand bars	42
Area covered by forest	4 069
Existing wildlife sanctuaries	301
Total area if extended into Bay of Bengal to national marine border (12 nautical miles)	7 620
Additional marine area (inc. in total above)	1 603

2.1.2 History

The forests of the Sundarbans have been exploited by man for many years. Indeed the original reservation of the forest, over 100 years ago was "*not so much for the realisation of profit as the preservation, for public benefit, of a valuable property which was being recklessly destroyed*". (Heinig, 1892). The area reserved was only a small proportion of the forest that existed during the early part of 19th century. (Prain, 1903).

The area was first mapped by the Surveyor General in the 1760s, following acquisition by the East India Company in 1757 from the Mughal Emperor, Alamgir II,(Hunter, 1876). The first Forest Management Division to have jurisdiction over the Sundarbans was established in 1869 and the first management plan was introduced in 1892 (IUCN, 1994).

Early management simply concentrated on revenue collection and by the enforcement of felling rules to reduce the over cutting in the eastern portion of the Sundarbans.(Chaffey *et al*, 1985).

More recently forest resource management has shifted to increase the emphasis and regard for both environmental and socio-economic issues.

2.1.3 Legislation

The Sundarbans were first reserved in 1875 and 1876. The initial reservation covered 5 418 km^2. There were minor changes between 1890 and 1910. These were consolidated and re-notified in the official gazette in 1915. In 1932/33 a further 20 square miles was added to give a total area of 6 003 km^2. (Choudhury, 1964).

At partition, the SRF was divided between East Pakistan and India, with the new international boundary following the Harinbhanga-Raimangal-Kalindi river system. The new area covered some 4 071 km^2 (land area). The boundary has remained unchanged since[1].

The most important laws, rules and government orders that cover the Sundarbans are:

- The Forest Act (Act No.XVI) of 1927
- The National Forest Policy of Pakistan, 1955
- The National Forest Policy of Bangladesh, 1979
- The Wildlife Ordinance 1973 and Wildlife Act, 1974
- The Brick Burning Act, 1991
- The East Bengal Protection and Conservation of Fish Act, 1950
- The Protection and Conservation of Fish (Amendment) Ordinance, 1982
- The Protection and Conservation of Fish Rules, 1985
- The National Environment Policy and Environment Act - NEMAP (under preparation)
- The National Conservation Strategy - NCS

The effects of these statutory instruments on the management of the SRF are discussed in IRMP section 8.2.

2.1.3.1 The Forest Act 1927

The purpose of the Forest Act of 1927 was to consolidate the previous rules relating to forests, the transit of forest products and the duty leviable on timber and other forest produce. The Act was up- dated on several occasions by both the Government of East Pakistan and the Government of Bangladesh (Choudhury, 1989). The Act is reproduced as IRMP Appendix A6.

The Act makes the following provisions:

- to grant the Government the power to reserve forests;
- to grant the Government the power to impose duty on timber and other forest produce;
- to prohibit the acquiring of rights over the land described in the notification except in accordance with such rules as may be made by the Government;
- to prohibit the clearing of forest, or breaking up any land for cultivation or any other purpose;
- to prohibit the removal of timber;
- to prohibit the felling of trees;
- to prohibit hunting, shooting, fishing, poisoning of water or the setting of traps or snares; and,
- to allow any act done by permission in writing of the Forest Officer or under any rule made by the Government.

The Act, at the moment, is interpreted to prohibit any form of permanent structure or settlement within the SRF with the following exceptions:

- Forest Department buildings;
- the Mongla Port Harbour Authority Rest House at Nilkamal;
- the Bangladesh Navy Camp at Nilkamal;
- a semi permanent camp for the extraction of timber by the Khulna Newsprint Mill
- concrete cyclone shelters on Dubla Island;

1 The difference in the area figure quoted here and the one given in Table 1 could be due to differences caused by accretion and erosion and also different methods of mapping and calculating area

- a semi-permanent hospital near Nilkamal.

Under terms of the Act the Forest Department issues permits to allow various operations in the Forest Reserve.

2.1.3.2 Government Orders

Under the Forest Act 1927 (clause 76), the Government has the power to make new rules which can affect the management and regulation of the forests. These new rules are issued in the form of Government Orders which are set by the Ministry of the Environment and Forests (MOEF). The levels of Forest Royalties are set and periodically revised by Government Orders.

The Government Order which has had the biggest implication to the SRF is the moratorium on the felling of all trees within Natural Reserved Forests. This in effect led to the cessation of all felling in SRF during 1988.

For the SRF two exceptions to the moratorium are:

- an initial annual allowable cut of 2.2 million cft of Gewa (later increased to 4.7 M cft) for the newsprint at the Khulna Newsprint Mill. (Hussain et al.,1990).
- The harvesting of Sundri with more than 50% of the crown dead due to die back is permitted by approval of the Secretary for MOEF. This has now been modified to allow the trees showing any symptom of top-dying to be removed.

2.1.3.3 Agreements

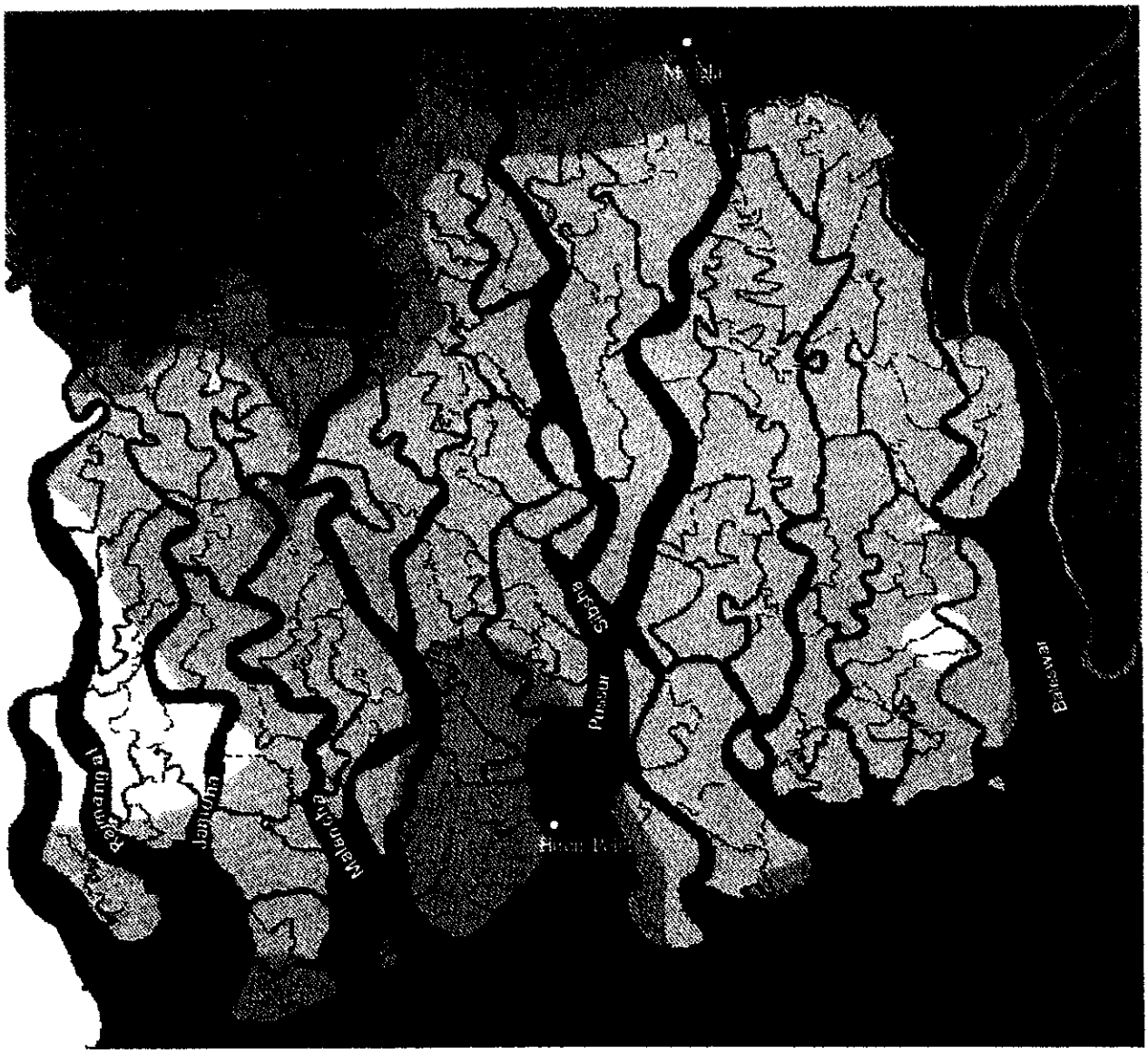
Agreements have been made by the Government for supply of wood products to certain industries notably:

- Khulna Newsprint Mill Limited (KNM)
- Dada Match Factory
- Khulna Hardboard Mill (KHBM)

2.1.4 Climate

The climate is classified as humid, maritime and tropical with a marked seasonality shared between heavy monsoon rains and a dry, relatively cool winter. The monsoon coincides with the arrival of the moisture-laden south-west trade winds during the period May to October. This is a time when mean temperatures reach 35°C, with maxima of over 40°C, and high humidity peaking at around 95%. The monsoon declines with a change in wind direction to the north-east ushering in cool dry winters which last until March. During this time the days are sunny, skies clear and temperatures equable. The months of May and October (pre and post monsoon) are noted for violent short duration thunderstorms and severe cyclonic storms generated in the Bay of Bengal. Nearly 80% of the storms occur during these months.

Maximum Flood Depth, Flood 1988



Depth (m)	1.00 - 1.50	2.50 - 3.00
0.00 - 0.50	1.50 - 2.00	Above 3.00
0.50 - 1.00	2.00 - 2.50	Not mapped

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HYDRAULIC MODELLING STUDY

SWMC

Mean annual precipitation for Khulna during the period 1947 to 1978 was 1 836 mm, with the average highest rainfall occurring in June (349 mm) and the lowest in December (15 mm).

2.1.4.1 Cyclones

The SRF, located near the apex of the Bay of Bengal, is in the immediate path of cyclonic storms generated over the sea. Cyclones and tropical storms are associated with strong winds and low barometric pressure, which combine to form surges of water along the coast (SWMC, 1995). Major cyclones have been reported for centuries causing loss of human life and destroying vegetation. During the last 125 years more than 42 cyclones have crossed the coastal belt of Bangladesh, of which eleven tracked through the Sundarbans. In November 1988, a cyclone that hit the Sundarbans coastline had a wind speed of 160 km/hour produced a 2.8 m wave surge above normal tidal level at Mongla and killed much wildlife and devastated other forest resources (Statistical Yearbook of Bangladesh, 1990). Data from this storm have been used by the Surface Water Modelling Centre (SWMC, 1995) to model the tidal surge. This is presented graphically as map 2. The effect of the surge would have been considerably greater if it had not occurred at low tide.

Records available at the Surface Water Modelling Centre (SWMC) show that cyclone occurrences have averaged 1 every 5 years in the area since 1882. The frequency appears to be increasing this century from 1 in 3 years in 1950 to around 1 in 2 years now.

2.1.4.2 Sea Level Rise

There is growing literature and extensive research on the "greenhouse effect". Bangladesh heads the league of the 27 most vulnerable countries (IUCN, 1995). The expected sea level rise (SLR) of 83 cm by the year 2050 is would be disastrous for the Sundarbans (WHOI, 1986).

Current trends in climate change, extrapolated to the middle of the next century, predict a serious impact upon coastal mangroves but which could be ameliorated by isostatic movement, increased delta building or a reversal of the trends themselves. Models of climate change caused by CFC emissions and other causes of global warming are possibly not yet accurate enough to provide more than a warning.

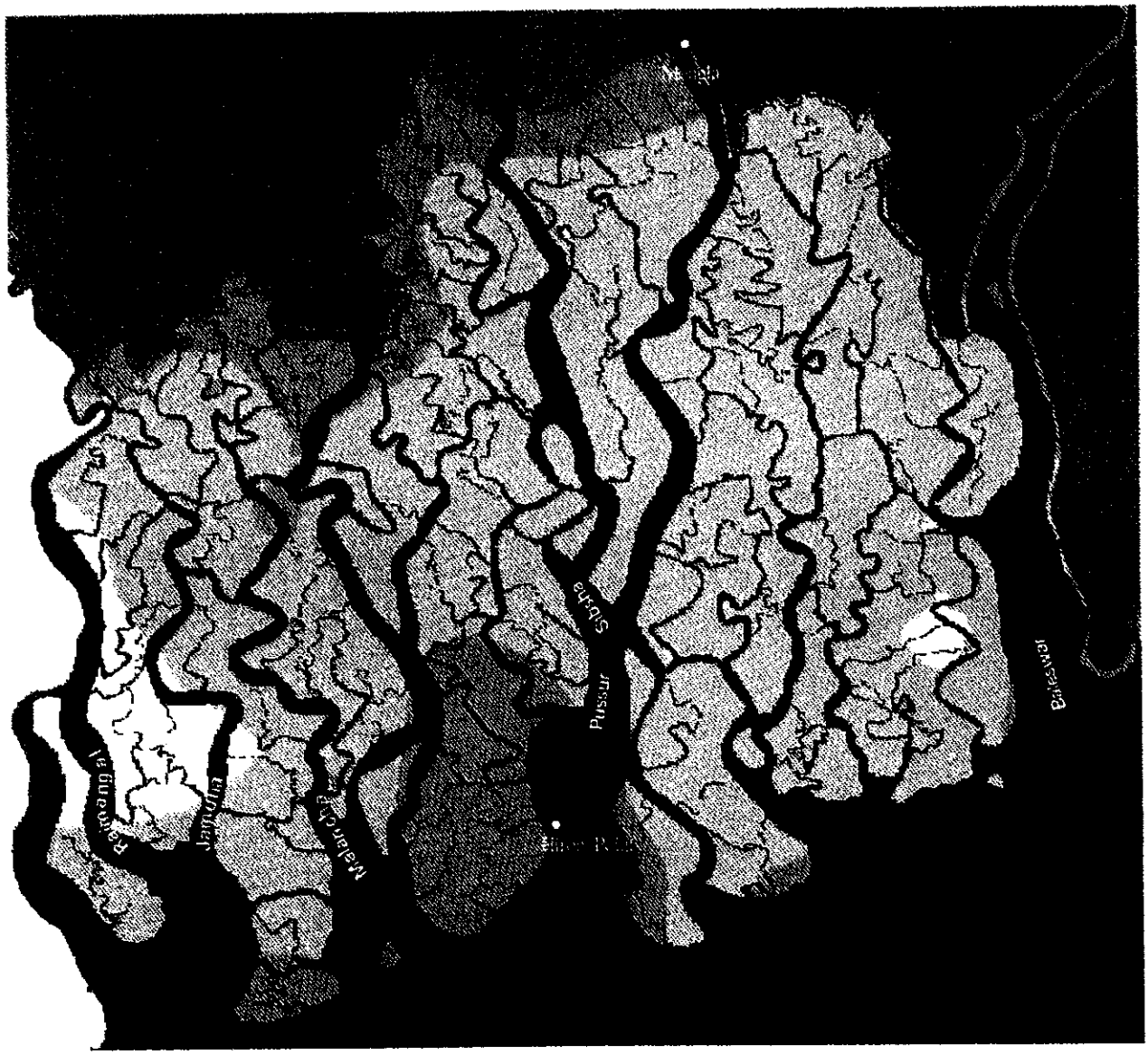
2.1.5 Soils

Unlike the forest inventories a complete soil survey has never been accomplished. Research along non-random transects by Bhuiyan, 1994; Karim, 1988; Chaffey *et al.*, 1985; Hassan, 1982 offered data which are sometimes conflicting particularly in relation to the phenomena of Top-dying of Sundri and occurrence of acid sulphate. They are though of help in describing soil types and associated vegetation.

Four sets of soil data have been consolidated in IRMP Volume 2, Appendix A35, covering the period 1985-1995. These relate to wet and dry seasons and are set out so that comparison may be made with IRMP Map 4 and vegetation maps listed in IRMP Appendix A28.

The link between the soil and plants types is unambiguously recognisable on the 1:50 000 vegetation maps (IRMP Appendix A28).

Maximum Flood Depth, Flood 1988



Depth (m)		
0.00 - 0.50	1.00 - 1.50	2.50 - 3.00
0.50 - 1.00	1.50 - 2.00	Above 3.00
	2.00 - 2.50	Not mapped

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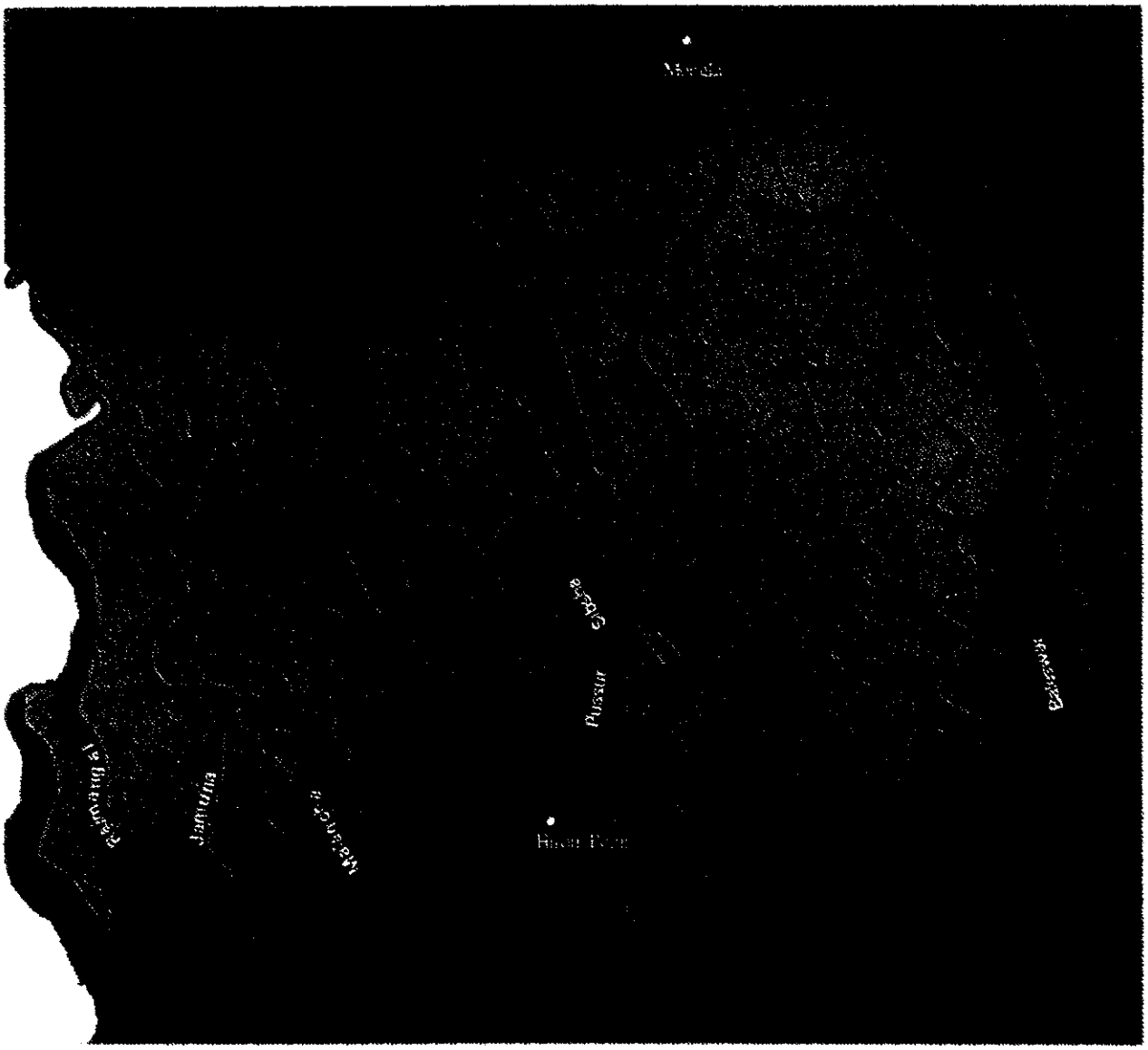
HYDRAULIC MODELLING STUDY

SWMC

Plate 3.2

Digital Elevation Model of The Sundarbans



Elevation (m) PWD Datum				
1.0 - 1.1	1.4 - 1.5	1.8 - 1.9	2.2 - 2.3	
1.1 - 1.2	1.5 - 1.6	1.9 - 2.0	2.3 - 2.4	
1.2 - 1.3	1.6 - 1.7	2.0 - 2.1	2.4 - 2.5	
1.3 - 1.4	1.7 - 1.8	2.1 - 2.2	Above 2.5	

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HYDRAULIC MODELLING STUDY

SWMC

Plate 2.1

The soils of the SRF are derived from a mixture of deltaic flood plain deposits and tidal marine deposits. The surface soil is a slightly saline silty clay loam overlying alternating layers of clay and sand. In general, soil fertility decreases from east to west and from north to south (Choudhury 1962). In the north and east portions of the Sundarbans, relatively high fertility is maintained by annual silting.

Although the soils have practically no profile development (Bhuiyan, 1994; IUCN, 1994), studies indicate that there are recognisable variations in characteristics at different depths depending upon the local topographical and drainage patterns.

Other factors which affect the nature of SRF soils are: the marked the seasonality of precipitation and the accompanying fluctuations in water depth; the duration of flooding; and salinity levels. None of these is static. Preliminary analysis of soils and water salinity data indicate a remarkable lack of correlation between salinity concentrations in water and surface soils. (Rahman and Bhuiyan,1995)

Partial compaction, due to a short period of drying out in the dry season, gives the soils high bulk density. The characteristics of the parent material dominate in the soil morphology. (Hassan, 1983).

2.2 Hydrology

The hydrology of the Sundarbans is dealt with in detail in the IRMP (section 3.5.), The Hydraulic Modelling Study (SWMC,1995) and The Hydrological Study of the Sundarbans (Wahid, 1995). Some of the results of the Hydraulic Modelling Study are presented here as maps 2 to 5.

The whole ecosystem of the SRF is entirely dependent upon the hydrological regimes and their characteristics. The scientific study of hydrology is therefore fundamental to the understanding of all other disciplines.

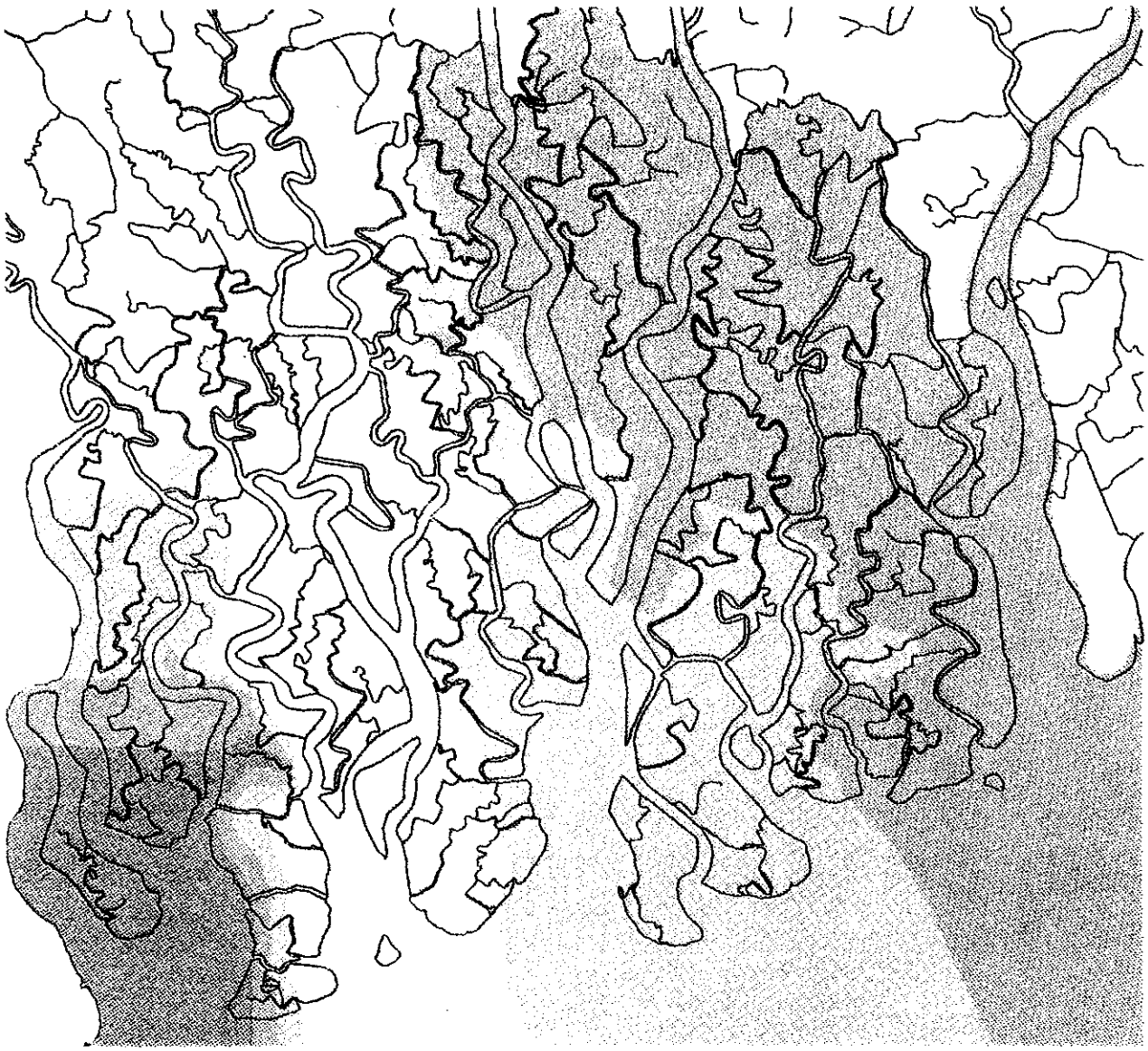
The SRF is a relatively small but very complex part of the larger river network of the south-west region of Bangladesh. In hydraulic terms, this represents the entire area extending south of the Ganges to the Bay of Bengal, and west of the Meghna estuary to the Indian border. The northern part of the region is gently sloping, with land elevations in the range of 6 to 14 m. The rivers in this area are fed from local runoff, plus spill flows from the Ganges and Meghna rivers. The Gorai is the largest distributary of the Ganges, and is the major source of freshwater for much of the region. South of Khulna-Jessore, the topography flattens out; land elevations in the SRF and surrounding areas range from 1.0 to 2.5 m (map 3). Consequently tidal action dominates the hydraulics of the river systems in this area.

Tides in the Bay of Bengal are semi-diurnal, with a period of approximately 12½ hours. From the coastline, the tide propagates up the main estuaries in the Sundarbans; the Raimangal, Jamuna, Malancha, Passur, Sibsa and Baleswar. From these main rivers the tidal waves spread into the smaller channels, which penetrate the forest. The average tidal change at Hiron Point on the coast is approximately 3m and there is time lag of about 2½ hours between the time of high tide at Hiron Point on the coast and at Nalian on the land ward edge.

Flows in the smaller cross channels which connect the main estuaries depend on the timing and magnitude of the high water. In some cases the difference in timing may cause a net flow of water from one estuary to another, which may vary in direction depending on the prevailing conditions. In other instances the timing and magnitude of the incoming tidal waves in the connecting channels may coincide, forming complex interface patterns and stagnation zones with low water velocities. Such zones are important as they constitute possible areas where channel siltation may be taking place (map 7).

Freshwater flows enter the forest through five main rivers: Kobadak, Kholpetua, Passur, Sibsa, and Baleswar. These are fed during the monsoon by runoff from the polder areas north of the forest and indirectly by the Gorai river and other spills from the Ganges and Meghna rivers. In the dry season, these sources of freshwater become diminish as the Gorai becomes dry. (SWMC, 1995).

Minimum Salinity, Monsoon Spring Tide - September 1994



Salinity (ppt)

0 - 2	8 - 10	16 - 18	24 - 26	Not mapped
2 - 4	10 - 12	18 - 20	26 - 28	
4 - 6	12 - 14	20 - 22	28 - 30	
6 - 8	14 - 16	22 - 24	Above 30	

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HYDRAULIC MODELLING STUDY

SWMC

Plate 4.2

2.2.1 Salinity

Salinity conditions in the tidal channels are dependent on the freshwater flows in the rivers entering the forest and the salinity on the coast. The salinity of the coastal waters is in turn affected by the freshwater flows discharging into the Bay of Bengal. The enormous volume of water discharging into the bay through the Meghna estuary and smaller rivers during the monsoon is such that it affects the salinity along the entire Bangladesh coast. During the monsoon a huge plume of brackish water extends from the coast and pushes the saline front far out into the bay, but this decreases with distance from the Meghna. The western Sundarbans therefore experiences higher salinity levels. This is shown graphically as map 4.

During the dry season as the freshwater flows decrease, the salinity along the coast gradually increases. The system never reaches equilibrium as salinity is still increasing when the first monsoon river flows rapidly flush the saline water from the estuaries. Maximum salinity spring tide in February 1995 is shown as map 5

Map 6 is a duration map showing how long areas within the SRF have a greater salinity than 15 ppt. Table 2 shows the variation in salinity between monsoon and dry seasons; during the monsoon, over 60% of area has salinity of less than 4 parts per thousand whereas in the dry season 60% of the area has a salinity of greater than 16 ppt.

Table 2 **Percentage of the SRF Exposed to Different Salinity Levels for Monsoon and Dry Season**

Salinity Range (ppt)	Monsoon		Dry Season	
	Spring	Neap	Spring	Neap
0-4	62	62	6	7
4-8	18	17	3	2
8-12	14	15	6	9
12-16	6	5	17	20
16-20			26	28
20-24			30	24
24-28			12	10

source: SWMC (1995)

2.2.2 Sedimentation

Mangrove areas are characterised by sedimentation and the sequence of accretion and erosion followed by emergence, settlement and subsidence. Lowered areas may then become buried by sediments.

Vast quantities of sediment are carried from the upper river catchments in India and Nepal and are deposited in Bangladesh. These sediments are the base material which formed the Sundarbans delta and which continue to accumulate there or are carried out to the Bay of Bengal.

During the rainy season sediments that have accumulated in river beds are flushed to the sea by rivers which pass through the SRF. Annually deposition occurs on the forest floor. The pattern is far from simple as a significant proportion of the sediments are swept out to sea but are probably then brought back into the forest by the tide. (Grepin, 1995; IUCN, 1994 and SWMC, 1995).

Stream flow, currents, turbulence, tidal effects and seasonal flooding modified by, poldering and extreme events, all affect the rates and locations of sedimentation. These in turn affect the physical structure of the environment and the successional states of plant communities.

Maximum Salinity, Dry Season Spring Tide - February 1995

Salinity (ppt)

0 - 2	8 - 10	16 - 18	24 - 26	Not mapped
2 - 4	10 - 12	18 - 20	26 - 28	
4 - 6	12 - 14	20 - 22	28 - 30	
6 - 8	14 - 16	22 - 24	Above 30	

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HYDRAULIC MODELLING STUDY

SWMC

Plate 4.5

Salinity Duration Map (Above 15 ppt condition)

Duration (in months)

- Less than 1 month
- 1 month
- 2 months
- 3 months
- 4 months
- 5 months
- 6 months

Note: Colour shadings indicate Duration of Water Salinity in months

HYDRAULIC MODEL STUDY OF THE SUNDARBANS

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SWMC

Although it has not been possible to make reliable quantitative assessment of the rate and pattern of sedimentation, there is evidence gathered for the Chalna, Mongla and Kharma Khal areas that indicates that because of the continued reduction of fresh water inflow from upstream, the annual silt load is not being flushed down during the monsoon and many rivers are silting up. It is possible that due to soil elevation there could be changes to the floristic composition (Grepin, 1995).

In the medium term, (5-10 years), the sedimentation problem may become prominent with consequential changes, not only in the nature of the mangroves but of the entire environment opening up new options of land use and resource management. For example Kharma Khal has become completely silted up in less than 10 years; FD launches (draught: 2 m) were crossing this Khal at high tide in 1986/87. Qualitative analysis by SWMC (1995) showed that where there was interference between tidal waves running in conflicting directions occurs sediment deposition may be taking place. Map 8 shows the tidal meeting points.

It has been observed that top dying Sundri, on a newly accreting site, is being replaced by Kankra, growing on fresh sediment overlaying degraded organic matter. Tall Sundri trees are often found in low lying areas behind levees (Grepin, 1995). These areas are subject to prolonged inundation and during tidal surges are exposed to sudden and excessive siltation. Prolonged water-logging, i.e. 4-6 weeks, is known to kill most mangrove species (Saenger, 1987).

2.2.3 Water Pollution

All kinds of waste - solid or liquid - are dumped into the rivers. This waste ultimately finds its way into the Bay of Bengal through the Sundarbans. This could produce changes in the physical and biological characteristics of the ecosystem (Wahid, 1995).

Pollution can either originate from specific sources such as industrial sites or from diffuse sites such as ocean currents or agricultural runoff. The level of ground water contamination from agricultural runoff is unknown.

There are about 165 industries in Khulna which discharge untreated waste into the Bhairab-Rupsa river system. In addition, several match factories, the Khulna shipyard and fish processing units discharge effluent into the Rupsa river. Khulna Newsprint Mill, Goalpara Power Station, some jute, hardboard and steel mills discharge untreated wastes into the Bhairab river. From the Bhairab the pollutants are transported to the Sundarbans through the Pussur-Sibsa system.

Oil pollution also affects the SRF (Wahid, 1995; Grepin 1995). Bilgewater and crude oilslicks frequently occur, derived from the mechanised boats and ships which travel along the Pussur River to Mongla Port (a distance of about one hundred kilometres through the SRF). Recently, two severe oil spills occurred in the Bay of Bengal, one of which caused an oil slick of about 64 Km along the SRF sea face (SWEDMAR, 1994). Under present operating rules it is estimated that accidental oil spillage, oil slicks, ballast and bilge water discharges will increase four fold by the year 2000 (ESCAP, 1988).

The Hoogly estuary in West Bengal is probably the most polluted estuary in the world discharging about half a billion litres a day of untreated wastes. However a comparison of environmental conditions in the estuary in 1960 and 1988 showed that there were no significant changes in the chemical parameters. The regular flushing by tidal water had evidently taken most wastes out to sea (SWEDMAR, 1994). This could mean that pollution discharged from the Hoogly estuary into the sea could be carried into the SRF (Wahid, 1995).

In the greater district of Khulna, the area of land under cultivation between 1983 and 1989 remained almost constant; during the same period fertiliser use increased from 45 kg/ha to 247 kg/ha. The trend is expected to continue.

Many toxins are synergistic in that the combined effect of two or more pollutants acting together has greater pollution potential that would be expected from the simple sum of the individual effects. Temperature, salinity and dissolved oxygen greatly increase the effects of most pollutants (Wahid, 1995).

Toxins accumulated in soils can lead to hindrances in microbial processes and mineralisation, thereby impeding plant growth, or may be directly taken up by plants. Oil pollution alone can cause defoliation and mortality to mangroves and can damage breeding grounds and nurseries of both fish and crustaceans. (SWEDMAR, 1994)

Coastal and marine fisheries are also affected. Qualitative deterioration reduces the nutritional value of fish. The thin layer of oil on the water surface hampers light penetration and air-sea gas interaction, affecting the multiplication of plankton. This affects physiology of marine fish living on plankton. Fish can also absorb oil directly, resulting in tainted fish tissue. The aromatic hydro-carbons present in crude oil are persistent and carcinogenic. Since they tend to accumulate in fish tissues, they be can passed further up the food chain.

Although water pollution has become widespread in recent years, there has been no systematic study assessing the impacts of pollution on the mangrove forests and the fisheries.

2.2.4 Potable Water

There is no dependable organised water supply system within the SRF and generally, the scarcity of potable water is acute. The river water is highly turbid, saline and contaminated with pathogens for most of the year. Out of 69 FD offices inside the SRF, only 3 use tube-wells while 66 collect their supply from ponds which trap rainwater during the monsoon. At only 3 locations are sand filters available. The SRF FD Inventory of Potable Water Sources is provided in IRMP Appendix 30.

2.3 Ecology

2.3.1 Flora

A total 245 genera and 334 plant species were recorded in the Sundarbans by Prain in 1903. Chaffey and Sandom (1985) provide a list of trees and shrubs (IRMP Appendix A18).

Mangrove vegetation was at one time distributed along much of the coastal belt of south-western Bangladesh but is now confined to the SRF and offshore chars and islands stretching as far east as the relic forest of Chakaria near Cox's Bazar. While mangroves in other parts of the world are characterised by members of the ***Rhizopheraceae, Avicenniaceae*** or ***Lagancullariaceae***, the mangroves of Bangladesh are dominated by the ***Sterculiaceae*** and ***Euphorbiaceae*** (IUCN, 1994). Sundri, ***Heritiera fomes***, is the dominant species.

Generally it is considered that forests in the northern and eastern parts of the SRF are better supplied with freshwater and are floristically richer than those in the south and west. Indicators are the quality of Sundri and Golpatta, ***Nypa fruticans***, which become progressively less frequent and smaller in the south and west. Historically three principal vegetation types have been recognised in broad correlation with varying degrees of water salinity, freshwater flushing and physiography. These vegetation types are primarily found in the following regions of the Sundarbans:

1. Sundarbans east, where freshwater and Sundri dominate interspersed with Gewa, ***Excoecaria agallocha***, and Passur, ***Xylocarpus mekongensis***, with Kankra, ***Bruguiera gymnorrhiza***, occurring in areas subject to more frequent flooding. Here there is an understorey of Shingra, ***Cynometra ramiflora***, where soils are drier and Amur, ***Amoora cucullata***, in wetter areas and Goran, ***Ceriops decandra***, in more saline places. Golpatta palm is widespread along drainage lines.
2. Sundarbans south, where there is the greatest seasonal variation in salinity levels (Maps 4 and 5) and possibly represents an area of relatively longer duration of moderate salinity (Map 6). Gewa is the dominant species, it is often mixed with Sundri. It is also frequently associated with a dense understorey of Goran and sometimes Passur.
3. Sundarbans west supports sparse Gewa and dense stands of Goran and discontinuous patches of Hantal palm, ***Phoenix paludosa***, on drier ground and river banks and levees.

Sundri and Gewa occur prominently throughout the area with discontinuous distribution of Dhundal, ***Xylocarpus granatum***, and Kankra. Among grasses and palms ***Portresia coarctata, Myriostachya wightiana, Imperata***

cylindrica, ***Phragmites karka***, and Golpatta are well distributed. Keora, ***Sonneratia apetala***, is an indicator species for newly accreted mudbanks

During the forest inventory of 1981 to 1983 (undertaken by ODA (Overseas Development Administration of the United Kingdom) and the Forest Department) the forest was stratified into thirteen forest types based on floristic characteristics and a further four categories of non-forest (Table 6). These were further sub-divided by height class and canopy closure. The addition of some minor floristic differences meant that 302 forest types were identified and mapped. (Chaffey *et al*, 1985). These maps have since been up dated and digitised and are reproduced in Volume 3 of the IRMP as 15 maps at 1:50 000 scale.

As part of the Forest Resource Management Project (FRMP), 1995 aerial photos have been interpreted. These are now in the process of being digitised. The interpretation of the new photographs is following the same ODA forest types. Once the new interpretations have been digitised interesting comparisons will be possible to show not only the changes due to accretion and erosion but also the changes in forest type.

2.3.2 Fauna

Although the faunal resource of Bangladesh has recently diminished (Ahmad, 1981; Hussain, 1979; Khan, 1985; Phillipson, 1985; Seidensticker, 1980; Blower, 1985; Tamang, 1993; IUCN, 1994), the SRF retains good wildlife habitats. The total mangrove ecosystem, including the Indian portion, has a contiguous area of 10 000 km^2 and this provides ample space for wildlife. Table 3 lists the fauna by family and species found in Bangladesh and for the Sundarbans. This shows the importance of the SRF for the conservation of fauna.

Table 3 Fauna of Bangladesh and the Sundarbans Reserved Forest by Family and, Species

Group	Total Families in Bangladesh	Total Families in Sundarbans	Percentage %*	Total Species in Bangladesh	Total Species in Sundarbans	Percentage %*
Mammals	35	14	40	119	42	35
Birds	64	39	61	660	315	48
Reptiles	20	16	80	124	59	48
Amphibians	04	04	100	19	08	42
Fish	133 (110)	39?	35	474 (260)**	120 (65)***	25+

Khan (1985)
Tamang (1993)
Harvey (1989)

* Percentage recorded for the Sundarbans expressed as a percentage of Bangladesh as a whole.

** Rahman (1989),Hussain (1971)

*** Total number of species (65) recorded to date 30/11/93 in BGD/84/056. No definitive list for entire country. Freshwater zone only in brackets (Rahman 1989), marine and estuarine fish, Hussain (1971).

Table 4 lists the estimated numbers of some important mammals inside the Sundarbans.

Table 4 Estimates of the Population of some Important Mammals within the SRF

Animal	Numbers
Tiger	362
Spotted Deer	80 000
Wild Boar	20 000
Rhesus macaque	40 000
Otter	20 000

Source: Tamang 1993

The following species or groups of animals are considered to be of particular importance:

- Bats strong following among wildlife specialists;
- Tiger main national animal therefore of inestimable value; man killing behaviour;
- Fishing cat small but common secondary carnivore;
- Spotted deer common sub-continental deer but unusual in this habitat;
- Wild boar common and with much commercial potential;
- Barking deer rarely seen but well represented;
- Crocodiles infrequently seen but important in food chain and ecological stability;
- Otters of great value for biodiversity management and a tourist attraction with traditional fishermen;
- Turtles strong interest for wildlife conservation. The protection of breeding areas is now urgent;
- Python infrequently seen. No longer occurs in Indian Sunderbans.;
- Dolphin indiscriminately harvested.

Of these, the tiger, dolphin, crocodile and turtles are outstandingly important in wildlife management planning and tourism development. They are high profile and vulnerable animals they are strong indicators of the general condition of wildlife and its management.

Although there are wildlife sanctuaries within the SRF and the whole of the Sundarbans represents valuable habitat, management of the wildlife resource is at present virtually non-existent.

Lists of Mammals, Birds, Fishes and Crustaceans, Molluscs, Amphibians and Reptiles, and Insects are given in Appendices 21 to 27 of the IRMP. A study of wildlife was undertaken by Tamang (1993) and the insects of the SRF were investigated by Chowdhury in 1994/95.

2.4 The Wood Resource

The Wood Resource is defined as the source of products arising from the woody parts of a tree. Timber and firewood are therefore included, other products derived from trees such as leaves for fodder, bark for tans and dyes and sap for alcohol are excluded.

2.4.1 Area of Forest Types

The production forest is the forest used for the utilisation of timber, firewood and other products. The production forest of the SRF is thus classified as the total forest land area less the Wildlife Sanctuaries.

For inventory purposes, the forest is stratified into forest types with similar mixtures of species and or qualities of tree. In 1957 to 59, a forest inventory was undertaken by Forestal (Forestal, 1960) and during this inventory the forest was stratified into 8 different forest types, based on aerial photography and subsequent ground truthing.

The most recent stratification was undertaken by ODA during the 1981 to 83 inventory. Table 5 presents a comparison of the two stratifications. It should be noted that the Forest Types were not stratified by the same methods and that the definitions for the Forest Types are similar but not identical. Therefore care should be taken when comparing the figures. It is for this reason that percentages and not areas are quoted.

Table 5 Percentage Area of Main Forest Types Classified by Forestal (1959) and ODA (1984)

Forest Type	Species composition		Area expressed as a percentage of the total Forest Area (%)		
	Species	(%)	Forestal	ODA	Difference
Sundri	Sundri	75+	31.6	21	-10.6
Sundri-Gewa	Sundri Gewa	50-74 26-50	24.4	29.7	5.3
Sundri-Passur#	Sundri Passur	50-74 26-50	0	0.5	0.5
Sundri-Passur -Kankra	Sundri Passur Kankra	26-50 20-40 20-40	2.4	1.6	-0.8
Gewa*	Gewa	75+	3.3	4.9	1.6
Gewa-Goran	Gewa Goran	50-74 26-50	8.6	9.2	0.6
Gewa-Sundri	Sundri Gewa	26-50 50-74	15.6	14.8	-0.8
Goran#	Goran	75+	0.7	2.3	1.6
Goran-Gewa#	Goran Gewa	50-74 26-50	11.3	14.6	3.3
Passur-Kankra#	Passur Kankra	40-60 40-60	0	0.3	0.3
Passur-Kankra- Baen#	Passur Kankra Baen	20-40 20-40 20-40	0	0.2	0.2
Baen Keora	Baen Keora	90+ 90+	0.2 1.9	0.1 0.8	-0.1 -1.1

* includes Gewa mathal, which comprises virtually pure stands of widely spaced Gewa coppice

Forest type not included in the Forestal assessment

Source Chaffey *et al* 1985

The most obvious and major change is the decrease in pure Sundri forest and an increase in Sundri - Gewa forest. This has major implications with regard to the total value of the forest. There is also a decrease in the forest classified as Keora forest. According to ODA this was possibly due to successional change to other forest types and the reduction in areas of accretion for colonisation by Keora. Table 6 gives the Areas of Forest Types based on ODA stratification, updated by digitised information satellite imagery (1989 SPOT imagery).

Table 6 **Areas of Forest Types**

Forest Type	Area (km²)			Percent (%)
	Production Forest	Wildlife Sanctuary	Total	
Sundri	827	1	828	20
Sundri Gewa	1 140	93	1 232	30
Sundri Passur	22	0	22	1
Sundri Passur Kankra	68	0	68	2
Gewa	167	19	186	5
Gewa Sundri	556	44	600	15
Gewa Goran	326	49	376	9
Gewa Mathal	8	0	8	0
Goran Gewa	524	52	576	14
Goran	70	17	87	2
Passur Kankra	9	0	9	0
Passur Kankra Baen	16	0	16	0
Baen	4	4	8	0
Keora	26	9	35	1
Other	4	0	4	0
Sub total Forest land	**3 769**	**287**	**4 056**	**100**
Agriculture	0	0	0	
Grass and bare Ground	41	5	46	
Sandbar	31	9	40	
Total Land Area	**3 841**	**301**	**4 143**	

Source: FRMP Geographic Information System derived from IRMP database as of September 1995

Since 1976, a number of plantations have been established in the SRF. Table 7 presents the areas of plantations. The plantations are discussed in greater detail by Karim (1995).

Table 7 **Areas of Plantations in The SRF by Range**

Range	Area (ha)
Satkhira	89
Khulna	353
Sharankhola	467
Chandpai	302
Total	1211

Source FD Plantation Journals

2.4.2 Sundri Top-Dying

Sundri, ***Heriteria fomes***, represents the most valuable timber resource in the SRF. The tree is however, affected by a condition known as top-dying. Top-dying begins with a thinning of foliage, mostly in the upper crown, followed by branch dieback. Decay fungi enter the affected portions of the crown causing breakdown of both sap

and heart wood. Attacks by insects are common in the dead branches and stems. Top-dying is progressive and can lead to mortality. (Ciesla, 1994).

It is thought likely that the cause is due a combination of factors. Some of the causal factors which have been discussed in relation to top dying of Sundri include:

- reduction of fresh water supply due to upstream diversion resulting in increased salinity and reduced flow of nutrients;
- the moratorium on tree felling between 1972 and 1976;
- occurrence of a fungal gall canker;
- infestation by a wood boring beetles;
- damage resulting from cyclones;
- variation in the depth and frequency of flooding;
- siltation; and,
- normal senescence as part of the phenological cycle.

Further information on top-dying can be found in Rahman (1994), Ciesla (1994) and Karim (1995).

According to Rahman (1994), approximately 16% of the Sundri affected by top dying are totally dead. The wood contained in these trees is often degraded by fungi and insects and is no longer suitable for lumber production and must either be used as firewood or for hardboard production.

Unfortunately the studies to date, apart from ODA (1985) have not been designed to quantify or describe in detail the occurrence and extent of top-dying. This requires an inventory. This information is vital for the purposes of forest management. (Ciesla, 1994).

2.4.3 Estimates of Growing Stock

To date there have been three major attempts to assess the growing stock:

1. Curtis 1928 to 1931 for the working plan which covered the period 1931 to 1959;
2. Forestal 1957 to 1959; and,
3. ODA 1981 to 1983.

These inventories are discussed in detail in sections 10.2.1 to 10.2.4. in the IRMP and in Mitchell (1995b).

Table 8 shows a comparison of the results of the ODA and Forestal inventory results.

Table 8 Volume per ha and Total Standing Volume as Estimated by Forestal (1959) and ODA (1983)

Species	Mean Volume/ha (m^3/ha)		Total standing volume (millions m^3)	
	Forestal 1959*	ODA 1983#	Forestal 1959*	ODA 1983#
Sundri	34.5	19.9	13.04	7.87
Gewa	8.7	4.6	3.30	1.82

* Forestal volumes are for all Sundri over 14.2 cm dbh and all Gewa 11.7 cm dbh

ODA volumes are for all Sundri over 15.0 cm dbh and for all Gewa 12.0 cm dbh
Source: Chaffey **et al**, 1985

Table 9 compares the growth estimates made by Forestal and ODA.

Table 9 Growth Rates of Gewa and Sundri as Estimated by Forestal and ODA in all Forest Types

Species	Annual Volume Increment m^3/ha/yr	
	Forestal	ODA
Sundri	0.71	0.6
Gewa	0.61	0.8
Total	1.32	1.4

The growth figures in Table 9 show that the two estimates to be fairly similar. Table 8 though, clearly shows a huge difference in the volume of timber as estimated by the two different inventories. **From these figures it would appear that there had been a vast depletion in the standing volume**. Unfortunately the two inventories did not follow the same methodology. Similar but not identical stratifications were used. There were different volume equations and assumptions. Therefore the two sets of data are not strictly comparable.

ODA compensated for this source of bias by reassessment of field data for stocking and basal area, using Forestal's Forest Types and also Forestal's Imperial diameter classes. Accordingly the differences between the stocking and basal areas of the two inventories for specific blocks should be valid. The comparison showed that there was a significant drop in the number of stems per hectare and that this was spread more or less evenly throughout the size classes for both Gewa and Sundri. **This unequivocally confirmed the decrease in the growing stock between the two inventories.**

The discussion of the two inventories and the ODA analysis of data are discussed in much greater detail in IRMP sections 10.2.5 to 10.2.5, Leech (1995) and Mitchell (1995b).

Subsequent to the ODA inventory a total of 120 permanent sample plots were set up (derived from some of the ODA original inventory plots and 12 BFRI plots). These plots were first measured in 1986/87 and by the time the IRMP was prepared 69 had been re-measured a total of four times. These measurements were then used to refine the estimates of the growing stock. For a full description of the method used in deriving the results please refer to IRMP sections 9.1.5.1. and 22.3, Mitchell (1995b) and Leech (1995). The results of the PSP analysis are summarised in Tables 21 and 22 of the IRMP.

The average net growth across the 69 plots was 1.62 m^3/ha/yr. Gross growth was 2.91 m^3/ha/yr composed of 2.46 m^3/ha/yr of growth and 0.45 m^3/ha/yr of ingrowth into the lower tree diameter classes. The PSPs also showed 1.30 m^3/ha/yr was lost due to mortality, missing trees and illegal harvesting operations. It was shown that there was 45% mortality, implying 0.71 m^3/ha of illegal cutting or other unofficial consumption. There were no marked differences in the proportions by species in each of the categories.

The results are approximately consistent with the total increment of 1.4 m^3/ha/yr estimated by ODA although this appears to be gross growth less mortality, but excluding harvesting.

The proportion of Sundri in the growing stock stayed constant at 53%. This conflicts with previous assessments by ODA. The effect of the Moratorium and the fact that consistent tree volume equations were used in this analysis, add some credibility to the general conclusion that overall the proportion of Sundri is not changing markedly, if at all, through natural ecological change (i.e. in unlogged areas). The proportion of Gewa has increased slightly from 38.1% to 39.0% over the same period.

It must be remembered that the PPSs have been excluded from normal harvesting operations and so do not reflect the true status of change in the Sundarbans. It could be inferred that in the absence of harvesting, species composition is on average not changing very rapidly. The advantage of these analyses is that they are based on remeasured plots and consistent volume estimation methods. The disadvantage is that the PSP's have been excluded from normal harvesting operations.

However the net growth of 1.62 m^3/ha/yr, does not indicate the real changes in the Sundarbans. It is necessary to subtract the official consumption estimated at 0.80 m^3/ha/yr in total (of which 0.45 m^3/ha/yr was of Gewa, 0.19 m^3/ha/yr was of Sundri).

2.4.4 Annual Allowable Cut

The Annual Allowable Cut (AAC) is the annual yield allowed from a forest set to fulfil given management objectives. In a forest managed on a sustained yield basis, the AAC would be equal to or less than the annually sustainable growth of the forest.

The SRF has been managed on a sustained yield basis for over a century. Initially the yield was set by simply dividing the forest into a number of areas equivalent to the number of years in an assumed felling cycle. One of these areas was then cut each year. In a mixed forest this clearly would give very varying yield each year depending on the forest type and quality. A number of formulas were later developed to calculate the yield. This coupled by the standing stock information would be used to set the areas to be cut each year. Nowadays with growth and yield modelling work it is possible to predict the growth rates of given forests. This can be used to forecast yield and set AACs. Table 10 summarises the history of the AAC.

Table 10 History of the Annual Allowable Cut by Working Plan Author

Author	Period	Area Covered (Km^2)	Species or Grade	AAC		Remarks
				Area (Km^2)	Volume ($m^3 \times 10^3$)	
Heinig	1893-1903	5418	some timber	304	42 156	Uncontrolled areas of firewood cutting was allowed and not all timber species were covered by the plan.
Curtis	1931-1951	6003	all timber firewood	278 280	214	Sundri, Gewa & Passur were controlled by Volume as well as area. Some areas were to be cut twice in the plan period
Choudhury	1960-1980	4071	Sundri Keora Gewa	224 4 160	204 10 165	Includes Passur Dhundal Baen & Kankra KNM & match factory allowance
ODA	N/A	4016	Sundri Gewa		78 57	These were recommendations based on the inventory undertaken from 1981-83
Balmforth	1985-90	4016	Sundri Gewa		141 91	Interim felling prescriptions based on the ODA inventory
KNM GOB	1986 1989		Gewa Sundri Gewa		127 0 91	Inter-ministerial meeting adjustment of Gewa Government moratorium introduced - exception for Gewa
GOB	1990		Gewa		133	Inter-ministerial meeting

Note: Table compiled all in metric units to avoid confusion over Hoppus and true cubic feet.

At present because of the moratorium there is no AAC for species other than Gewa.

The total timber production since 1986/87 is shown as Table 11.

Table 11 Timber and Firewood Removals from the SRF by Year (m^3 x 1000)

Species	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
Sundri	74	116	110	66	21	48	92	36
Sundri B/wd	7	12	15	9	2		0	0
Kankra	1	2	3	1	0	1	0	0
Keora	4	1	1	1	0	0	0	0
Goran	27	26	23	23	23	16	20	69
Gewa	173	165	145	171	189	200	182	126
Baen	4	2	4	2	0	0	0	0
Amur	0	0	2	0	0	0	0	0
Shingra	2	13	15	6	11	13	8	0
Others	1	0	71	9	14	9	11	12
Total	291	339	388	288	261	286	313	243

Source: FD records

Even taking the moratorium into account the production of Sundri has exceeded the AAC as recommended by ODA in all but three years, but was less than the AAC prescribed by Balmforth. Apart from in 1993-94 the Gewa removals have exceeded the AACs recommended by all parties.

Figure 1 Bar Chart Showing Timber Production by Year

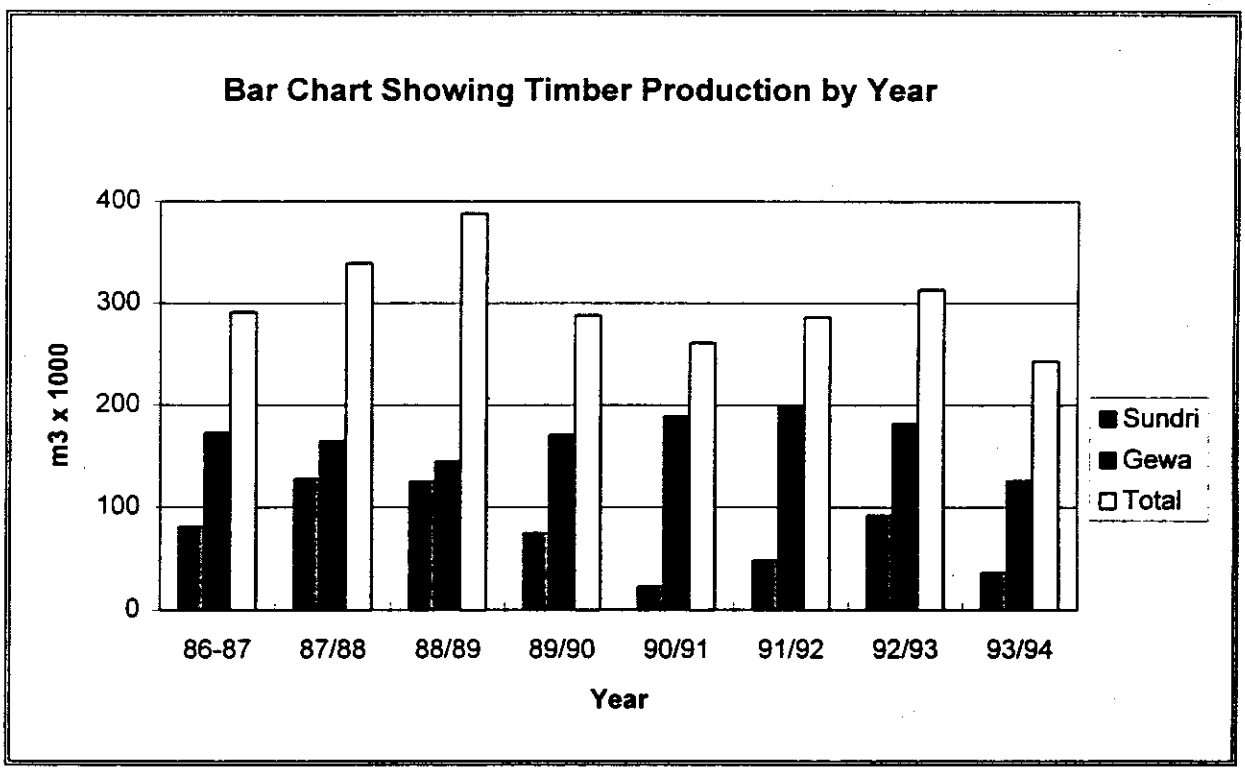


Figure 1 shows that Gewa accounts for most of the forest production.

2.4.5 Silvicultural Systems

2.4.5.1 Selection System

The SRF has been traditionally managed under a modified version of the Selection System. The main exceptions being the clearing of small areas for plantations and the moratorium. In the Selection System proper, some trees or groups of trees of all sizes are removed so that the remaining forest comprises trees of all size classes. This creates an uneven aged type of forest in which all size classes should occur at all times and in all areas. After felling, natural regeneration should fill the gaps created and the forest should grow until the next harvest. This system should maintain forests of an uneven age structure with size classes mixed throughout. (Matthews, 1989).

The Selection System has been implemented in the SRF by the application of management rules set by the prevailing working plan. Generally, the fellings have been controlled by only allowing the felling of trees above certain diameter limits, for each species, in each site quality class, with the proviso that a certain number of seed bearing trees should be left per unit area. In some areas poor quality trees below the set diameter limits were felled to improve the quality of the remaining forest. In addition, limited amounts of thinning were undertaken in certain dense stands of a young crop. These adaptations led Curtis to term the SRF silvicultural system "Selection-cum-Improvement". This system was not easy to follow and eventually it reverted to one based solely on control by diameter limits. By the 1960s it was no longer felt necessary to undertake thinning operations. (Chaffey *et al*, 1985).

With long felling cycles and felling to diameter limits, the forest has been found not to maintain an uneven size class structure and Chaffey *et al* (1985) noted that in most stands in the SRF there is usually a discontinuous set of two or three even aged classes.

Thus, to maintain an uneven size structure, immature trees should be thinned at the same time as fellings of trees of exploitable size. This should be done on a fairly frequent cycle but to a light intensity. In large areas of low yielding forest, such as the SRF, it is too costly and impractical to undertake these operations on a frequent but light basis. This leads to more concentrated fellings of an accumulation of mature trees which have had the chance to grow on during a longer time interval. Obviously a longer interval between fellings results in a larger volume per hectare available for removal.

Whilst longer felling cycles may have economic benefits, it may favour the regeneration of light demanding species, such as Gewa, through the creation of large gaps; many of the silvicultural benefits of the system are lost. Sundri seedlings will not establish themselves readily except under fairly heavy shade (Curtis, 1933). The ingress of weed species could also be a serious problem. This phenomenon may be a contributing factor to the apparent decrease in the amount of pure Sundri forest as shown in Table 5.

Anecdotal evidence from KNM (Khulna Newsprint Mill) suggests that there is an increase in the proportion of Gewa in the forests that they are now working on the second cycle. Study of the PSPs indicate that when there are no official cutting operations, the proportion of Sundri remains constant and that the Gewa is only marginally increasing but at the expense of species other than Sundri. Currently the forest is only being worked on the selection system for Gewa by KNM.

2.4.5.2 Salvage Felling

Due to the imposition of the moratorium in 1989, timber felling operations were restricted to the extraction of Gewa to KNM and to the salvage felling of top-dying Sundri. Initially, only trees with more than 50% of their crowns dead could be removed. This rule has since been modified and for the past three years any tree showing the slightest symptom of top-dying is marked for removal. This is so that timber which has started to decay can be harvested before it becomes rotten. However, it is likely that healthy trees will be included to increase the yield.

The amount of Sundri regeneration is variable in top dying areas; ranging from plentiful to zero. In some instances salvage felling has serious implications. Should the tree cover be removed in areas where the Sundri

is not regenerating and so encourage the establishment of other less valuable or weed species? There is hearsay evidence that other valuable species such as Dhundal and Passur can readily take over some of the sites which have been lost to top-dying but that these do not regenerate naturally there, due to the sparsity of seed bearing trees.

2.4.5.3 Goran

Goran, ***Ceriops decandra***, is a small tree or shrub which covers large areas of the western part of the Sundarbans Reserved Forest. This species is often found in nearly pure stands or as an understorey to other larger tree species. The present moratorium does not affect the harvesting of Goran firewood.

Goran is harvested by cutting in a cycle within a silvicultural system similar to cyclical coppicing. In the coppice system, trees are cut at regular intervals and the stumps resprout to produce a number of new stems from either the stump (termed the stool) itself or from suckers. Coppicing produces many small stems which can be cut on short cycle. This is an ideal system for producing firewood and poles or rods.

The SRF system for Goran requires that at least one stem or shoot is left per stool. Curtis (1933) suggests that Goran does not readily recoppice from a totally cut stool. Often the worst stems on each stool are left and many stools are damaged during extraction. This leads to the degrading of the Goran areas so that most of the bushes are stunted and twisted. Due to its high value, sometimes the entire stool is dug out of the ground.

Under the current system there is no fixed felling cycle for Goran. In each range the area available for Goran cutting is surveyed and allocated annually. The time taken between fellings depends upon on how long it takes for the Goran to grow back to a utilisable size.

2.4.5.4 Plantations

The extensive use of plantations as a system of silviculture has not been practised in the Sundarbans. Plantations have only been established on a pilot basis. Currently there are just over 1200 ha of plantations established since 1976 with a variety of native and exotic species. Unfortunately the status of these plantations has not been reviewed adequately. It appears that quality ranges from being well stocked to nearly non-existent (mainly due to the lack of maintenance). The growth rates from these plantations have also not been properly assessed. Nursery techniques are currently available for many of the species growing in the SRF (BFRI, 1992).

"If however natural regeneration is occurring in gaps left by failed planted trees, this should be accepted as part of the crop. During the weeding of the plantation, this regeneration could be respaced to a similar density as the planted trees."

2.4.6 Wood Products

The wood products for the main tree species are summarised here but are discussed further by Larsen (1994), and IRMP section 10.5. Wood properties of some species are presented in IRMP Appendix A13.

2.4.6.1 Sundri

Sundri is a strong and durable timber with a reddish colour. The timber is relatively hard to work and is not often used for decorative purposes.

Sundri is harvested in four main forms:

- transmission poles for the Rural Electrification Board (REB) sold by royalty;
- logs sold at auctions;
- brushwood (from the tops of the trees) sold by royalty to Khulna Hardboard Mill (KHBM); and,
- firewood from the tops of the trees sold by permit.

The poles for the REB are generally produced in a special felling operation. REB poles are sold through Bangladesh Forest Industries Development Corporation (BFIDC). REB poles are selected from the largest and

best quality trees available (poor silviculture). The royalty rate for REB poles is 154.25 Tk/cft and 162.25 Tk/cft (Takas per cubic foot) for 25' and 30' + poles respectively.

Most of the Sundri timber is sold at auction. Sawn wood is generally used for structural purposes such as house posts, window and door frames, boats, bridges, truck and bus chassis and cold storage shelving. Sundri logs are also used for pilings for the foundations for houses, bridges and jetties, and the shoring up of embankments. Limited amounts of Sundri are sold by permits.

All the brushwood from tops of the trees harvested is sold to the Khulna Hardboard Mill (KHBM) by royalty. As all the wood is currently coming from Top-dying areas, much of the wood is rotten. This has serious implications for both the quality of the end product and the efficiency of the processing.

KHBM also use limited amounts of Shingra ***Cynometra ramiflora***, although this causes problems due to its small diameters.

Prior to the moratorium, after felling and extraction of Sundri timber, the tops were left in the field and it was then sold *in situ* to firewood merchants. Sundri is a desirable fuelwood species as it has a high calorific value and burns with little smoke. Since the moratorium the sale of Sundri firewood in this manner has ceased. However, Sundri firewood is still available in the local markets at premium prices.

2.4.6.2 Gewa

Gewa has qualities suitable for newsprint pulp. The low density, white wood is not durable; it has low strength properties and oozes white latex from cuts. Currently most of the annual harvest of Gewa is sold on a royalty basis (Tk 15/cft) to supply pulpwood to KNM.

Other uses have included the supply of matchwood and the supply to sawmills producing packaging materials. These were also sold on the basis of royalty payments. In 1994/95 there was an allocation of 300 000 cft for matchwood which was not fully utilised. This allocation was over and above KNM's AAC. In 1993-94 only 6 000 cft was utilised. At present all Gewa harvesting operations are controlled by KNM under the supervision of the Forest Department.

Gewa logs are also used by bowallis (wood cutters) to stabilise the loads on the country boats that haul produce out of the Sundarbans. One set of these stabilising poles is allowed per registered boat per year, without the payment of any royalty. This practice is a source of significant unofficial harvesting as many of the boats replace these poles on every trip.

2.4.6.3 Firewood

Demand for fuelwood from the Sundarbans is huge. The harvest of fuelwood is dominated by Goran, but includes numerous other species.

Goran is harvested most intensively in the western compartments of SRF. It produces good quality fuelwood. It is therefore much sought after and attracts premium prices. The Goran royalty rate is Tk 500/100 maunds (1 maund = 37.32 kg).

Shingra, ***Cynometra ramiflora***, is also readily saleable as firewood. The royalty for Shingra firewood is Tk 90/100 mds.

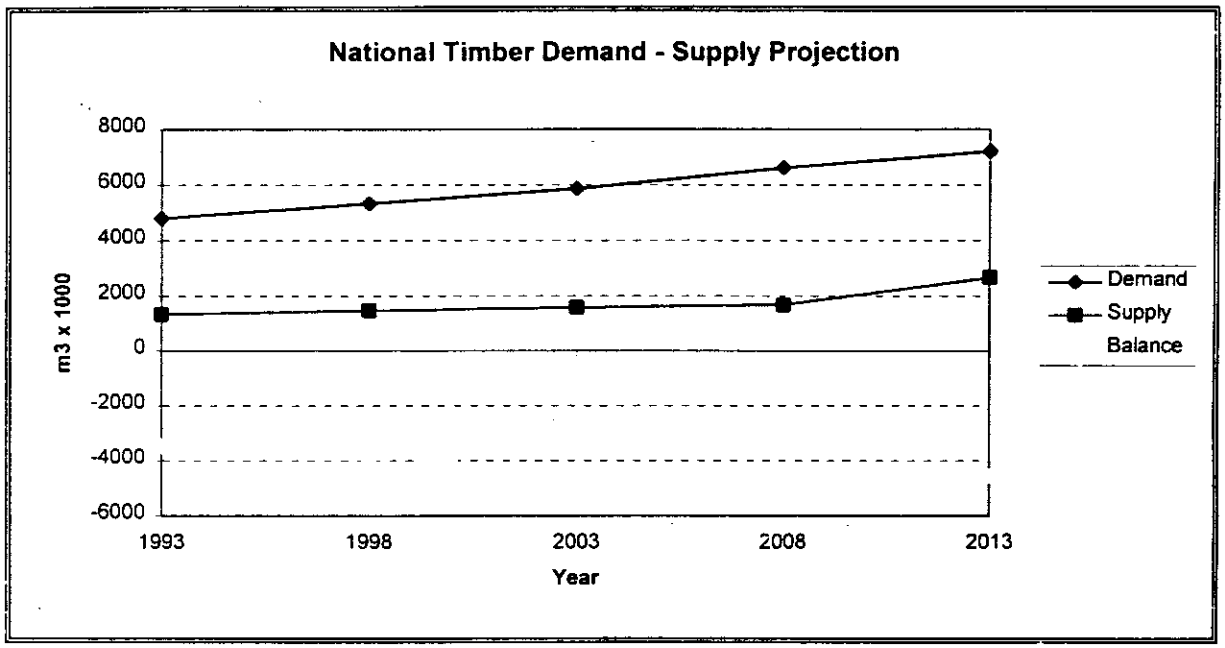
2.4.7 Supply and Demand

Demand for the three main categories of wood products (timber, fuelwood and pulp) is considerably in excess of supply (ADB, FMP, 1992d). The projected demand and supply until the year 2013 following the scenarios considered most likely, shows the gap continuing to widen but that investment made in plantations would start to have effect by the year 2008 for timber. The National Timber Demand Supply Projection is presented graphically as figure 2.

The situation for fuelwood is similar although it is projected that plantations established now could possibly meet the demand by the year 2013. It is considered that the demand for SRF fuelwood will remain high due to its preference in the market place over other species. If fuelwood became more readily available then other markets

such as charcoal would develop. It is also likely that the rural populations would revert from using dung (which is a useful fertiliser) to firewood.

Figure 2 National Timber Demand - Supply Projection



Source: ADB, FMP(1992 d)

There is also growing demand for all types of board and paper products. This growing demand mill not be met by the existing capacity of the county's mills. Gewa from the SRF is already being supplied beyond the current AAC. KNM have recently installed a second line which uses green jute as raw material. As Gewa has few other bulk markets an increase in the use of other raw materials by KNM could have serious implications.

2.4.8 Harvesting

The felling, cross cutting and extraction of all timber is by handtools and manual labour. It is normal practice that both the felling and cross cutting are done by axe. Due to the large amount of chips created when using an axe a lot of wood is wasted. Often trees are cut above the buttresses to ease felling but wasting a good part of the tree. The timber is extracted by carrying or dragging the logs to the nearest creek where they are loaded onto boats. The logs are frequently cross cut into short lengths to ease extraction but this reduces their value. Logs too big to be carried have rope holes cut in the butt end and are then dragged out. It is estimated that the waste per tree is 12%. Tools such as cant hooks and tongs are not used.

Sawlogs are transported to the depots by the contractors in unpowered boats, where they are sold at auction. All the loading and offloading is done by hand. Logs are not sorted and are sold in mixed lots. Since contractors are paid on out turn, there is a tendency to include undersize or rotten stems which should have been left on site as brushwood. This practice reduces the average quality of logs sold at auction.

Before the moratorium, trees were marked by the FD and sold standing by auction. It was the purchaser's responsibility to fell and extract the timber. For more details see Mitchell (1995a).

The felling and cross cutting of Gewa for pulp is also done entirely by axe (Gewa exudes a sticky latex which precludes the use of saws). The logs are cut into lengths of four foot multiples and are then hand carried to the nearest creek, where the logs are then towed to collecting stations. Here the logs are removed from the water, sample measured by the Smalian method for yield regulation and royalty payment. The bundles are then put back in the water where they are fastened into rafts of 220 bundles (around 23 000 true cft). The rafts are then towed by tug to the mill in Khulna, where they are removed from the water by cranes.

2.4.9 Measurement of Wood Removals

2.4.9.1 Timber

Timber is traditionally measured by the Hoppus system in Bangladesh. Since 1985-86 all timber production has been officially reported by the Divisional Forest Officer's reports in cubic metres. Timber, apart from Gewa, is actually measured in Hoppus feet and later converted to cubic metres. Gewa is measured in true cft. The conversion factor used throughout is 35.315 cft equal to $1m^3$. This is correct for true cubic feet, i.e. the Gewa. In the Hoppus system $1m^3$ actually equals 27.736 Hp ft. Therefore the figures presented in the DFO's annual reports are under-recorded.

Whilst it is true that the Hoppus system does under-estimate true volume, the system itself does not mask inefficiency. That only occurs when the Hoppus feet are recorded as true cubic feet and are then converted using the wrong conversion factors into cubic metres.

Timber is sold by the Hoppus foot and the purchasers understand how the product was measured. If the system is to be changed then there is the danger that potential purchasers would be alienated. The Forest Department's own staff are familiar with the existing system and they would require retraining before any new system could be implemented.

However, inventory and PSPs however use metric volume measurements. It is inconsistent to estimate volumes one way and to then measure the removals in another.

2.4.9.2 Firewood

Firewood and Golpatta removals are measured by assessing the capacity of the boats used in hauling the produce out of the forest. The assessment is made annually when the boats are issued with Boat Loading Capacity Registration Certificates (BLCs). The procedure of issuing BLCs is detailed in the Heinig Working Plan of 1892.

The BLC in maunds (1 maund = 37.3 kg) is calculated according to the following formula:

$$BLC = 0.356 \times L \times B \times D$$

Where:

0.356 is a constant conversion factor;

L is the length of the boat a long the water line when under full load;

B is the average breadth measured in 3 places; and,

D is the vertical distance between the water line at full load and the bottom of the boat.

When the boat is measured it is empty and the loaded water line must be estimated. This is defined by a level mark being painted on the side of the boat. It is recorded that it is so many inches below the gunwale. All the measurements, the maundage capacity and the BLC number are noted in a ledger in the FD station office. The BLC number is also painted in the side of the boat.

The royalty based on the estimated BLC capacity must be paid prior to commencement of harvesting. On departure from the SRF, permit holders must report with loaded boats to issuing station offices for load reassessment. Any extra royalty due must be paid before departure.

This system was designed many years ago and is based on a formula that was probably derived by trial and error by weighing loads and measuring the boats the loads were carried in.

Since the formula was designed, the shape of boats has evolved to maximise carrying capacity whilst minimising the calculated loading capacity. This has gone so far that boats are often unbelievably unstable when they arrive for BLC assessment. Following assessment, stability is re-established through the addition of 'mallam' boards on the sides which also increases the load capacity.

Analysis of two boats has shown that the BLC under-estimated the capacity by 65 and 30%. Part of the problem is that linear measures are used in the estimation of weight. All firewood and Golpatta leaves will loose a considerable proportion of their weight as they dry.

2.4.9.3 Reporting

At present information travels along a series of consolidation points loosing valuable information at each step. The following reporting process is followed:

- primary records collected at SRF FD station office;
- second stage consolidation in transfer to range office;
- third stage from range office to DFO's headquarters office, Khulna;
- finally the refined data are remitted to the FD head office, in Dhaka.

A lot of important management information is lost. For example information regarding timber removals from sub compartments is often not available at the Divisional Office or even the range office but only at the station office.

2.5 The Non-Wood Resource

The definition of Non-Wood Forest Products (NWFPs) is taken '*to include all goods of biological origin as well as services derived from forest and to exclude wood in all its forms*'. (Chandrasekharan, 1994). Thus is can be seen that non biological components such as tourism and recreation are included in the non wood resources.

2.5.1 Golpatta

The leaves of Golpatta (a stemless palm, ***Nypa fruticans***) are harvested on an annual felling cycle for thatching material. This is controlled through a system of issuing permits.

The system of harvesting is to annually remove all the leaves but two (the central leaf and one supporting leaf) per clump. Areas of Golpatta are cut over during the dry season. During the following monsoon the plant regrows a number of new leaves from the root ready for the next harvest. Prior to harvest, the Forest Department undertakes a sample survey of the areas to be cut (annual coupes). From the results of the survey a target figure is set. At the onset of the harvesting season permits are issued up to the target. The detailed list of rules can be found in the IRMP section 11.2.1, in DDC (1995) and in Shiva (1994)

Golpatta also reproduces from seeds. The Forest Department sometimes try, with mixed success, to enlarge the size of the coupes by direct sowing of the seeds in suitable areas. The seedlings take about 5 years before they can be harvested.

The leaves are cut with a machete and are trimmed to size (roughly six to eight feet long - judged by the eye of the cutter). This tends to waste one to two feet of each leaf. This wasted section is just left on site to rot or float away. During the Golpatta cutting season many rivers can be seen with floating Golpatta detritus.

Once the leaf has been cut and trimmed it is split and stacked on the side of the bank. It is loaded onto a small boat which takes the split leaves to a larger country boat which hauls the finished product out of the Sundarbans. Table 12 presents the out turn and the revenue collected for Golpatta as recorded by the Forest Department

Table 12 Production and Revenue from Golpatta by Year

Item	Unit	Year									
		84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Production	t x 1000	61	62	71	79	68	67	72	72	67	68
Revenue	Tk x 1000	2160	3760	3825	4215	3976	6723	5799	5822	5447	5906
Price	Tk/t	35	61	54	54	58	101	80	80	82	87

Source: Forest Department Records (DFO's Annual Reports)

This table shows that the level of production has remained fairly constant over the ten year period. The price fluctuation follows precisely the changes in the level of royalty that occurred. Golpatta represents a valuable resource, as it generates between 5 and 6 million Taka annually. It can also be seen that the price of around Tk 80 to Tk 100 per tonne is very low considering the resources required to produce the product in terms of the number of plants and area required to grow the leaves.

Surveys undertaken by MARC and DDC in 1995 have shown that the BLC method of measuring the Golpatta removals underestimates the true figure substantially (see section 2.4.9.2). MARC further estimate that the total production for 94-95 was nearly 46 000 Kahons (1 Kahon = 16 Pon, 1 Pon = 80 pieces). This equates to 110 thousand tonnes. This is comparable to the average recorded annual production if the allowance is made for the under measurement. It is therefore considered highly likely that the true annual production is nearer 100 thousand tonnes than the 70 thousand tonnes shown above.

The growth and yield of Golpatta has not been studied in detail. The calculation of yield based on increment measurement is therefore not possible. However, as the production of Golpatta is on an annual cycle and as the area and production of Golpatta is perceived to remain fairly constant, it is felt that the yield for Golpatta under the present system is sustainable.

The market for Golpatta however, is not static. It appears that there is decreased demand and not all areas targeted for harvesting are cut. This drop in demand is thought to be due to the fact that low quality thin corrugated iron sheets compare favourably in price and do not require replacing after 2 or 3 years.

The only commercial use for Golpatta in Bangladesh is for thatching material. Golpatta does have a number of other potential uses (see IRMP section 11.2.1 and Shiva (1994). These other uses include:

- sap production for alcohol for both industrial and consumptive purposes;
- sap production for sugar and vinegar;
- medicinal purposes; and,
- manufactured roofing shingles.

2.5.2 Hantal

Hantal, ***Phoenix paludosa***, also a member of the palm family is commonly found throughout the SRF. It is usually a slender, straight, small tree which can attain a height of six metres. It sometimes forms nearly pure stands of dense thicket which are often located along river banks and shorelines. It can occur as undergrowth beneath a sparse over storey.

There is little knowledge about either the standing stock or the growth rates of Hantal. The stems from Hantal are harvested by permit issued throughout the year. The produce is sold for rafters, purlins, fence and house posts. The ribs of Hantal are both light, relatively strong and reasonably durable when kept off the ground.

There is scope for increasing Hantal utilisation. The leaves are suitable for paper pulp (Naskar and Bakshi, 1987) and the fruits are edible. Table 13 presents the production and revenue from Hantal.

Table 13 Production and Revenue from Hantal by Year

Item	Unit	Year									
		84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Production	tonne	8910	5412	6087	7848	8339	7203	6747	9032	6053	6725
Revenue	Tk x 1000	39	142	170	210	223	339	334	448	391	339
Price	Tk/t	4	26	28	27	27	47	50	50	65	50

Source: Forest Department Records

There is a wide variation in the production for a resource supposedly produced on a sustainable basis. However, within the range of figures shown there appears to be no discernible trend. This should be verified during the inventory of 1996-97. The price of Hantal, at around Tk 50 per tonne, as for Golpatta seems to be remarkably low.

According to DDC (1995), due to its versatility, Hantal is a popular product among the local poor population with a constant high demand

2.5.3 Bhola

Bhola, ***Hibiscus tiliacus***, is a scrambling woody shrub found growing along river banks and in dense patches in dry to moderately moist areas around north and central part of the forest. It is extensively harvested for firewood.

Hantal and Bhola are harvested under the miscellaneous permit system for fuel wood. Felling is not well regulated and this encourages illicit removal of other species. Only readily accessible areas tend to be harvested; areas where removal of Bhola as a weed to help more valuable species seldom occurs.

2.5.4 Grasses

Grasses are dealt with in more detail by the IRMP sections 11.2.4 to 11.2.7 and by DDC (1995). Three species of grass and one sedge referred to as a grass are harvested in the SRF:

- Ulu grass ***Imperata cylindrica***;
- Nal grass ***Eriochloea procera***;
- Hogla grass ***Typha elephantina***; and,
- Malia grass(sedge)***Cyperus javanicas***.

These grasses are cut annually and production is controlled by the Forest Department through permits and royalty charge (see IRMP Volume 2 Appendix A12 for the relevant rates).

Ulu or Sungrass grows extensively on well drained sandy soils on the southern seaface and similar sandy areas elsewhere. A prime commercial use is for shading betel fields (a valuable cash crop). Ulu produced from the Sundarbans has a ready market since it is more durable than that grown elsewhere (DDC, 1995).

Nal grass grows on river and canal banks and newly accreting char lands. It can also be found in association with some tree species. According to DDC the production of Nal is increasing due to the increase in areas of this grass on new chars. The species can reach up to six feet in height. It is used in the manufacture of baskets and rice containers. The products are utilised by the low to moderate income farmers.

Hogla or elephant grass, is a tall, strong grass and is well distributed in the SRF. It is used in the manufacture of furniture, woven utensils, mats and handicrafts. The rhizomes are sometimes used as a cure for dysentery, gonorrhoea and measles and the spike floss and down are used in protection of wounds (Shiva, 1994).

Malia grows along rivers and canals and in low lying hinterland areas with impeded drainage. It attains a height of three to four feet growing in uniform patches. Malia is used in the manufacture of mats. Production of Malia is

not restricted to the Sundarbans. DDC (1995) estimated that around 75% of the Malia used in the locality comes from outside the SRF, the principal source being polder embankments.

The production of grass products is associated with many of the poorest inhabitants of the surrounding area. Women particularly, are involved in the manufacture and marketing of woven grass products.(DDC, 1995)

Quantitative data are scarce since the FD consolidates all the grasses under one heading. There is also no record of the area of grassland within the SRF. The ODA inventory recognised "Grass and bare Ground".

The recorded production and revenue of all these species are presented in Table 14.

Table 14 Grass Production and Revenue by Year

Item	Unit	Year									
		84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Production	tonnes	9305	11064	11740	13441	13531	11566	7133	4585	5749	5140
Revenue	Tk x 1000	25	33	94	108	119	104	57	37	73	78
Price	Tk/t	3	3	8	8	9	9	8	8	13	15

Source: Forest Department Records

From this table it can be seen that the production of grass from the SRF has decreased substantially during the last ten years, with the production from the last 4 years being less than the annual production for each of the previous years. DDC (1995), make no comment on the production for all the grasses combined, but mention that supply for two out of the four grass products has been increasing. The drop in production may in part be due to the apparent increase in price in 92-93. However, there appears to have been no official increase in the royalty rate in that year; the royalty rate for Nal and Malia grass works out at approximately Tk 8 per tonne and all other grasses Tk 16 per tonne.

2.5.5 Medicinal and Aromatic Plants

This subject is dealt with in greater detail in section 11.2.9 of the IRMP and also in Shiva (1994).

Currently there is no commercial harvest of medicinal or aromatic plants although according to Shiva (1994) there is good potential to do so. There is no record of any serious enquiry having been made on this subject although some studies have been made in India (Naskar and Bakshi, 1987).

2.5.6 Tannin

Skins treated with tannins from mangrove barks, fruits and leaves combined with imported tanning material can produce a full range of leather qualities and colours.

Tannins and dyes are no longer produced commercially from the SRF although traditionally they were extracted from many plants. The tannin extraction factory in Khulna no longer functions.

About 10 000 tonnes of mangrove barks are estimated to be available annually from the trees currently removed from the SRF. Bangladesh produces about 10 million square metres of raw hide, of which only one fifth is tanned using imported tannin material (Razzaque et al., 1987). There appears to be abundant scope for manufacture of tannins from bark off-cuts

2.5.7 The Fisheries

The fisheries of SRF represent an extremely important resource that has been, for many years, under valued and under managed. The fishery contributes to society by providing employment, contributing to exports, providing a cheap and protein rich food for the population and also to generating revenue for the government. Traditionally the Forest Department have managed the SRF fishery. Further details of the SRF fisheries can be found in IRMP section 11.3, Chantarasri 1994, Khulna University 1995, Ahsanullah 1995, and Azam 1995.

Management of the fish stocks is limited to the issuance of permits to fish and the collection of revenue. Permits are granted (without restricting the total numbers issued) on payment of the appropriate fee. The estimates of the number of people fishing in the SRF range from just under 200 000 (Chantarasri, 1994) and to just under 300 000 (Shiva, 1994). Given the large numbers it is likely that many are fishing without permits.

No attempt is made at either monitoring the growing stock or regulating the yield. Consequently, although the SRF in theory is a controlled resource, in practice there is open access to the fishing grounds provided the appropriate fees are paid.

The Sundarbans Reserved Forest boundary is defined by legal statute (map 1). However, for the purposes of fisheries management wider view needs to be taken; fish are mobile and do not recognise borders. Chantarasri (1994) identified an inshore and an estuarine/offshore fishery in the SRF. However, the areas encompassed by either fishery were not delineated. The estuarine/inshore fishery is considered to lie north of latitude 21°50' (Smith, 1995) which approximates the 2m depth marine contour and the old Curtis (1928) boundary up to which most of the traditional fishing is said to occur (Shahid, 1985).

2.5.7.1 Estimated Total Production

Figures for total production from the SRF vary and are mostly incomplete. The measurement of fishery production is notoriously difficult. The Forest Department produce statistics annually on the fish harvest and the numbers of shrimp fry caught (Table 15). The average fish harvest over the period 86-87 to 93-94 is estimated to be around 5 700 tonnes. However, these estimates are not produced by measuring the production but are made on the basis of the number of fishing permits issued each year. The estimates of production are made by assuming a level of productivity per permit. However, the level of productivity is not assessed by scientific sampling but by a rule of thumb handed down from year to year. The estimates therefore do not indicate the true productivity of the resource and do not take account of the numbers of people fishing without a permit.

Data collected by Chantarasri during 1993 and 1994 were reanalysed by Khulna University (1995). The estimated total production of both onshore and offshore fisheries was estimated to be 11 787 tonnes.

By comparing data from other coastal districts Ahsanullah (1995) has shown that the recorded harvest from the Sundarbans is unusually low. The SRF fishery is believed to be extremely rich. Based on records of other districts collected by the Directorate of Fisheries the production from the SRF is estimated to be more likely in the region of 45 000 tonnes per annum.

During the fishing season of 1994-95 a socio-economic survey was undertaken of the fishing communities and the entrepreneurs (MARC, 1995). This survey estimated the fish production as a result of asking a sample of the fishermen how much they caught. By multiplying the sample figures by the estimated the total number of fishermen it was possible to derive an estimate of the total production. This data was correlated with details obtained from traders regarding the sale of dried fish from the offshore fisheries. Due to the size of the assumptions and also the unknown statistical validity of the survey and the estimation techniques these figures should be viewed with caution.

A comparison of the various estimates of the total production is presented as Table 15.

Table 15 Estimates of the Annual SRF Fisheries Harvest by Source

Source	Fishery harvest (tonnes/annum)			Shrimp fry No. x 10000
	Offshore	Inshore	Total	
Forest Department#			5699	8014
Khulna University 1995~	8733	3054	11787	
Ahsanullah 1995*	33485	11765	45250	
MARC 1995^	59200	15500	74700	180000

Average figures from DFOs annual reports from 86-87 to 93-94 collected from issue of permits

~ Based on field data collected by Chantarasri 93-94 and reworked by Khulna University

* Based on comparisons with Fisheries Directorate statistics collected from neighbouring areas

^ Based on Socio-economic survey of fishermen and entrepreneurs during the 1994-95 fishing season

These figures show that there is a very wide discrepancy between the available estimates, indicating that far more research and better record keeping is required.

Unfortunately these figures only represent the estimated production for one year and as such give no indication of trends. Table 16. presents the Forestry Department's historical estimates. Although it is thought that these figures are an under estimate it is hoped that they will at indicate the trends in the fisheries harvest.

Table 16 Fish Production as Recorded by the Forest Department by Year

Type	Units	Year							
		86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Fish	tonnes	6800	6221	7502	5076	4821	4702	5468	5002
Shrimp Fry	No. x 10 000	1410	2410	3043	3034	7269	11036	12797	23115

Source: Forest Department DFO's Annual Reports.

It would appear that the yield from the fishery is in fact slowly decreasing but that the numbers of shrimp fry that are being caught are rising rapidly.

The data available on the effort required to sustain this level of catch are strictly limited. Calculations to show the catch per unit of effort are therefore not possible. However, intuitive analysis of the situation would imply that there is increasing effort to catch a decreasing amount of fish. Interviews with fishermen have also revealed that more equipment and time are needed to catch a smaller amount of fish each year.

The level of shrimp fry production is increasing annually. This is demand led as a result of the increase in the number of shrimp and prawn farms in the areas surrounding the SRF and also as a result of decreasing alternative employment opportunities. However, it should be stressed that the Forest Department figures actually indicate that effort is increasing almost exponentially. This has serious implications for the juvenile fish and shrimp stocks.

As stated already the reliability of the data presented on the fish resource are questioned. Intuitively the figures presented by the Forest Department and Khulna University are far too low. If the harvest were only 11 787 tonnes per annum and there were 200 000 people fishing in any one year this would give a yield of less than 60 kg per person per year. If were assumed that on average each person fishes for only 4 months per year (the inshore fishery lasts the whole year and the offshore fishery for 5 to 6 months), that would give less than half a kilogram of fish per day per person. From the Forest Department's register of fishing boats there were 133,198 fishing boats in 1992-93. If each boat has average of 4 people (derived from field observations) then there would a total of over 530 000 people fishing in any one year. This excludes the many unregistered boats.

The figures given by Ahsanullah and MARC are felt, from an intuitive point of view, to be far more likely to be closer to the actual figure.

2.5.7.2 Estimates of Maximum Sustainable Yield

The data available on the Maximum Sustainable Yield (MSY) are also limited. The best analysis to date has been produced by Khulna University based on the data collected by Chantarasi (1995). It must be stressed however, that these estimates are based on insufficient data and as such should only be used as an indication of the true situation. More data of greater reliability are required before precise target yields can be set. These estimates do however, give enough information to act as a guide to the current levels of exploitation. The results are summarised as Table 17.

Table 17 Estimates of Annual Actual Yield and Maximum Sustainable Yield for Seven Commercially important Fish and Crustacean

Species	Common Name	Yield (tonnes)	
		Actual	MSY
Hilsha ilisha	Hilsha	762	523
Pangasius pangasius	Fatty catfish	135	92
Plotossus canius	Canine eeltail catfish	141	92
Lates calcarifer	Barramundi	150	160
Pomadasys hasta	White grent	232	457
Johnius argentatus	Silver jewfish	548	593
Macrobrachium rosenbergii	Giant freshwater prawn	274	711

Source: Khulna University (1995)

From this table it appear that some of the species are being over harvested (especially Hilsha) and that there is more potential harvest for others (especially ***Macrobrachium rosenbergii***).

This indicates the urgent need for the SRF fishery to be properly monitored and managed. Without control, recruitment over-fishing will occur and the stocks of the currently most heavily exploited species will begin to crash. This in turn will lead to other species being targeted and these too will then be over exploited and crash. It can be seen from the fact that effort is increasing and the total catch is decreasing that this has already started to happen.

2.5.7.3 Crabs

Until the late 1980s crabs were given scant attention. In recent years edible crabs have become a much sought-after aquatic resource particularly the mud crab, ***Scylla serrata***. Unfortunately extensive harvesting is carried out against a background of inadequate data on the ecology and status of the populations. Thus over harvesting is a possibility. There is a need for further research and data collection.

2.5.7.4 Oyster Shells

Dead shells from the giant oyster, ***Crassostrea gigas***, and other large oyster species are taken from the SRF and burnt to produce the powdered lime which is taken together with betel nut and leaf.

In 1993 there were an estimated 2030 oyster collectors operating who worked an average of 12 days per month collecting shells during the neap tides between June and October.

There is very limited information on the size of oyster stocks and also their productivity. Since only dead shells are harvested there appears to be no threat to the stocks of these species.

Table 18 Production and Revenue of Oyster Shells

Item	Unit	Year									
		84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Production	tonnes	2675	2657	3184	3599	3640	2854	2446	3169	3348	4364
Revenue	Tk x 1000	9	16	43	48	49	65	66	85	90	117
Price	Tk/t	4	6	13	13	13	23	27	27	27	27

Source Forest Department Records

2.5.8 Wildlife

Wildlife is discussed in greater detail in IRMP section 11.4, Tamang (1993) and de Vere Moss (1994). The fauna of the SRF are described briefly in section 2.3.2 of this summary.

The current status of wildlife management in the SRF is that there are three wildlife sanctuaries covering an area of 324 km^2, map 9. Currently, there is no revenue collected under the heading of 'Wildlife'. There is no managed utilisation of wildlife, but with the recent restoration of the Environment and Conservation wing of the FD, a foundation has been laid for re-establishment of positive ecosystem conservation.

There is little data on illegal consumption of wild animals. There are however, indications that demand for animal products is high. The killing of supposedly man eating tigers, the availability of deer meat in border markets, the lack of visibility of many species and the known export of turtle and dolphin meat, suggest that there is pressure on all marketable wild animals. It is estimated that 4000 spotted deer are poached per annum. This is a considerable loss.

In 1994 there was some official discussion on the prospects for introduction of licensed hunting. There is potential for the harvest of wild animals from the natural surplus which is currently either wasted naturally or poached. Poaching rewards those who take the small risk of being apprehended. The resources are not managed or utilised properly and the potentially substantial economic benefits are lost.

Wildlife is still present in the Sundarbans in adequate abundance to justify management in its own right. It is a valuable resource which currently receives little active management. The mud crab, for example is a most important species in the dynamics of the mangrove ecosystem but has recently become a valuable export product and is subjected to intense harvesting pressure.

The term wildlife is not defined in the Bangladesh Wildlife Preservation Act of 1973. Wild animals though, are defined as 'any vertebrate creature, other than human beings and animals of usually domesticated species or fish, and includes the eggs of birds and reptiles'. As well excluding fish the definition fails to include invertebrates and plants. Many of the excluded species are under intense, unregulated harvesting pressure.

The Act specifies which Game Animals can be hunted with a licence and lists others which are totally protected. Although the Forest Department can issue hunting licences none in practice are, thereby closing the SRF to official and managed consumptive utilisation.

Wildlife sanctuaries are defined as 'an area closed to hunting, shooting or trapping of wild animals and declared as ...undisturbed breeding ground primarily for the protection of wild life inclusive of all natural resources, such as vegetation soil and water'. Cutting vegetation, lighting fires and trespass are common in the sanctuaries.

Six, spectacular mammal species have been lost in recent times to the SRF: the Javan rhinoceros; the one-horned rhinoceros; the wild buffalo; the swamp deer; the gaur; and, the hog deer.

There is a wide variety of plant genetic resources in the ecosystem including timber species, wild relatives of cultivated plants and endemics. Environmental changes, natural succession and interference by man, may cause loss of viability and extirpation of some species. Recently, three species of ***Bruguiera*** have been lost and unregulated felling threatens other genera, notably ***Cynometra, Amoora and Rhizophora***. (IUCN, 1994)

2.5.9 Apiculture

For more details on apiculture please see IRMP section 11.5 and Zmarlicki (1993).

Collection of honey from the migratory honey bee colonies of ***Apis dorsata*** has been practised for centuries. The bees build a single large comb in an open place on the branches of a large tree. The demand for honey is large and with improvements in the quality there is potential to increase the price and productivity.

Honey is traditionally a resource that is exploited by the local poor. The honey collectors (mowallis) represent a relatively small yet ecologically and commercially significant user group. The wondering honey collectors are often victims of attacks by man-eating tigers and for this reason honey collecting is only done during the daylight when they face fierce colony defence by the bees.

At present management of the resource is restricted to issuing permits and collection of revenue. It is unknown if the present production is sustainable. It is unknown if the number of colonies is rising or falling or whether the productive potential of the pollen and nectar producing plants is fully utilised. The effect of the current harvesting practices on the bee population or the ecology has not been adequately studied.

Honey collectors not permitted by the Forest Department to enter the SRF until April 1st each year. However, due to the varying flowering periods of the different nectar producing plants the honey ripens in different nests at different times. Spurred by the need to collect as much honey as quickly as possible, all nests encountered are harvested whether ripe or not. The techniques of collecting are still rudimentary. These wasteful practices often destroy the newly established colonies thereby reducing the productive potential. Due to the high moisture content the honey is prone to ferment soon after collection. It is frequently contaminated large quantities of pollen and wax compelling quick sale and consumption locally thereby limiting opportunity of value added processing.

Table 19 presents the honey and wax production and revenue as estimated by the FD,

Table 19 Honey and Wax Production and Revenue by Year as Recorded by the Forest Department

Honey	Unit	Year									
		84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Production	maunds	6853	6015	6130	5956	2652	3909	5634	4265	4890	2841
Revenue	Tk x 1000	103	180	184	179	85	625	563	426	489	284
Price	Tk/md	15	30	30	30	32	160	100	100	100	100
Wax	**Unit**										
Production	maund	1713	1504	1533	1487	670	975	1407	1159	1223	710
Revenue	Tk x 1000	51	89	92	89	40	195	211	148	183	107
Price	Tk/md	30	59	60	60	59	200	150	127	150	150

Source: Forest Department Records

This indicates that the production of honey is fairly constant at around 4 000 to 6 000 maunds per annum. There was a large drop in 1988-89 which followed a severe cyclonic storm in November 1988. There is no apparent reason for the drop in 1995. Wax production follows similar trends. These estimates however are based on an assumed productivity per permit issued. They are not an actual measure of the honey removed. The socio-economic survey (MARC 1995) showed that in 1993-94 the total harvest was 16 000 maunds for honey and 4 000 mds for wax. These estimates are based on interviews with the honey collectors. This shows the wide range in estimates of production; which data is the most accurate is open to debate.

2.5.10 Tourism

Tourism and recreation are the subject of a separate study (de Vere Moss, 1994); for more details reference should be made to this report and section 11.6 of the IRMP. From these reports it is obvious that the tourism industry for the whole country has great potential for expansion and that for the SRF in particular there is scope for sustainable, environmentally friendly development for both domestic and foreign tourism. The development of tourism is also a stated government policy featuring in the Strategic Masterplan of 1985 for the ten year period until 1995.

The numbers of visitors to the Sundarbans Reserved Forest for a six year period are presented in table 20.

Table 20 Number of Tourists Visiting the SRF and Annual Revenue from Tourism by Year

Year	Numbers of tourists			Revenue (Taka)	Annual percentage change (%)			
					Numbers			Revenue
	Local	Foreign	Total		Local	Foreign	Total	
1986-87	5687	227	5914	5000				
1987-88	5318	298	5616	10000	-7	31	-5	100
1988-89	4982	328	5310	19500	-6	10	-5	95
1989-90	5172	420	5592	41000	4	28	5	110
1990-91	2117	210	2327	35000	-59	-50	-58	-15
1991-92	4595	291	4886	32500	117	39	110	-7
1992-93	7115	271	7386	72500	55	-7	51	123
Average annual increase in total numbers = 4%								
Average annual increase in revenue = 56%								

Source: based on de Vere Moss 1994 and Forest Department Records

The average trend is for an annual increase in the numbers visitors, with the numbers of locals increasing at roughly twice the rate of foreigners. The rate of increase is not steady with decreases in some years for both foreigners and nationals, especially in 1990-91. The reason for this is not clear. The revenue figures also do not appear to correlate with the numbers and show a much larger rate of increase. There are no corresponding changes in the Forest Charges.

This increase is without any investment in improving the infrastructure or facilities and with only limited advertising. This shows that there is an increasing demand for tourism in the SRF. It is thought that the level of demand for local tourism will increase with standard of living. As the part of the population becomes wealthier, so the demand for leisure activities will rise. There already exists many sites with tourist potential. In most cases however, most sites and facilities require improvement to bring sites up to international standards.

Tourism has grown phenomenally in Asia during the last decade. For example a tourism business based in Hong Kong recorded a growth in trade of 375% in 1992, mostly in tours to mainland China, where cultural differences, structural problems, a conservative society, and political uncertainties are prevalent. During the same period tourism in Bangladesh declined.

The Sundarbans is a unique and fascinating place. As such it has many features that give it a vast potential for development for international tourism. (See IRMP section 11.6.1). The possibility exists to attract low volume high value tourism which would generate significant revenue, create local employment opportunities and have considerable economic benefits in terms of multiplier effects. The SRF has such strong international appeal that it could be the main reason many tourists would visit Bangladesh. Whilst in the country many would want to visit other national attractions. The National Tourism Policy (NTP, 1992) proposed that, because of its unique and diverse attractions, the SRF should be developed as the springboard for the tourism industry.

2.6 Socio-Economics

The Sundarbans to the land ward side is surrounded by densely populated agricultural land. Data from the 1991 census has shown that the human population, within 20 Km of the Sundarbans, is 2.0 million. The population

growth rate is estimated at 2.04% per annum which, if sustained, would mean that the population would double by the year 2025.

2.6.1 Results of the Socio-Economic Survey

In 1994/95 a socio-economic survey was conducted by MARC (1995) During this survey 981 households were interviewed, providing data on 6211 people residing within 10 Km of the SRF. For more details reference should be made the socio-economic study (MARC, 1995) and section 12 of the IRMP.

About two-thirds of the households reported some degree of dependence on the SRF; for 38 % it was for seven months or more of the year and for 21 % the dependence was virtually for the whole year. It was found that the poorer families depended less on the SRF than the middle and upper income groups. Restricting access to the SRF resources would hurt substantial numbers of households, with the middle and upper income households hurt comparatively more.

Most people, (94-95 %), felt that their food and clothing needs were met. The situation was also reasonable in respect of housing. However, the education and transportation needs were not met for nearly a third of the households. Security and recreation were found to be serious problems for the majority. Unmet recreational needs were articulated by two-thirds of the households possibly indicating heightened awareness that basic needs extend beyond essential items such as food, housing and clothing.

Substantial proportions of respondents had conflicting opinions about the status of tigers, deer and monkeys. There was unanimity with regard to the decline of all other wildlife. Turtles, in particular, were thought to be on the verge of extinction, shells, crabs and crocodiles were seriously threatened and in decline. Trees, fishes, lizards and shrimps were said to have substantially decreased in recent times.

When asked what management controls should be imposed to save the SRF the most common response was to completely ban or have firmer regulation of the extraction of resources, particularly in respect of the use of fine mesh nets for capturing shrimp fry. The people in the SRF border are clearly aware of the seriously degraded status of the forest and its wildlife. It is likely therefore, that management proposals designed to save the SRF would not be rejected, provided there is enough consultation and dialogue during the preparation phase.

The following three problems facing the local resource users were most frequently expressed:

- lack of personal security;
- FD malpractice; and,
- income inadequacy.

When asked how their occupational problems could be solved, the answers were mostly related to security followed by financial assistance from the government and donors. Stopping malpractice also featured, but not as prominently as might have been expected. Whether this can be interpreted as fear or resigned acceptance is not clear.

Community problems recorded were: incidence of disease; lack of drinking water; and, inadequate education facilities. Corresponding recommendations were made by respondents urging assistance in extending tubewells, medical facilities and schools. Strong statements were made about the community's own role and desire to solve their own social problems, particularly those related to marriage, divorce and banditry.

2.6.2 Employment Opportunities in the SRF

By taking the current production figures (from all available data sources) and productivity estimates the total amount of employment generated by the Sundarbans Reserved Forest has been estimated. These figures must be treated as indicative as they were based, often on small sample sizes and on some large assumptions. The figures presented only refer to the employment directly generated in exploitation of the resources and do not include secondary production such as the processing the products in say the sawmills, pulp and papermills, or fish processing plants. Further employment is also generated by the traders and purchasers who take the raw products on from the Sundarbans to other markets such as Dhaka. For further details see Mitchell (1995a).

Table 21 Derived Annual Level and Value of Employment from the SRF by Product

Product	Units	Average Annual Harvest	Number of mandays per unit	Total No of mandays	Value of labour only	Labour plus living costs	Total Value of Labour only	Total labour plus living costs
		Units x 1000	md/unit	md x 1000	Tk/unit	Tk/unit	millions of Tk	
Forestry Dept staff	No.	1038		379				24
Sundri timber	m3	49		1059		872	42	42
brushwood				36				1
Gewa				234				9
Goran	BLC mds	1608	0.39	626	30	39	48	63
Golpatta	BLC mds	1882	0.40	754	57	65	108	122
Fish	tonnes	40	325	12987	4123	6322	165	253
Shrimp fry	thousand	1613	10	16130	400		645	645
Honey	kg	230	0.48	111	76	16	18	21
Others				427				17
Total				32742				1198

The total number of mandays worked per year is in the region of 33 million which has an estimated value of 1.2 billion Taka. If it is further assumed that there are 293 working days per year then this is the equivalent of 112 thousand full time jobs. Most of this employment however, is both seasonal and part time. It is likely, therefore, that this figure in reality would be many times greater.

2.7 Current Administration and Management

At present the responsibility for administration and management of the SRF is vested in the Forest Department. The Chief Conservator of Forests is the administrative head and is responsible for overall administration of the Department and acts as adviser to the Ministry of Environment and Forest. The administrative structure is illustrated in Figure 3 which demonstrates and hierarchical nature of the organisation and the anomalous lines of command for the Conservator of Forests (CF) Khulna Circle and the Divisional Forest Officers (DFOs) Environment and Management Planning.

2.7.1 The Forest Department

The forest has been managed by the FD for over 100 years and it is too their credit that the Sundarbans remains more or less in tact to this day. However, the management structures, staffing and responsibilities have changed little over the years. Traditionally management has concentrated on the wood resource. As the use and value of the other resources increases, there needs to be increasing emphasis on management of these resources. The knowledge of ecology and conservation has increased dramatically over the past two decades. The management of the SRF has not kept pace with this change.

The CF Khulna Circle is responsible for overall administration of the Circle which only includes the Sundarbans Division. His responsibilities cover budgets, staff appointments and discipline and execution for all functions of

the Division as set by Government Acts, Ordinances, Rules and regulations. He is also responsible for the execution of work programmes, supervision of DFO's, for revenue collection and audit of accounts.

The DFO Sundarbans Division is responsible for administration of the SRF, including operational plans, staff discipline, revenue collection, budgets, execution of the Forest Act, silvicultural work and sales of forest produce. He is assisted by Range Officers, (ACFs) at Chandpai, Sarankhola, Burigoalini, and Nalianala. There is a total of 1038 people who work for the FD in the Sundarbans Division.

The post of DFO Environment Management was created in line with the FRMP. The responsibilities for this post are: conservation and maintenance of the SRF's wildlife sanctuaries; maintenance of biodiversity; planning and implementation of nature conservation activities; and, research and environmental monitoring. His work is in the SRF but the line of command circumvents the CF and DFO Sundarbans.

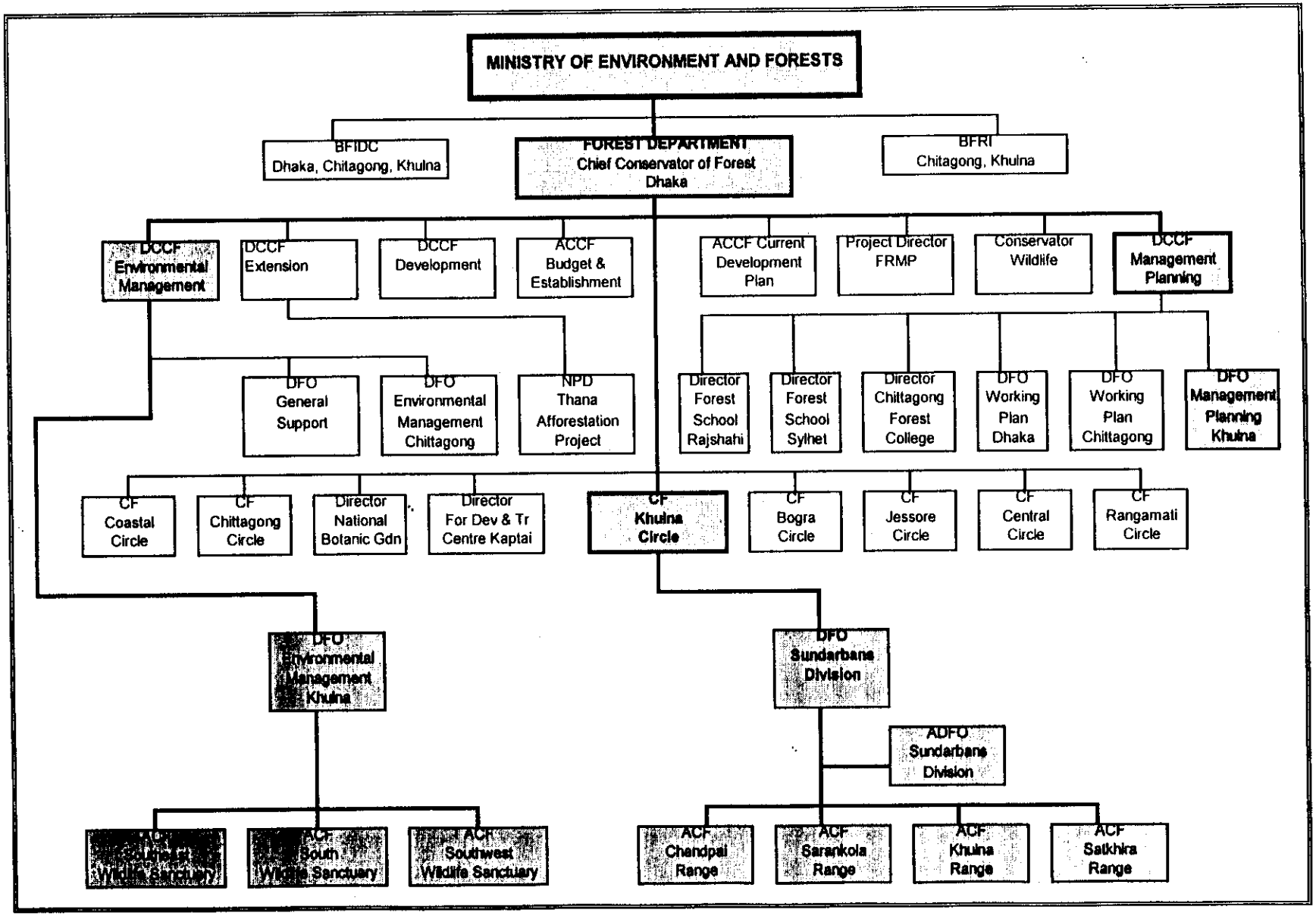
The DFO Forest Management Planning is stationed at Khulna and is responsible for the preparation, updating and revision of forest management plans for the SRF and the four coastal afforestation divisions of Chittagong, Noakali, Bhola and Patuakali.

2.7.1.1 Law and Order

A primary function of the FD staff has been to enforce the various laws designed to ensure the integrity of the reserve and its resources. Whilst the policeman's role is obviously essential, it is felt that the forest will not be better conserved simply through improved policing. A conservation strategy which antagonises local people and does not sufficiently regard social as well as environmental problems is bound to fail. Ignoring the economic, social and ecological realities will fuel the unstoppable pressures on the resources of the SRF.

The FD staff are often regarded policemen who simply collect revenue, restrict access to a common resource and pay little heed to the equitable sharing of benefits. To plan for better policing through provision of better guns and faster boats will only serve to heighten this view and will increase the tension and confrontation (Bhuiyan, 1995; MARC, 1995). The decline in status of nearly all resources underlines the continuing failure of this approach.

Figure 3 **Administrative Structure of the Forest Department**



The majority of infringements of the law stem from poverty, lack of employment and the growing demands of an increasing population for land, employment and social justice. The FD is well positioned to foster development as well as conservation but this will only be successful if the needs of people are fully reflected in the law and in the actions of the law enforcers. This can best be achieved by greater participation of the people themselves in the conservation process with more co-operation and less confrontation.

2.7.1.2 Expenditure and Revenue

The FD's budgets are discussed in greater detail in Mitchell (1995a) and in the IRMP section 13.

The total expenditure and revenue for the Forest Department as a whole and for the Sundarbans Division are presented in Table 22.

Table 22 Forest Department Total and Sundarbans Division Expenditure and Revenue (millions of Taka)

Expenditure	Year						
	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	Average
Forest Department							
Development Budget		414	437	371	569	753	
Revenue Budget	148	181	198	236	293	306	
Total		595	635	607	862	1059	
Sundarbans Division		30	29	31	34		
SD as % of revenue budget		17	14	13	12		14
SD as % of total		5	4	5	4		5
Revenue							
Forest Department Total		260	194	322	356	382	
Sundarbans Division Revenue	284	128	68	138	115	172	
SD as % of total revenue		49	35	43	32	45	41

Source: Forest Department Records

The Sundarbans Division contributes on average 41% of the Forest Department's revenue but it only receives 5% of the total expenditure and 14% of the Revenue Budget expenditure.

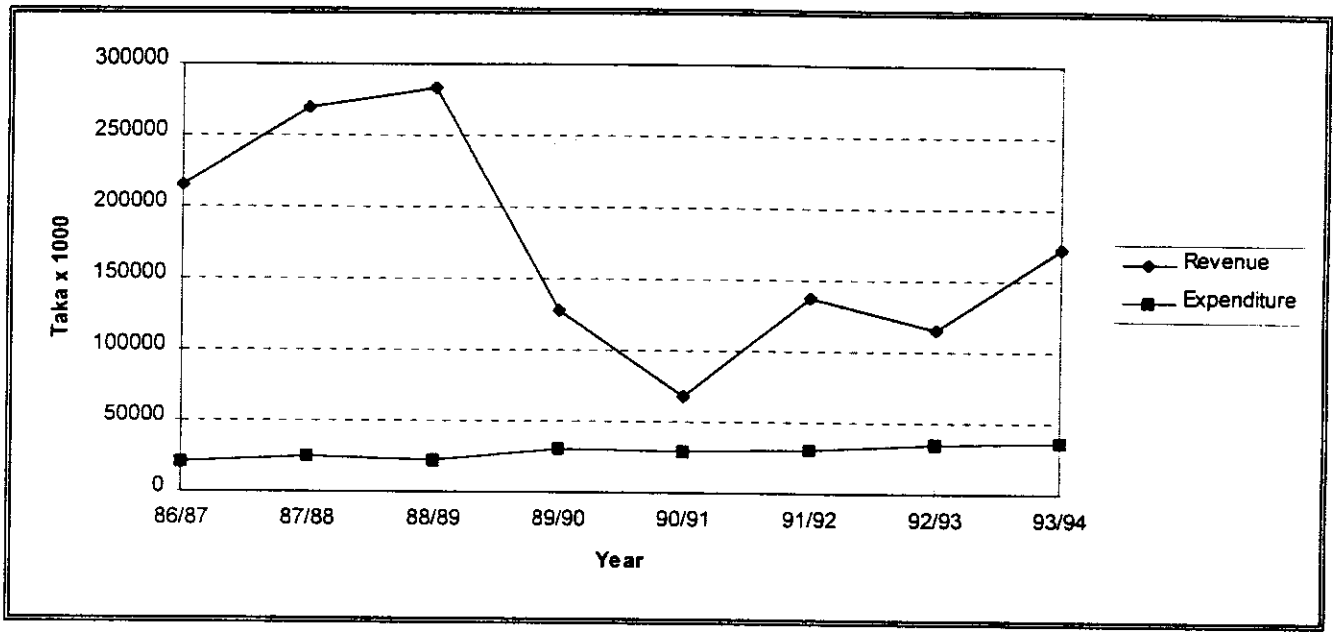
Administration Costs include salaries, staff allowances and office running costs. In 1992-93, the cost of salaries and allowances amounted to 80% of the total expenditure. With so much of the budget taken up with the cost of staff, it can be clearly seen that there is very little left over for either capital projects or for increasing the operational capacity of the department.

The figures however, only include the costs of the Sundarbans Division and exclude any central over heads, which within a centralised structure such as the Forest Department would be high. The figures also exclude any expenditure of the FRMP.

Given the way the FD's Sundarbans Division expenditure accounts are presented it is very difficult to undertake further analysis of the expenditure figures without making some fairly large assumptions. For example, it is not possible to ascertain how much the FD spend on protection and policing the reserve.

Figure 4 shows the Sundarbans Division's level of expenditure in comparison to the amount of revenue collected. Revenue considerably exceeds expenditure. The graph also shows that the expenditure has been reasonably constant but that the levels of total revenue are varied. Whilst the Sundarbans Division accounts for only 5% of government expenditure on Forests it contributes between 35 and 49% of the annual revenues.

Figure 4 Graph Showing Forest Department Revenue and Expenditure



Leader-Williams (1990) estimates the cost of protecting areas for the conservation of large endangered mammals at US $ 400 / km^2. This would give an annual budget for simply protecting the tiger, with no other activities in the SRF, of nearly Tk 100 million (three times the current total expenditure). Obviously such large expenditures are not feasible over large areas and when resources are limited it is better to concentrate high levels of expenditure over smaller areas such as more intensively managed wildlife sanctuaries.

Analysis of the FD's expenditure on the SRF over the years (since the Heinig working Plan of 1892) shows that there has been very little change in the proportion of total expenditure spent on staff salaries, and also the amount of expenditure in relation to the amount of revenue. Given the increase in the objectives of management for the SRF, the huge increase in the numbers of people dependent on the SRF and consequently the problems of policing the reserve, it is questioned whether these ratios should in fact remain constant. It is felt that an increase in the resources devoted to management and protection would eventually lead to increased revenue and better protection.

The low funding of SRF is the direct cause of the following :

- a large fall in real living standards for the FD staff, leading to reduction in morale and status;
- an inability to maintain buildings and equipment;
- an inability to carry out capital improvements; and
- the provision of a justification to abuse the system

As the gap between a reasonable standard of living and the official remuneration continues to grow, society can only expect otherwise loyal civil servants to devote more time filling the gap rather than carrying out official duties. The Division's equipment is run down and wholly inadequate to carry out its demanding functions.

The revenue obtained for each of the individual natural resource components is presented as Table 23.

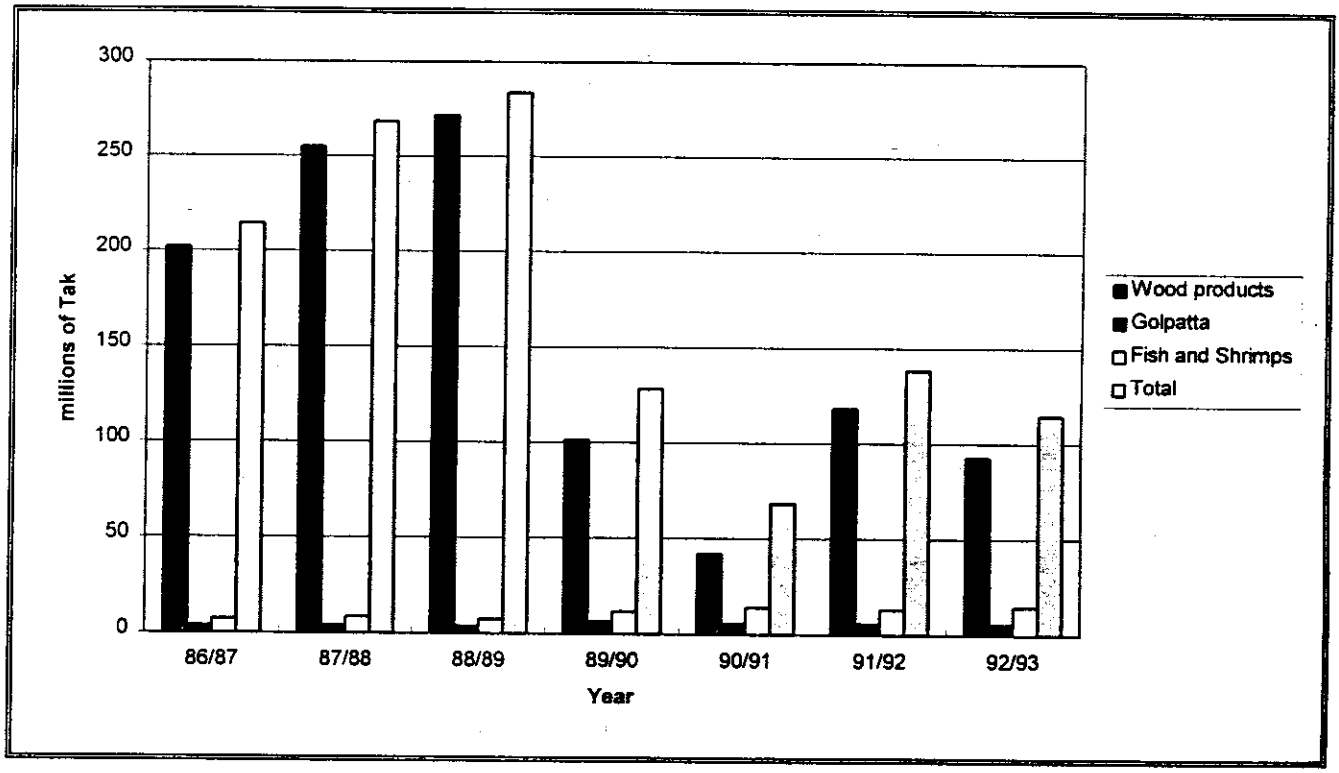
Table 23 Forest Revenue Since 1986-87 by Product (Taka x 1000)

Product	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
Wood products	201869	255097	271688	101438	42024	118108	92907
Golpatta	3825	4215	3976	6723	5799	5822	5447
Hantal	170	210	223	339	334	448	391
Honey	184	179	85	625	563	426	489
Wax	92	89	40	195	211	148	183
Fish (all)	7069	8469	7492	9237	11188	8888	9468
Malia grass	94	108	119	104	57	37	73
Oyster shells	43	48	49	65	66	85	90
Shrimps							
Shrimp fry				2269	2849	4323	5225
Miscellaneous	1023	26		7143	5174		454
Sub total	12501	13344	11983	26701	26242	20176	21820
Total	214370	268441	283671	128139	68265	138284	114727

source: Forest Department records (DFO's annual report)

This table is expressed graphically as Figure 5.

Figure 5 Graph showing the Revenue of all Forest Products by Year



Wood products account for by far the biggest proportion of revenue. The Sundri sold by auction contributed 90% wood product revenue. All other products are either sold by permit or royalty.

2.7.2 Other departments and agencies

A fuller description of the other agencies and departments with an interest in the SRF is described in section 8.4 of the IRMP.

Although the Forest Department is the authority responsible for administering the Forest Act there are areas where support from other departments and agencies is required. These areas include:

- rights of passage
- security
- harvesting of non-wood forest produce
- fisheries management
- shared water resources
- wildlife movements
- artificial boundaries
- international marine waters
- international boundaries
- pollution
- meteorology
- tourism
- socio-economics
- research and monitoring

Within central Government there are Ministries with executive functions. The Ministries most concerned with the SRF are the Ministry of Environment and Forests (MOEF) and the Ministry of Fisheries and Livestock (MFL). The Forest Department is a department within MOEF and the Fisheries Directorate within MFL. Under the Forest Act of 1927 the Forest Department has powers of arrest and seizure of products suspected of being illegally procured from the forest. Other criminal activities within the study area are the responsibility of the Bangladesh Police Force. The Port Harbour Authority is responsible for the international shipping which travels up through the Sundarbans Reserved Forest via the Passur river to Mongla Port.

International policing both on the Indian border and in the high seas are the responsibility of the armed forces, namely; The Bangladesh Rifles and the Bangladesh Navy.

Local government is entrusted to locally elected bodies. In rural areas the lowest level of locally elected body is the Union Parishads (Union Councils). There are also Zila Parishads, and Thana Parishads.

The SRF and border areas fall into three districts: Khulna; Bagerhat; and, Satkhira, all of which are within Khulna Division. Civil matters are the responsibility of the District Commissioner based in Khulna.

Other organisations such as the Bangladesh Forest Research Institute (BFRI) and Khulna University have interest in the SRF for research proposes. Bangladesh Parjatan Corporation are interested in the Sundarbans area for its development potential for tourism.

2.7.3 Research

The IRMP section 9 describes in detail the major research efforts to date.

Existing research has focused upon forest inventories, permanent sample plots, partial soil, salinity and plant ecology surveys and uncoordinated studies on silviculture, plantations, wildlife and tourism and on some non-wood products notably the Golpatta inventory. More recently research efforts have included the study on the hydrology and the setting up of the GIS and Integrated Databases.

Research has often been inadequate for making informed judgements. This is largely a reflection of past narrow introspective policies and insufficient investment in research programmes, lack of continuity in the deployment of staff and a lack of co-ordination between concerned agencies.

2.7.3.1 Research Organisations

As well as the research directly undertaken by the Forest Department, the following organisations have an interest in undertaking research in the Sundarbans or could be the source of specialist skills. For details of past and present research programmes please refer to IRMP sections 9.2 to 9.9:

- Bangladesh Forest Research Institute (BFRI);
- Khulna University;
- Bangladesh Water Development Board (BWDB);
- Fisheries Directorate;
- Bangladesh Parjatan Corporation (BPC);
- The International Union for Conservation and Nature (IUCN);
- The Soil Resources Development Institute (SRDI);
- The Khulna Newsprint Mill;
- Bangladesh Forest Industries Development Corporation (BFIDC);
- Bangladesh Small and Cottage Industries Corporation (BSCIC);
- Coastal Area Resource Development and Management Association (CARDMA); and,
- Flood Action Plan (FAP).

With research covering so many fields, with so many potential contributors, co-ordination and the setting of priorities is essential.

2.8 Revenue Systems

For more details on revenue systems please refer to the IRMP section 13.2.1 and Mitchell (1995a). Forest charges have been collected from the Sundarbans Reserved Forest area from before the original reservation in 1876 (Heinig, 1892). Historically forest charges have been collected by a system comprising royalty payments, permit fees and auction sales. This combination of methods still prevails.

2.8.1 Permits and Royalties

Forest charges for many different products are collected by either a royalty charged per unit of production in arrears (usually for timber to the large scale industries) or by charging for the issuance of a permit, for a specific quantity of the product prior to collection. Generally, permits are issued for the lower value products and most of the non wood forest products. Rates are periodically revised by modest amounts. When the rates are revised there is generally a survey of prevailing market prices. The permit fees are set to approximate to 10% of the market value.

The fees are also charged using many different units such as cft, mds, 100 mds, pieces, pon etc and in some instances by different size classes. The entire system is cumbersome and inaccurate and the lack of financial precision is made worse by the contradictory custom of collecting under numerous headings and then sometimes

aggregating these under a single miscellaneous head. Inevitably important financial and management information is lost.

The permit system also indicates, incorrectly, that many of the products are sold by the quantity produced. For example shrimp fry are charged for at the rate of Tk 5.00 per 100 fry caught. However, it would clearly be impractical for Forest Department to count the number of fries produced. In practice it is assumed that one net will catch 1400 fry in a week. The FD staff are not actually recording the number of fries caught but the number of nets that are used. From this it is obvious that the statistics produced are wholly misleading.

As well as the official fees announced by Government Order other fees are collected under such headings as 'miscellaneous fish', 'under size fish'. There are also arbitrary fines imposed when an offender is caught red handed (Chandpai Range Annual Administrative Report 1993 - 94).

Revenue is collected for permits for a specific quantity of relevant product. The schedule of rates has only been revised 6 times in the past 19 years so that the value of permits in relation to market values of products tends to be low. For most non-timber resources the volumes and value of the products are so low that the current system of permits would seem appropriate. There are however three notable exceptions to this due to their quantity and value, namely Goran, Golpatta and fisheries.

REB Transmission Poles

The FD produces Sundri poles for the REB. The REB pays a fixed royalties of Tk 156 / cft and Tk 164/ cft. Whilst the royalty paid by REB is high in comparison to the other royalty fees listed, it is extremely low when compared to the prices obtained at auctions. The REB poles are of a selected quality so it is not possible for them to buy them in the present auction system where lots are made up of mixed quality timber. Currently REB poles are produced by the FD as a separate operation and are not included in other felling operations.

Sundri Brushwood to KHBM

Khulna Hardboard Mill preferably utilises green Sundri branchwood or Shingra. Since the moratorium KHBM have been restricted to using the branchwood from the Sundri trees that have been felled because of top dying and only a limited amount of Shingra, often of small size. Inevitably much of the Sundri supplied is rotten and dry. This results in a lower quality product with poor conversion rates. Currently KHBM pay Tk 3 / cft for Sundri and Tk 1.73 / cft for Shingra. This produce could however, be readily sold for firewood even if the degree of rot and small sizes are taken into account.

Gewa Pulpwood to KNM

The Khulna Newsprint Mill currently pay a royalty rate of Tk 15.00 per cft (true cft) for Gewa pulpwood. KNM also arranges for the cutting and extraction at their own expense. The royalty rate traditionally, was much lower (Tk 0.06 per cft until 1992 when it was revised to Tk 6.03 per cft); in effect the pulpwood was supplied virtually free of charge. The cost of importing substitute pulpwood is estimated by ADB at Tk 6000 per air dry tonne (ADT) in 1993 delivered to the mill. (ADB - FMP, 1992). This equates to Tk 206/cft (assuming $1m^3 = 1$ tonne). KNM's total costs to fell, extract and haul the Gewa to their yard is Tk 45/cft including royalty payments. During 1993-94 KNM started to use jute as a substitute supply of fibre. Initially, the jute consumption was set at 5000 tonnes. This, according to KNM, provides the same amount of fibre as 500 000 cft (approximately 14 000 m^3) of Gewa. The jute costs KNM between Tk 15 000 and Tk 18 000 per air dry tonne of pulp. This equates to Tk 150 - Tk 180/cft of Gewa, assuming that processing costs are the same.

The price paid for rough pulpwood bought standing in the Britain is comparable to the royalty that KNM are pay suggesting that the current royalty is probably appropriate.

The demand for Gewa is by no means limited to the pulpmill. Match companies like to use Gewa for splints, it can be used by sawmills for pallet wood the inside of furniture, and it can also be used for firewood.

Goran Firewood

The measuring of Goran removals by BLC has been shown to underestimate the volume by around 40%. Consequently even before the level of permit is set there is a serious undervaluing of the product. Analysis of the production costs has revealed:

- the cost of harvesting and transport represented 42% of the total costs;
- legitimate forest charges were 7% of the total costs;
- the cost of finance, middleman and marketing charges were 16% of the total costs; and,
- the remaining 35% of the cost production were payments that had to be paid as unofficial levies.

To cover these losses the contractors (bawallis) are forced to take more than the permit allows to avoid bankruptcy. The real loser is the State which does not receive the full value of revenue from the resource. If there were no unofficial levies, then the level of permit could be raised nearly five times and the bawallis would be able to earn a modest profit on their labour which does not happen at the moment.

Golpatta

Prior to 1972 Golpatta was sold standing by area at auction. This led to a small group of traders monopolising the Golpatta business. This was seen to cause hardship to consumers and smaller traders. To make the market fairer, the MOEF introduced the permit system, whereby the maximum permit per person was for 500 mds (later reduced to 300 mds) with the cost deliberately set low to benefit the harvesters. Perversely, this created opportunities for windfall profits. Vested interests distort an otherwise equitable system by purchasing much of the Golpatta harvest through third parities and assumed names.

The permit fee, low as it is, still remains beyond the reach of the local poor. The product is under-valued, unfair profits are made and benefits do not reach the targeted disadvantaged section of society.

The analysis of the costs of harvesting Golpatta has revealed:

- the official permit charge represents 5% of total costs;
- the cost of production is 58% of the total;
- the cost of finance and trading was 10% of total costs; and,
- the costs of unofficial levies represented 27% of the total costs.

The loser is again the nation. The bawallis make up for their losses by taking more than the nominal amount registered by the FD for the permits.

If the unofficial levies were removed, the level of permit fee could realistically be increased fourfold. This would allow the contractor to make a modest profit of 30%, still allow the existing methods of finance and trade, and increase the annual revenue considerably.

Auction sales

In the past, two types of auction have been used for the sale of sawlogs; standing and depot auctions. Standing auctions are where the trees to be sold are marked in the forest and they are then sold to the highest bidder. It is the buyer's responsibility to harvest the trees. In depot sales the Forest Department fell and extract the timber to a depot where it is then sold at auction. Both systems have advantages and disadvantages Currently top dying Sundri is sold at depot auctions.

Generally the auctions are highly competitive and much higher return to the state is obtained than would be possible if the logs were sold by permit. The average price for Sundri at the auctions in 1993 - 94 was Tk 219 per cft. The current rates for sale of Sundri timber by permit is Tk 18 per cft, approved in 1986.

2.9 Valuation of the SRF

In order to make rational management decisions it is essential to know the economic value of the resources. Without this yardstick it is impossible to calculate costs and benefits of alternative management actions or to set priorities for work plans.

The valuation of the Sundarbans is a complicated task; many of the benefits of the ecosystem can not be directly attributed a cost, price or benefit. It is not possible for example to ascertain the price of protection from tidal surges. Intangible benefits may well be worth more than many other benefits or land uses.

Traditionally only the direct land use benefits were compared with a new proposed treatment. For example the production of wood in the Chakaria Sundarbans would have been compared with the value of producing shrimps for export. In that case the production of shrimps would have far out valued the production of timber from the forest. However, as is now apparent the production of the shrimp farms was not sustainable and the environment has become degraded. From this it is evident that the true value of the forest was not compared with the production from shrimp farming in the first instance. In other words the protective value of the forest that initially sustained the shrimp farming was lost over a few years following the destruction of the forest.

The direct use values are the benefits accruing from the ecosystem that can be both defined in terms of quantity and price. The indirect use values are those that are usually derived from the protective and existence functions of the forest. These are obviously less tangible and are hence more controversial.

The total economic value is the sum of the direct and indirect uses less the cost of managing the resource. In the valuation certain assumptions have been made. All figures quoted must therefore be treated with caution and should only be taken as indicative. It has been assumed that:

- future revenue is restricted to what is currently possible within the existing infrastructure. Potential value is ignored. Valuations are for the value of the SRF under the current management regime;
- wildlife is valued under Indirect benefits because at the moment there is only an existence value;
- inflation will be constant in terms of both prices and costs;
- the value placed on the timber in the Sundarbans may be artificially high by intentional standards. Sale prices attained at auction of the Sundri timber are exceptionally high. Prices compare with timber from superior species of better quality and size on the international market. Also importation of timber is discouraged and local timber prices protected from competition through import duties which range from 7.5% to 60% **ad valorem**. (ADB FMP, 1993a);
- with the exceptions of Sundri sold at auction and the Gewa to KNM, the current prices paid for many products are undervalued;
- where the data were are available new estimates of economic values have been derived.
- for other products the current royalty rates are correct;
- there is a general lack of sound raw data for all the resources

The derivation of the values quoted here can be found in Mitchell (1995a) section 6. Table 24 summarises the direct use values.

Table 24 Summary of the Direct Use Values and Costs of Management

	Annual Revenue	Capital Equivalent	Standing Value	Estimated Total	
	Tk x 1000	millions of Taka	millions of Taka	millions of Taka	millions of $
PRODUCT					
Wood	715659	5505	47202	47202	1180
Fish	302436	2326		2326	58.16
Shrimp Fry	541185	4163		4163	104
Apiculture	2200	17		17	0.42
Golpatta	22591	174		174	4.34
Hantal, Grasses and Oysters	594	5		5	0.11
Miscellaneous	2420	19		19	0.47
Gross Total					
	1587086	12208		53905	1348
Estimated Cost of Managing the Resources					
Forest Department Costs	34169	263		263	6.57
Net total	1552917	11946	47202	53642	1341.05

source: Mitchell 1995a

It is clear that the total annual economic value of the non wood resources production is in fact greater than the value of the wood resource production. This however, is not reflected in current management priorities.

Table 25 summarises the total direct and indirect benefits of the Sundarbans Reserved Forest.

Table 25 Summary of the Total Direct and Indirect Benefits of the SRF

Net Benefits	Annual Benefit	Capital Equivalent	Standing Value	Estimated Total	
	Tk x 1000	millions of Taka	millions of Taka	millions of Taka	millions of $
Direct use values	1552917	11946	47202	53642	1341
Indirect Use Values					
Flood and Storm Protection	320000	2462	16000	18462	462
Marine and shrimp production					
Existence values					
Tiger			80	80	2
Spotted deer	20 000	154		154	4
Biodiversity					
Total	**1892917**	**14561**	**63282**	**72338**	**1808**

source: Mitchell 1995a

Dependent industries

Some major industries are either partly or totally dependent upon the SRF for their raw materials. If alternative forms of land use were to be considered then the loss of these dependant industries, the employment generated and other multiplier effects must be added into to the values described above. Table 26 shows their relative values, their estimated total annual turnover and estimates dependency on the SRF.

Table 26 Annual Turnover of Industries Dependent on SRF Production

Industry		Annual Value	Percentage dependent on SRF	Value of dependant production	source
		millions of Tk	%	millions of Tk	
Extraction of Resources		1198	100%	1198	derived
KNM		838	100%	838	BBS
KHBM		85	100%	85	BBS
Sawmills#		315	100%	315	derived
Marine	fish~	49	20%	10	DOF+derived
	shrimp*	1542	60%	925	DOF+derived
Total				3371	

Based on the average timber production per year multiplied by the average sawmill selling price, with an assumed recovery of 70%

~ average annual production of 2458 t per year based on recorded harvests from 88-89 to 94-95 multiplied by assumed sales price of 20 Tk/kg

* average annual production of 4820 t per year based on recorded harvests from 88-89 to 94-95 multiplied by assumed sales price of US$ 8/kg = 320 Tk/kg

source: Mitchell 1995a

It can be seen that there is a annual derived production of Tk 3.4 billion with a net present value at 13% of a further Tk 26 billion (US$ 0.65 billion) dependent on the SRF. Any alternative land use scheme must consider these values in the cost benefit analysis.

3. EVALUATION

In this section it is proposed to draw conclusions and highlight facts which need to be addressed in the future management of the Sundarbans. It shows why the various proposals in part four are made.

From the preceding sections it is clear that the management of the Sundarbans Reserved Forest has already reached a critical point. There are areas of the ecosystem which have only recently been studied in a continuous and systematic nature and the complexities and interactions of this dynamic ecosystem are far from being completely understood. Studies are revealing that the area is changing both in terms of physiography and ecology at unprecedented rates, yet there has been little recognition of these factors in current management practices. There are indications that the resources of SRF are becoming depleted and that some are being harvested at unsustainable levels. Many of the harvesting techniques are wasteful or destructive. Management of the NWFPs is characterised by simply the issuing of permits and collection of revenue. The recording of removals is normally by estimating the quantities from the number of permits issued not from the actual resources removed. The local poor who depend on the SRF for all or part of their livelihood are being exploited by traders, dacoits and other vested interests. There is an increasing number of people accessing the SRF with consequent increasing confrontation between harvesters and officials.

The ecology and the physical environment of the SRF is governed by the hydrology. There are areas silting up, leading to possible floristic changes, salinity levels are variable and there is accretion and erosion. There is increasing evidence of pollution affecting both the mangroves and the aquatic life. Research has shown that sea level could be disastrous for the Sundarbans. The hydrology of the area has only recently been studied on a continuous basis, and this too, has now again ceased. Possibly, the most significant single factor with regard to the well being of the Sundarbans is the hydrology. It is considered that it is an absolute prerequisite that the

monitoring and reporting on all aspects of the hydrology is undertaken. Without this knowledge the future 'Integrated Resource Managers' will not have sufficient knowledge of this dynamic environment to make informed and correct decisions. This complex and comprehensive study can no longer be left to conjecture or *ad hoc* uncoordinated studies but must be the subject of continuous survey and analysis.

Before any area can be managed, it is necessary that it is clearly defined. Whilst the SRF has been reserved since the last century, there are a number or border anomalies which need to be addressed. The most significant, for management purposes, is the definition of the southern boundary and the extent of the fisheries which should be included inside the reserved forest.

The plant ecology of the area is dependent on edaphic factors. There has, to date, been no complete, organised and systematic soil survey. This again is a key area where there is a lack of hard data. How can key silvicultural and ecological decisions be made with out this fundamental data set?

It has been shown that both the value of the forest and the growing stock has decreased significantly over the past 30 years. The extent of this will not be fully known until after the FRMP inventory has been completed. There are significant areas of Sundri top dying the extent and cause of which are still not known. Some of the areas where top dying Sundri has been salvaged are not regenerating. All this points to a lack of knowledge of the resource and a lack of stringent monitoring and control. Major efforts in the past to inventory the growing stock have produced data only valid for one level of stratification. Poor recording of removals and a lack of knowledge of the growth dynamics and mortality have meant that the information of the inventories have soon become out of date. It is clear from this that the system of one off project inventories is not meeting the requirements of management. The past inventories have been undertaken with technical assistance; once completed, the technical advisers have left and those local staff trained in inventory work are moved on to other tasks. The capability to continually collect and analyse this key resource data is not maintained. The future must move towards building the technical capability that will not be lost as soon as a project is over. As information needs are continuous, so the capacity to obtain and analyse the information must also continue indefinitely.

Previous inventories have concentrated simply on the commercial timber species. Little work has been done recently on other species such as Goran and Golpatta in particular which annually are harvested at significant levels and other species such as Hantal and the grasses which are produced in smaller quantities. How is possible to know if these products are being produced sustainably, are being over cut or could harvested at a higher level if the extent of the stocks and the growth rates are unknown? This lack of knowledge of all the non wood resources is of fundamental importance and the scientific collection of resource data, the assessment of growing stocks, measurement of growth and yield and the recording the removals is essential for sustainable integrated resource management.

The review of the harvesting methods of the wood and plant based resources has revealed a number of wasteful practices which could easily be addressed through incorporation new rules, procedures and instructions to contractors and permit holders.

There are a number of products which are either currently under utilised or not used at all which have potential to be developed further. These include medicinal and aromatic plants and tans and dyes. There is also the possibility of bio-prospecting. All these activities require further research and development.

It has been shown that fisheries and shrimp fry collection are by far the most important resources of the Sundarbans in terms of employment and subsistence. Yet these important resources are managed simply through the issue of permits and collection of revenue. There is no continuous monitoring of the growing stocks, removals or fishing gears utilised. There are no reliable estimates of sustained yield. Within the managing department there are no fisheries biologists or fisheries managers. There is more than a tenfold variation between different estimates of the current harvest. It has been stated that if overfishing continues then it is likely that the stocks will crash. It is therefore clear that there needs to be continuous monitoring of the fisheries, estimates of sustained yield made, methods of controlling the yield designed and set, and finally monitoring the removals. There is a definite need for skilled, technical fisheries management.

Likewise, the honey production is poorly quantified. The number of colonies and the potential production are not known. The resource base on which the bees depend has yet to be quantitatively defined and the effects of harvesting on the bee population and the ecology of the forest are not understood. Some of the harvesting rules

seem to be based more on administrative expediency than ecology. Honey production and processing affords one of the few avenues immediately available to assist disadvantaged social groups, women in particular. Much of the honey collected in the SRF is badly handled and is often mistakenly assumed to be of inferior quality. A good avenue for improving the local apiculture industry would be to integrate production from the SRF with small scale growers in the surrounding area through positive extension services. Assistance to farmers and rural communities for training of honey collectors, introduction of apiaries in the Sundarbans and optimisation of the use of variations in honey flow could be of great benefit to the rural economy. It would also demonstrate, in a positive way the indivisibility of the SRF and the needs and activities of local people, especially mowallis, who should be looked upon as part of ecosystem management and not simply a source of resource exploitation and resultant revenue.

The wildlife of the Sundarbans has been studied but not on a continuous basis or in enough detail to give the requisite information for managers. The ecology and behaviour of the tiger is still poorly understood. There is the possibility that populations of deer and wild boar could be managed for consumptive utilisation within certain areas of the forest. This however is dependent of further research to generate sufficient knowledge on the life cycles and fecundity to ensure that it is sustainable and will not adversely affect the interactions with other species. This has the potential for generating substantial revenue, employment and subsidiary industries as well as providing meat for local consumption.

Forests and wildernesses usually have great capacity to absorb many visitors without much investment. However, the SRF is an unusual case as it is dependant on the supply of suitable boats for access, Forest Guards to act as guides and Forest Officers to approve and issue permits. The demand for domestic tourism is predicted to continue rising. International tourism's potential for significant growth will only be realised however, if there is investment in the infrastructure. This development, in line with the national tourism policy, has the potential to generate significant tourism revenues and employment, without degrading the environment. Tourism, perhaps has the largest potential to provide markets for secondary industries. The economic multiplier effects of tourism are substantial.

Given the increasing population it is no longer a viable option to control access to the resources through exclusion. The sustainable way forward is through less confrontation and more co-operation especially with disadvantaged user groups; by sharing of information; by establishing the means for equitable access to the resources and equitable sharing of benefits; with independent audit and multi-sectoral accountability.

Considerably more integrated research is needed to achieve the requisite level of understanding of the ecosystem. Sufficient research will only be generated once it is accepted that research in the SRF is multi-sectoral and has local, regional and international aspects. Clear direction is required to reach integrated research goals. Integrated management of all resources demands broadly based multi-disciplinary action in a co-ordinated programme of continuous data acquisition, storage and analysis.

New research techniques include methods for making accurate and repeatable physical measurements, hitherto impossible, such as hydraulic modelling, elevation mapping, remote sensing for vegetation and landform analysis, GIS data bases and multi-variate analysis. Together these provide managers with the data necessary for preparing, implementing and monitoring management plans. The ultimate research aim is to understand and conserve the entire ecosystem and to help managers set sustainable yields.

The Sundarbans Reserved Forest has been managed by the Forest Department for over a century. The forest contributes in revenue far more than it costs the FD to run, yet there is a serious lack of funding. Most of the infrastructure in terms of both the buildings and the transportation requirements are run down and are in urgent need of repair or replacement.

The Sundarbans Reserved Forest is a unique and wonderful place. It has been well managed in the past. The future however, due to changing needs requires a different approach. It is hoped that if the future management recommendations made in the IRMP are adopted these needs will be met.

4. FUTURE MANAGEMENT

In this section proposals for future management of the Sundarbans Reserved Forest are summarised. For greater detail please refer to part 2 of the IRMP. It should be stressed that the IRMP is not an operational working plan. The necessary information was not available when the IRMP was prepared. However, before such operational plans can be prepared, certain policy and institutional decisions need to taken by the government. The IRMP therefore covers the following areas:

- it identifies the information gaps;
- it suggests how these gaps can be filled;
- it suggests methods how, once the information is available, the operational plans can be prepared;
- it identifies areas where institutional change may be required;
- it suggests three different options for institutional change and the possible implications of each option;
- it outlines the philosophy behind integrated resource management; and,
- it identifies follow on self sustaining projects.

However, before these items can be addressed it is first necessary to state the goals and objectives of management for the Sundarbans Reserved Forest.

4.1 Goal, Objectives and Scope

The ultimate goal of the IRMP is to prepare management guidelines which will enhance the contribution of the production of the various resources to provide a wider range of socio-economic benefits on an environmentally sustainable basis. (UNDP/FAO,1992).

The objectives of the plan are to:

- conserve biodiversity;
- minimise environmental degradation;
- ensure that the production of the resources is sustainable;
- optimise the benefits of production of the various resources and help ensure fair distribution of those benefits within society;
- manage the ecosystem holistically so that no single resource is managed to the detriment of others;
- utilise new technologies where appropriate for management purposes; and,
- suggest options for institutional change.

The scope is to provide management guidelines for the whole Sundarbans Reserved Forest and to assess the implication of these guidelines for those who utilise and access the forest.

The future depends upon the will to reform management practices. The IRMP provides a framework for action which must establish functional links between multi-disciplinary technical agencies activities.

4.2 Boundaries and Zoning

4.2.1 Boundaries

Before management planning can be undertaken the extent of the resource must be defined. Many of the borders and boundaries of the SRF are vague and not definitive (the boundary of offshore fishery for example). The boundaries should therefore be studied by the relevant agencies and that the anomalies and controversial issues rationalised. There are four boundaries which require either clarification or new definitions:

1. the National boundary;
2. the shared marine waters boundary;
3. the SRF boundary rivers; and,
4. the Wildlife Sanctuaries.

4.2.2 Zoning

In order to meet the mixed objectives of management it is necessary that different areas are managed for different purposes. In order to secure biodiversity, it is necessary to protect examples of as many of the habitats found in the SRF as possible. To meet the productive requirements, some areas need to be devoted to sustainable resource management. Obviously with mixed objectives there is a trade off between the different methods of utilising the different resources. At the time the IRMP was prepared there were insufficient data to estimate the effects of the different management options. However, the plan was prepared with the following principles:

- wildlife sanctuaries would be created and managed to ensure that representatives of the various habitats are maintained;
- production would be sustainable; and,
- no single resource would be managed without considering the whole ecosystem holistically.

To achieve these goals the forest has been divided into zones primarily to separate the protection and production functions of the forest. The suggested zones are presented as map 10. The border zone encompasses the area within 10 Km of the SRF to the land ward side; it is home to nearly a million. To the south, a marine zone is demarcated.

4.3 Management of the Protection Zone

Map 9 shows the existing wildlife sanctuaries with proposed extensions.

4.3.1 Immediate Action

Ratification of the boundaries and management of the Protected Areas (PAs) throughout the SRF should be addressed as soon as possible. The DFO Environment is installed with staff and equipment but definition of his role in integrated management needs to be finalised.

Other matters which require priority attention are to:

- arrange for the full integration of the PAs in overall SRF management;
- set up research programmes to undertake baseline surveys and study the boundary descriptions of the existing and proposed wildlife sanctuaries;
- follow up on the preliminary information on special management of fish breeding areas, bird sanctuaries, crocodile breeding areas and turtle habitats.

4.3.2 Extension of the Wildlife Sanctuaries

The main purpose of the wildlife sanctuaries (WSs) is to provide protection to representative samples of each of the biota in the Sundarbans and to maintain biological diversity. These areas should be actively managed in under the Wildlife Act. Agreement on development and expansions needs to be integrated in overall SRF management planning.

All three existing wildlife sanctuaries are bounded to the south by the Bay of Bengal. Two additional Protected Areas should be considered:

- a Sundarbans Coastal and Marine Protection Area (SCMPA) to protect coastal habitats and wildlife ; and,

- an area in the north-east of the SRF, to include habitats where siltation and changes in flooding regime seem be creating conditions not entirely favourable to mangrove species and where land pressure could become difficult to resist.

4.3.2.1 The Sundarbans West Wildlife Sanctuary

The Sundarbans West WS in Satkhira Range should be extended towards the west to link up with the Sundarbans National Park in India to establish a cross-frontier protected area. The existing sanctuary covers an area of 9 069 ha. The extension would give this sanctuary a total area of 37 195 ha. This expansion to the west is of vital importance for the long-term welfare of tigers. There are no tiger habitats surrounding the Sundarbans to allow immigration of tiger from outside. The space provided by the Sundarbans (both in Bangladesh and India combined) is considered essential for the conservation of tigers in the wild and in maintaining a viable population and necessary genetic diversity.

It is recommended the classification of protected areas and the manner in which they are managed is standardised. Consideration should be given to changing the status of Sundarbans West Wildlife Sanctuary to a National Park. The feasibility of establishing ecotourism facilities might also be undertaken.

4.3.2.2 The Sundarbans South Wildlife Sanctuary

This WS (17,878 ha) lies between the Malancha and Kunga rivers and includes Putney Island. The sanctuary headquarters are located at Hiron Point. Fairly extensive grasslands provide good habitat for spotted deer, wild boar and tigers. The area for this sanctuary is considered adequate for the present.

4.3.2.3 The Sundarbans East Wildlife Sanctuary

Sundarbans East WS covers an area of 5439 ha. This sanctuary is not considered large enough to support viable populations of large ungulates and tigers. It is recommended that the WS should be extended to 18 538 ha.

4.3.2.4 Sundarbans Coastal and Marine Protection Area (SCMPA)

Protection of the coastal zone has been identified as a matter of great importance for long-term conservation. This is almost a totally unprotected and unmanaged zone which is wide open to abuse.

Animals which breed, nest or live on the beaches, or in shallow water along the coast or inside the estuarine part of the SRF need special protection, since they are either all subject to chronic human disturbance or are harvested on an unsustainable basis.

Endangered species of turtles such as the olive Ridleys, the coastal shell, and the green turtles are known to nest along the coast of the Sundarbans. All species of marine and estuarine turtles are also seriously threatened due to excessive fishing and disturbance to nesting sites. Estuarine and fresh water soft shelled ***Tryonix spp*** turtles are commonly sold in markets around the SRF. Harvesting is uncontrolled.

Grepin (1995) defined guidelines for establishment of a Sundarbans Coastal and Marine Protected Area (SCMPA). A network of marine and coastal protected areas should be designed primarily to protect breeding areas of endangered species along the coast.

The main goal of the SCMPA. is to protect, restore and assure sustainable use of the coastal and marine parts of the ecosystem. The SCMPA should:

- encompass inter-tidal and sub-tidal seabeds, mud flats, sandy areas and beaches;
- effectively protect these areas during breeding or nesting periods or over all the year, if necessary; and,
- make suitable provision for customary users to avoid conflicts and gain their active participation.

Preliminary action is required to:

- determine the level of use of areas by customary users and its consequences;
- identify the breeding and nesting sites to be protected;
- determine for each area the type of protection needed; the period of time of the year when control will be most effective;
- determine the necessary systems to enforce protection, preferably without heightening confrontation;
- obtain the support of traditional users and make provision to protect their rights;
- establish links with NGOs, universities and other organisations to undertake conservation studies;
- formulate new legislation which must consider scientific research, education, conservation and recreational objectives and international obligations concerning pollution or misuse of marine interconnected environments.

The SCMPA has the potential to be declared a Biosphere Reserve or be included on the World Heritage list.

4.3.2.5 The North-Eastern Protected Area

All three existing sanctuaries are located in the southern coastal areas and do not represent the more diverse environments to the north and north-east where freshwater flow is usually greater and where there appears to be increasing sedimentation.

Additional protected areas should be considered in this zone and immediate technical analysis should be made (see IRMP Map 10). The establishment of a Managed Resource Area (MRA) should be considered as wildlife re-introductions and plantation silviculture may be the most beneficial land use for this part of the SRF where siltation and habitat change appear most pronounced (Grepin, 1995).

4.3.3 Bird Sanctuaries

The SRF has a rich avifauna but there is no provision for management of the bird populations and habitats.

Previously two bird sanctuaries have been recognised:

1. Curtis (1933) described the Chunkuri Khal bird sanctuary at Kadamtala, which probably owes its recognition for birds on account of the diversity of vegetation.
2. The Jewdhara Bird Sanctuary, where "thousands of birds", especially vulnerable species such as the Greater and Lesser Adjutants were common at this site was described by Choudhury (1961).

It should be a high priority for the DFO Environment to research in detail over a period, the areas where birds are relatively abundant and also places which appear to be utilised by migratory species. Consideration should be given to establishing new or re-establishing the old bird sanctuaries. Production should obviously be excluded from new bird sanctuaries.

4.3.4 Seasonally closed areas

Lack of protection of breeding animals is a major deficiency in management. The DFO Environment should establish a research programme to study the distribution of wildlife breeding sites for terrestrial and aquatic species. This could be aided by help from foresters working in the field and from the wildlife and zoology departments of academic institutions.

This work can be part of continuous surveys and is both low tech and low cost. Thus the only burdens for the DFO would be planning, management and co-ordination of targeted field research. The data should be included into an integrated database (IDB).

4.3.5 Fish breeding areas

It is essential that a positive effort is made in the near future to research the breeding cycles of commercially important species and introduce some seasonal controls over specific breeding areas for specific species. This is work in which the Fisheries Directorate and Khulna University could collaborate with and DFO Environment.

4.3.6 Research and Monitoring

The FRMP nature conservation programme focuses mainly upon the "intensified management and expansion of the existing wildlife sanctuaries" and on the preparation of management plans. The former will need integration of management operations in the protection and production zones. The latter will require research and close collaboration with other research agencies such as IUCN, Khulna University and the Fisheries Directorate.

Monitoring changes in the environment is essential to Protection Zone management. The ecological research stations described in Section 9.1.1 of the IRMP could meet these requirements. Their future development will depend upon funding, staff and administrative support. These stations should have research and monitoring programmes which are kept separate from law enforcement and forest management activities.

Research and monitoring priorities should be oriented towards management planning, interpretation of data acquired by the continuous surveys, continuity for hydrology and meteorology data acquisition, and introduction of field research methodologies for wildlife populations.

4.4 *Management of the Production Zone*

The Production Zone (map 10) encompasses the parts of the SRF not classified as the Protection Zone. Production is defined as the management of resources for sustained yield of goods or services which have a direct use or can be sold. Thus everything that is harvested or otherwise utilised commercially is included but indirect benefits such as the protective function of the forest are excluded. Production management has been reported on in detail by Shiva(1994); Larsen(1994); Ahsanullah (1995); MARC (1995) and Mitchell (1995b).

For planning and practical management, each resource needs to be considered both independently but also as an integral part of the ecosystem. The number of interactions that are possible is enormous.

It is therefore essential that the database of information on all the components is as complete as possible. Only once the extent of the resources are known and assessments are made on sustainable yield is it possible for production to be planned.

It is necessary to not only have achievable short term objectives but that these objectives are included within longer term strategy. In order for this to occur it is essential that there is continuity of management and continuity of the aims of management. To manage the resource adequately therefore requires the continuous up dating of management and resource data. Managers will be required to up date and amend plans as and when new data are made available. This should mean that there is a trend away from project based 'one off' inventories and periodic management planning (i.e. 20 year working plans) to one of continuous assessment with continually up dated management plans.

4.4.1 Improvement to the Management System

In order to improve the management systems the following fundamental changes will be required:

1. the technical capabilities of the managers must be up graded by the sharing of skills and responsibilities with other agencies and technical departments to manage the non wood resources;
2. through the use of continuous field surveys, data collection, modern technology and new methodologies the managers will have up to date information on the status of all the resources it is managing;
3. by up-grading infrastructure, equipment, and facilities for staff in the field and by further training the flow of information could be improved so that exact statistics of resource utilisation can be collated and analysed;
4. by integrating research and monitoring functions, resource data could be acquired, stored and statistically analysed quickly and efficiently so that management plans could be continually up-dated and management responses rapidly effected.
5. the managers should work with local communities and NGOs to implement extension activities to increase understanding and reduce over-exploitation and encourage equitable utilisation of the products.

4.4.2 Yield Regulation Rules and Planning Methods

Production from one resource may have far reaching consequences for another. In some instances these effects are unpredictable but must be anticipated, if possible, through sufficiently sensitive control and monitoring. Also overall optimum yield may not be the sum of the optimum yield for all the individual resources. For many resources there may be conflicts in objectives of management.

The rules for regulation cannot be properly defined at this stage as there are many incomplete data sets. More research is needed in certain key areas such as fisheries harvesting and plantation silviculture. Some guidelines are proposed:

- despite the requirement for integration of activities with other agencies overall responsibility for production must rest with a single authority;
- yield regulation rules must be flexible enough to allow management to respond to changing circumstances so that planning should be proactive rather than reactive;

- yield data for all resources must analysed concurrently in order to maintain the requisite balance between resources.

It should be stressed that there is bound to be a trade off of resources. For example the extension of wildlife sanctuaries will undoubtedly reduce the wood production. However, it may well increase the net contribution through revenue from ecotourism or increased fisheries production.

4.4.3 Yield Control

Clearly with many of the resources being over exploited it is necessary to set levels of sustainable yield and then ensure that these levels are not exceeded. New methodologies for most resources must be developed to determine the sustainable level of production and the appropriate controls devised.

Once levels of production have been set it is also essential that the levels of production are efficiently monitored. With computers it will be possible to keep track of production on a more or less continuous basis. These data should be stored in an integrated resource database (IDB) so that the levels of any particular resource can be monitored and compared with predicted yields.

It should be possible to control the yield within short time frame (i.e. weeks). At present control of wood production operates on a yearly basis with a time lag of approximately six months before all yield data are collected and processed.

The exploitation of the wood resource is governed by statute and approved working plans must be adhered to. All produce harvested from the SRF should have the same mandatory control, although with the proposed system, with continually updated management plans, there needs to be flexibility. The existing "control forms" for timber felling form part of the mandatory control system. A new system for control of yield for all resources needs to be developed giving all the relevant production data for each resource.

This new system should also provide another method of monitoring the ecosystem and continually updating the database. The relationship between ecology and resource harvesting could thus be established as the foundation for sustainable management.

4.4.4 Information Requirements

For each resource an inventory or stock assessment is needed with growth and yield models. Without this there can be no management or development planning. From this starting point, various models can be designed and run to evaluate various scenarios, which in turn can show the effect of the different management decisions can have on the resource as a whole. This should prevent management of one particular resource to the detriment of others. Sensitivity analysis will allow the trial of different scenarios to show the effects of different management decisions.

Information from the production of all resources can now be processed at a level of resolution not previously possible. Production data in its entirety must be passed up the line to the management planning offices. Information thus collected will provide managers and planners a basis for decisions. It will be a simple matter to enter this information into a database which will then allow reporting at any level and under any heading.

The present system of information flow and the reporting procedures will need revision. This new system will require considerable forethought and systems planning.

Collection of market data for all the resources is also required.

4.4.5 Working groups - Working Circles

In the past a single level approach has been used in forest management with operations being primarily at the compartment, and in part at the sub-compartment level.

A land based management unit is obviously not suitable for management of the aquatic environment which might more reasonably be based on the major streams and associated khals. The future management of any complex

ecosystem requires consideration of all the resources, and that will require varying levels of spatial resolution in planning. A multi-level, multi-disciplinary approach to planning will increasingly be necessary.

Using the Forest Department's current terminology, consideration should be given to managing a number of overlapping Working Circles which may include:

- Sundri Working Circle
- Top-dying Sundri Working Circle
- Gewa Working Circle
- Other Timber Species Working Circle
- Goran and Other Firewood Working Circle
- Plantation Working Circle
- Golpatta Working Circle
- Offshore Fisheries Working Circle
- Inshore Fisheries Working Circle
- Shrimp fry Working Circle
- Wildlife Working Circle
- Apiculture Working Circle
- Tourism Working Circle
- Other Products Working Circle

4.4.6 Wood Resources

4.4.6.1 Silvicultural Systems

Silviculture is considered to be integral to forest ecology as a science for the management of forests for specific reasons. A key principle is that whatever interventions are practised the result should be gradual improvement of production from the forest. Two levels of recommendation are made :

1. where it is considered that the benefits of a given treatment are already widely accepted and that the proposed treatments will pay for themselves from the sale of produce.
2. proposals based on silvicultural improvements where the benefits need to be quantified and it is not known if the treatments will be cost effective.

For the second level of proposals a programme of trials is recommended.

"These programmes should be only be undertaken if they are found to be financially viable."

4.4.6.2 Natural Forest

Traditionally the SRF has been managed on lax version of the Selection System. Currently only Gewa is managed in this way. Sundri is salvage felled in the areas subject to top-dying.

Regeneration of Sundri in salvage areas ranges from poor to plentiful. It has been shown that the species mix in the worked forest appears to be changing with proportions of the high value Sundri decreasing and the low value Gewa increasing.

The level of silvicultural research is low and the effects of changing the silviculture is unknown. However, measures should be taken to halt the apparent decline in the value of the forest.

The current level of silviculture in the forest is rudimentary; simply felling to diameter limits with no maintenance or selection does not represent good silviculture. Curtis in 1933 tried to introduce better silvicultural practices but

the rules were found to be too complicated to implement and were subsequently abandoned. It is recommended that skilled silvicultural officers should be kept in their posts for longer periods so that experience and local knowledge of the forest can be built up.

New compartment and sub-compartment maps should be made using GPS, systematic sampling and the IDB. Details of areas for silvicultural treatment could be recorded in a perpetual calendar system. Areas treated at regular intervals could be monitored and any actions taken could be systematically recorded in the data base. This information system would be gradually developed to provide detailed sub compartment records. All treatments should be recorded in the sub compartment records together with the results. By recording information in this fashion the problems that normally arise when key members of staff are transferred or records lost would be overcome.

Timber Moratorium

Until the FRMP inventory has been completed it is recommended that the moratorium should continue. Once the results of the inventory and the growth figures from all the PSPs have been analysed then new recommendations regarding sustainable levels of cut can be made.

Selection System

For the time being, the present system of cutting Gewa to the diameter limits as currently set, on a felling cycle of 20 years, should continue. This needs to be reviewed as soon as the results of the inventory are known and revised in the light of the results.

Research

Trials into different or modified silvicultural systems in different areas should be implemented. Research plots should be set up within some of the Gewa cutting areas to measure regeneration and growth rates for different treatments.

Diameter limits and felling cycles

These should be raised but at the same time allow improvement fellings in sizes below the diameter limits reducing the length of the felling cycle. Trees for improvement fellings below the diameter limit would be marked by the FD. In this way it might be possible to see whether leaving some larger trees would increase the proportion of Sundri regeneration. The resultant increase in the cost of the harvest might be expected to be recovered through the eventual increase in value of production by the improvement.

Salvage Felling

Due to the incidence of top-dying, it is recommended that the salvage felling should continue so that valuable timber is harvested before it becomes rotten. This entire procedure should be reviewed once the results of the inventory are known. It is apparent that the current definitions of top-dying need to be tightened up and measures taken to ensure that only top-dying trees are harvested.

Within top-dying areas the level of regeneration has been shown to be variable. Karim (1995) undertook a regeneration survey in top-dying areas and it was found that the stocking of regeneration of all species ranged from under 40% to over 90% of what he termed adequate (1000 stems/ha). This definition of 'adequate' is considered for, practical management purposes, to be low.

The Salvage Felling operations should not be restricted to the top-dying of Sundri alone. Where and when there are areas of cyclone damaged or wind blown trees these should be harvested as a priority even over the current operations in top-dying areas or Gewa cutting areas. Once the areas have been harvested the volumes for the AAC for the Gewa (and other species where applicable) should be reduced by the amount harvested from the windblown areas. After being cleared these areas should be monitored for regeneration and erosion.

Enrichment Planting in Top-dying Areas

Prior to any felling operations a brief survey of the advance regeneration should be undertaken. In areas where there is limited regeneration the areas should be roughly measured. After the felling operations have been

completed these selected areas should be monitored and in the worst areas, trial artificial regeneration should be considered.

Usually a mixture of species should be tried. The choice should take into account the following:

- the species chosen should be one of the higher value species;
- there should be evidence that the species is growing in similar conditions in the locality;
- it should be a species for which nursery and establishment techniques are known;
- preference should be given to viviparous species which do not require an expensive nursery stage;
- if deer browsing is a problem thought should be given to re-introducing deer stalking in the vicinity of the plantations - fencing out wildlife in small areas or extensive areas of low density enrichment planting is not a cost effective option - spraying seedlings with deer repellents is expensive and has variable success;
- enrichment plantings if carried out for single species groups of say 50 plants are planted at a close spacing of say 2m x 2m - the year following planting the area must be beaten up and failed trees replaced;
- if a mixture of species is planted and one species emerges more successfully from the others this should be selected for replacing failed trees.
- plantings should be kept weed free for as many years as the weed species are competing with the planted trees - the intensity of weeding will very much depend on the speed and nature of the weed in growth - it should be stressed that within the planted groups, the presence of other tree species such as Gewa or even Sundri through natural regeneration after planting is undesirable and if the planted trees are surviving the natural regeneration of other species should be removed.

Thinning and Improvement Fellings

Thinning in areas of dense pole stage crops should be undertaken as routine practice. These areas can be quickly marked by FD staff following general silvicultural principles, of removing the worst stems and favouring the more valuable species such as Sundri, Passur, Dhundal and Kankra.

The selection of trees should be to an intensity to relieve the crowns remaining of competition for canopy space. In a stand that has grown up from prolific regeneration it is likely that in the first thinning operation as many as 50% of the stems could be removed. There must be adequate supervision of contractors otherwise unmarked stems will be removed. Selective thinning of young stands is the essence of good silviculture.

In subsequent years the thinned stand should be inspected. This will be facilitated with the help of the database and the perpetual calendar. Periodically the stand should be subject to further thinnings. In a slow growing forest such as this a thinning cycle of probably once in ten years will be sufficient. Again this needs to be monitored by the forest rangers on the ground and they should take the ultimate decision of when to thin the stands. In second or third thinnings the intensity would be less than for the first thinnings.

The use of improvement thinnings should also help encourage the establishment of Sundri under the shade of the final crop prior to felling.

Tending

In areas of younger regeneration the crop often becomes infested with weeds. These species compete for both canopy and root space and reduce the increment of the crop. These areas should be cleaned and the young crop freed from competing weed growth. Some weed species are sold as firewood suggesting that freeing of young crops need not be a cost operation.

Goran

Harvesting Goran on a cyclical basis leaving one stem per stool should continue, at least until the results of the inventory are known and sustainability calculated. Evidence from India has shown that other silvicultural systems also work well, including 200 m strip clear felling. This system has the benefit that the resulting regrowth is straight and is not spoilt by the extraction of the crop.

It is recommended that some trial clearfelling of Goran should be attempted. This should include other silvicultural systems and designs such as group felling as well as the strip system. Once these trials have been evaluated recommendations for large scale application can be made.

4.4.6.3 Plantations

Plantations aim to maximise the utilisation of the canopy by desirable species and to minimise the amount of gaps and weeds. Plantations therefore, even using slow growing indigenous species have the potential to increase the growth and yield.

It is recommended that the cost effectiveness of existing trial plantations be evaluated as soon as possible and new trial plantations established using the results as well trying other species. The trials should be rigorously designed so that site and species interactions can be monitored as well as growth rates measured.

Factors to be considered:

- species selection for given sites;
- growth rates by species and site;
- establishment and maintenance techniques;
- protection against damage by wildlife;
- should exotic species be introduced into the Sundarbans, where one of the main objectives of management is conservation and biodiversity management? Karim (1995) recommends that only native species should be planted. Grepin (1995, pers comm) has stated though, that in certain areas of higher lying land exotic species may be more suitable, and that these should not adversely affect the ecology.

It is also suggested that the establishment of a plantation extension unit should be considered. The concept behind such a scheme would be to encourage local land owners, villages and user groups to plant trees on and around their farms, shrimp ponds and polder embankments within the 10 Km border area.

Benefits which might accrue are :

- pressure on wood resources of the SRF from the local population would decrease;
- protective functions of trees against cyclones and flooding would be enhanced;
- financial rewards from the sale of timber could accrue to the local poor;
- it would be an indirect tool for environmental education.

Nurseries

Currently the technology exists to raise seedlings of most of the mangrove species. The size and scope of the nursery establishment cannot be defined until the level of planting stock requirements are known. It is therefore suggested that the nursery development programme is defined once the plant requirements have been assessed. By using of local populations near proposed planting areas it would be possible to contract grow seedlings. This could also help provision of seedlings for the plantation extension programme.

4.4.6.4 Management Prescriptions

Prescriptions for management of the wood resource are summarised below :

Selection System

- trials of different silvicultural systems should be initiated;
- abolish the sample measuring Gewa and install scales on the cranes in the KNM yard;
- the cutting of Gewa over the recommended AAC should cease;
- the cutting of pulpwood into only lengths of 4' multiples should be adapted to allow greater utilisation of the trees cut.

Salvage felling

- define top-dying and improve supervision of marking so that only trees which are definitely top-dying are selected for removal;
- consider environmental and regeneration impact of harvesting of wind blown areas.

New felling rules are needed to improve timber utilisation;

- mandatory use of cross cut saws for cross cutting and making the back cut during felling of species other than Gewa;
- mandatory low cutting of stumps - all stumps must be under 50 cm depending on butresses;
- train contractors in the use of handtools such as cant hooks and tongs;
- sawlogs should be cross cut in lengths which maximise the yield and not minimise the effort required to carry the log out of the forest.

Log measurement and Grading

- a new system of log measuring needs to be gradually introduced to convert the present Hoppus system to metric.
- once the logs reach the depot they should be sorted into graded parcels so that graded lots can be sold at the auction.

REB poles

- the practice of selling specially selected Sundri to BFIDC for REB poles should cease. With the introduction of a new grading system they will be able to purchase logs of selected quality at the auctions at the market price.

Enrichment plantations

- In areas where there is limited regeneration of desirable species, enrichment planting trials should be undertaken.

Thinning, Improvement Felling and Tending

- selective thinning should be undertaken in areas of dense pole stage crops;
- improvement fellings should be undertaken in stands where there are sufficient stems of large enough diameters.
- young crops which are infested with weed species such as Bhola should be cleaned.

Goran

- trials of new silvicultural systems for working Goran should be undertaken;
- the BLC method of measurement for removal of Goran should be discontinued. This should be replaced by stack measurement or sales by area of standing crop.

Plantations

- A programme of trial plantations should be initiated.

4.4.6.5 Inventory and Modelling

Details of the proposed inventory system are given in Leech (1995), Mitchell (1995b) and in the IRMP section 22.3.

A standard forest inventory is carried out to determine the status of the forest timber resource at a given moment in time. It is the base for planning, but alone it is not sufficient for fully integrated resource management planning. In order to assess growth rates, analysis of PSPs measured and remeasured over a period of time is required.

In the past inventories have tended to concentrate on the wood resources and have been project based. They also have been stratified random samples designed for a specific purpose.

The problem of holistic monitoring of a complex ecosystem such as the Sundarbans resolves itself into two issues:

1. the need to be able to apply any stratification to the inventory database at any time;

2. the need to determine changes in the SRF at shorter intervals than before.

With the new GIS capabilities it is possible to store and retrieve spatial information readily so that there is the possibility of many stratifications at various levels of resolution.

If different stratifications are required, it will not be possible to put in plots in the forest by stratified random sampling. The proposal therefore, is to use systematic sampling through the establishment of a network of Temporary Sample Plots (TSPs).

In order to get away from the previous project based approach it is proposed that only one fifth of the plots should be measured in any one year. This would mean all plots would be measured over a five year cycle. This would have a number of benefits; it would allow good assessments of growing stock at any time, it would highlight any possible trends.

It is also proposed that the data collected should cover ecological aspects such as soil and water data, wildlife observations as well as the usual forestry measurements.

Future planning systems will require a mixture of biometric and prescriptive models.

Biometric models are predictive and are generally based on statistical analysis. They predict for example the growth of a particular stand given certain management practices. Given a particular set of circumstances then the models should predict what the future yields will be. These are complemented by prescriptive models that define actions to be carried out.

It is necessary to carefully consider the objectives of the total modelling exercise to ensure that all necessary models, and only the necessary models, are defined. It requires systems analysis of the total system, not just part.

Future Needs

First the objectives of the modelling system must be defined then the models that need to be developed are determined. This is an evolutionary process with the models continually refined.

The IRMP section 22.4 gives further details about the possible modelling procedures.

4.4.6.6 Planning Systems

In the past planning in the Sundarbans has been relatively simple. However an integrated approach is now necessary. An improved forward looking planning system that effectively integrates modern technology and considers the complete ecosystem not just one or two component resources is required.

Philosophy

A sophisticated system that integrates all the technologies, including GIS, remote sensing, computers, and field inventory is proposed. This will take a lot of care to ensure that the planning system evolves satisfactorily.

It takes a great deal of time to build up the expertise that necessary to design and then implement a modern planning system. The task should be carried out by a highly specialised and dedicated team.

Aspects of the planning system will undoubtedly be addressed by the FRMP. The integration of the GIS with TSP field data and with remote sensing imagery is quite feasible, but requires care and expertise. It is essential that the planning system be flexible enough to cope with future change, it must be dynamic. It cannot be satisfactorily be carried out by a project based approach.

Uses of the Planning System

The planning system will have two different uses :

1. to determine the current level of stocking, and then to predict the future yields, essentially the AAC, if the current management practices are not changed;
2. to evaluate different scenarios. This could be to predict the effect of taking different management decisions such as increasing or decreasing the length of the felling cycle or increasing the utilisation of the trees harvested.

The evaluation of different scenarios should also include other resources so that the interactions can be assessed for given management decisions. For example effects of changes in the salinity and erosion and accretion may have major impact on forest growth. Cutting of the forest in certain areas may be unacceptable from the tourism perspective.

In developing the models and the system, the technical competence of the resource managers will be enhanced. Management planning decisions made with the benefit of this kind of information should lead to the resource being managed in more integrated way.

4.4.6.7 Research

Fundamental Research

Fundamental research should be encouraged by working with BFRI, the Fisheries Research Institute, Khulna and Chittagong Universities, NGOs and others. By having access to the PSPs and by sharing the use of ecological monitoring stations there could be considerable economies of scale. This would not only save in expense but would benefit from increased access to information from multi-disciplinary research. The principle should be that all data sets are available to all workers as this will facilitate a better understanding of the ecosystem.

Applied Research

There is a primary need for an essential subset of models to be developed and incorporated into the planning system. The PSPs provide considerable potential for research.

The decree that no official harvesting should take place in the PSPs should be maintained. The plots should be re-measured at least every 5 years. and preferably every 3.

A useful adjunct would be to establish satellite PPSs adjacent to a few of the existing PPSs in the more uniform ecological forest types, but separated by appropriate sized buffers. These plots could be silviculturally treated in different ways to provide data from a wide range of forest conditions on the different treatments as part of the trials programme.

It will also be necessary to establish research trials in the plantation areas so that firm recommendations about the future of plantation management in the Sundarbans can be made.

Integration of Research

Obviously in such a difficult working environment it is highly desirable that all available research effort be concentrated on topics considered to satisfy primary management and planning objectives. A fundamental goal is to avoid duplication of effort, share information and integrate data in a unified IDB system.

4.4.7 Non-Wood Resources

Even though non-wood products (NWFPs) are now more valuable in economic and social terms than the wood resources, existing management arrangements are virtually non-existent. The IRMP helps to address this and recommends future action.

4.4.7.1 Golpatta

There is a general lack of reliable inventory data on distribution, area, stocking and growth rates. It is therefore essential that assessments of the Golpatta resource are made during the FRMP inventory.

Simple growth plots could be put into make estimates of growth and yield. Once this has been done new AACs can be calculated.

In other parts of the world, Golpatta is cut completely and no leaves are left on the stem. Trials should be set up to see which treatments are the most productive.

It is also clear that the current practice of trimming the leaves down to size is wasteful. This could be prevented by selling what is cut and not what is taken away. In other words the crop should paid for before it is cut. Another way of preventing this practice but less likely to be effective would be to introduce some more cutting rules to insist that the whole leaf is utilised.

The BLC method of measurement for removal of Golpatta should be discontinued. This requires further investigation but it could perhaps be replaced by stack measurement or sales by area of standing crop by auction.

Other plant-based resources

Other plant based resources receive scant management under existing systems and it is recommended that new responsibilities should be arranged at Range level within the proposed new institutional structures to ensure that each resource receives more than simply revenue control. Detailed distribution mapping, seasonal changes in phenology and inter-resource planning should be prepared as part of an inventory exercise. Following this there must be increment studies. This would allow the calculation of the levels of sustainable production, which would show of current levels can be maintained, increased or decreased.

4.4.7.2 The Fisheries

Management of the Sundarbans fishery affects the wildlife sanctuaries, forest resource conservation, socio-economics, international boundaries and border area agriculture. This involves many agencies. It is not a case of giving foresters more training in another specialised field or of developing a new division with a multitude of skills overlapping with other institutions but a matter of integrating existing complementary functions, skills and responsibilities to mutual benefit. It is therefore recommended that a sub-committee is set up including all the concerned agencies to establish a course of co-ordinated management that will deal with following:

- straddled fish stocks especially ***Hilsha ilisha*** , ***Lates calcarifer*** and shrimps which have part of their life cycle outside the mangrove forest;
- international trespass in marine waters;
- migratory seasonal fishermen;
- management of shrimps, crabs and oysters; conservation biology, harvesting and post-harvest treatment;
- practical measures to increase the minimum sizes of fish and shrimps caught;
- further assessment of closed seasons and their enforcement;
- integration of research and monitoring data collection and sharing of information between the Forest Department, Fisheries Department, Fisheries Research Institute, universities and regional fisheries projects.

It is recommended that since little reliance should be placed on indirect estimates of current yield independent validation of fishermen's catches should be made in follow-on fishery research.

It is also recommended that an improved system of record keeping should be introduced which would help future assessment of numbers of fishermen, gears and catches.

Future yield

Ideally, catches of all species should be held at current levels until more data are available. Efforts should be made to reduce the size of the catch of those species identified as being overexploited. For species in which gross over-fishing is occurring the imposition of minimum size limits would eventually lead to increased yields without an increase in fishing effort. Better estimates of future optimum yields for the fish and crustaceans in the

SRF can only be made when more reliable data have been collected and for a greater number of species. It is recommended that this matter should be included in one of the priority follow-on research projects

The fishery should be managed by increasing the size of fish and crustaceans at first capture and restricting the numbers of gears in the fishery. Size at first capture can be increased by setting minimum size limits for each exploited species and/or increasing the mesh size of nets. Regulation of size at first capture and mesh size should enforced by random inspection. A subsidised net replacement programme may be more acceptable to fishermen. The size of the fishery could be controlled by limiting the number of weekly gear licenses.

It is recommended that the introduction of closed seasons and protected zones should be considered. The migration of fish and crustaceans from sanctuary areas into the surrounding over-fished waters would enable the fishery to be sustained.

In order to manage the fish resource it is recommended that the following should be undertaken:

- collect monthly length-frequency data for commercially important species.
- age fishes using hard structures, otoliths and scales to provide an alternative to length-frequency data.
- measure the abundance of fish and crustacean stocks.
- collect length-weight data for commercially important species to monitor the body condition of fish stocks.
- obtain data on size and age at maturity for commercially important finfish and crustaceans.
- record the distribution of fish species including seasonal changes in the SRF along with details of their age/size.
- re-examine preserved fish specimens and continue collecting and identifying non-commercial species to add to the species list.
- calculate a correcting factor to adjust for bias inherent in indirect data.
- make an independent assessment of the numbers of fishermen, fishing gears and catch composition.
- collect data on the catch size and composition of the offshore set bag-net fishery.
- determine where and when *Hilsa ilisha* that pass through the SRF spawn.
- identify different fish stocks and their movements in and outside the SRF using electrophoresis. This work could be done with the assistance of Khulna University.
- collect figures for mesh size of pangash gill nets and gill nets.
- research the effects of capture by rod and line on the survival of ***Macrobrachium rosenbergii***.
- introduce a minimum catch size for ***Lates calcarifer*** of 30 cm TL and 10 cm TL for ***Johnius argentatus***.
- restrict the numbers of hilsa gill nets, pangash gill nets and gill nets operating in the SRF or endeavour to keep to current levels.
- endeavour to hold exploitation of commercially important species (except ***Penaeus monodon*** fry) constant at present levels.

It is also recommended that when the management systems are developed a new system of regulation and revenue collection are designed and implemented.

4.4.7.3 Wildlife

It is recommended that implementation of wildlife management, conservation and research programmes should be instituted in consultation with all relevant agencies with particular regard to:

- definition by the CCF and DDCF Environment Management and the Conservator, Khulna Circle, of areas of responsibility and integration of activities of all the DFO's working in the SRF especially overlapping functions which stem from the Forest, Wildlife and Fisheries Acts;

- finalisation of Wildlife Sanctuary extensions;
- training of wildlife management staff;
- implementation of the Wildlife Management Plan outlined in the IRMP;
- research on the ecology of the tiger, spotted deer, wild boar, muntjac and crocodile populations;
- ensure integration of management, protection, research and monitoring activities with other forestry and fisheries staff and link data collection, storage and analysis with the continuous survey teams, GIS and IDB data bases;
- establish biodiversity conservation priorities in collaboration with IUCN and with due regard to NEMAP and the NCS.

Research

Despite the effective embargo on hunting there is declining biodiversity and loss of species. Since it is well known that spotted deer, monitor lizards, dolphins, python and turtles are killed and sold in local markets (MARC, 1995; Grepin, 1995) it is recommended that research should be undertaken to quantify the level of illegal off-take as a first step in reversing this wasteful situation.

Additional research should be directed towards the following objectives:

- improving knowledge of all major species populations and habitats;
- sustained yield harvesting;
- biodiversity management;
- re-introductions;
- deer ranching and captive breeding of crocodiles.
- the illicit trade in wildlife products.

Field Research Programme and Monitoring

It is recommended that the wildlife research should be conducted in close co-ordination with forest mensuration. Logistics should be shared as far as possible especially costly transport and radio communications equipment and all data should be stored and analysed in an integrated database (IDB).

Flora and Fauna inventories

Inventories should be undertaken using continuous survey techniques. The data should be added to the IDB and GIS data bases. Data on distribution, immigration and emigration, relative density, habitat preferences, predator-prey relationships, life tables of harvestable species and seasonal changes, are still virtually unknown and should be investigated.

Vegetation Studies

It is recommended that a full botanical survey be carried out leading to the analysis of the plant community types and confirmation of floristic composition of vegetation types. Permanent sample plots, exclosures and line transects should be studied over a period to determine the stability of associations and successional changes. This could be an area for collaborative work between the FD, IUCN, BFRI and the universities.

Ecology of Tigers

Whilst it appears that the tiger population is not declining, future activities in wood and non-wood resource harvesting, research and monitoring and tourism will require a much better understanding its behaviour, ecology and physiology.

It is strongly recommended that a tiger autecology study should be implemented using remote sensing and other advanced research techniques, as soon as possible with particular regard to :

- ethology;

- physiology; and,
- population structure.

The SRF tiger population is part of what is probably the largest single gene pool of the Royal Bengal Tiger and warrants international co-operation in Project Tiger or the Global Tiger Forum.

Ecology of other priority species

It is recommended that further studies are conducted on spotted deer, barking deer, wild boar, otters, fishing cat and rhesus macaque to properly understand the ecology of these populations. This work should be selectively extended to predator-prey relationships, smaller mammals, aquatic mammals and large reptiles such as monitor lizard, python, turtles and crocodiles.

Saltwater (Estuarine) Crocodile

The saltwater crocodile ***Crocodylus porosus*** population has declined to a critical point. Every effort should be made to conserve and manage the SRF population. It is recommended that:

- Sapla khal and Bhadra Gang are closed to fishing and traffic to stop disturbance and protect nesting sites;
- A crocodile expert should be recruited for six months to study the prospects for raising crocodiles in captivity to help increase the wild population and to establish a commercial crocodile farm. This could be a private sector venture and a feasibility study should be made for crocodile farming outside but near the SRF.

Consumptive Utilisation: Future Possibilities for Sustained Yield Harvests

Since there is a significant natural surplus of deer and wild boar and each year tigers continue to kill human beings, there could be a case for exploring the potential for controlled consumptive utilisation of these species as part of a sustainable yield harvest from a healthy natural resource.

Whilst licensed hunting of wild game animals, is often an emotive subject and the tiger is classified as an endangered species, it is nevertheless incumbent upon those who have responsibility for optimising returns from areas where viable populations of game animals exist, to consider objectively all options for their utilisation.

There are three basic options available for the management of game animals:

1. To keep the status quo; turn a blind eye to illicit off-takes and hope that in due course improvement in capacity for control will help better protect species. The resource is illegally exploited by a narrow group of people, up to the limit achievable under existing policing. The return is not quantified. Ultimately more and more resources are committed annually to law enforcement, often working against the best interests of the rural poor who derive some benefit from the illicit harvest. In the case of crocodiles this has almost wiped out one species and bringing another to the verge of local extinction.
2. To confine utilisation to non-consumptive photographic tourism. Usually a pastime enjoyed by the relatively well off. This however, will not address the problem of illegal harvesting any better than the first option.
3. Include the economic value of game animals as a natural resource with a potential for proper management and harvesting on a sustainable yield basis. Introduce controlled harvesting techniques, which would provide the optimum spread of benefits, and potentially significant economic returns. Where tourism is involved, the financial return per tourist is up to ten times the yield per photo-tourist. Big game hunting commands a 'daily' rate in some countries up to $ 1500 per day and this discounts the value added by the by-products industry. By providing a legal supply of game meat to the markets, by providing employment as guides and rangers and the presence of organised and official hunting will undoubtedly reduce the incidence of illegal game harvesting.

Promotion of sustainable consumptive utilisation:

- issue hunting permits under Section 47 (2)(d) of the Wild Life Act, in harmony with a pre-determined land use zoning scheme. Arrange for properly trained Forest Department guides, ensure local employment of shikaris, skinners and other staff and monitor taxidermy and by-product usage. Develop a small but valuable export industry round the by-products, skins, horns, teeth, bones, hooves etc.

- establish 'game farms' and obtain a harvest by managed culling and possibly include trophy hunting.
- establish a small-scale 'trophy hunting' industry based upon controlled harvesting of spotted deer and wild boar initially on offshore islands such as Putney or plantation chars near Kuakata. There is a well-established international market constantly seeking new destinations for trophy hunting even when the number of species is strictly limited.

Crocodile farming

Establishment of crocodile farms outside but near the Sundarbans should be given further consideration and a feasibility study is justified. Crocodile farming could have the multiple benefits of:

- introducing a small-scale industry which could supply raw materials to the export oriented leather industry;
- making a practical contribution to the conservation of one, perhaps two species, through easing pressures on wild populations and providing a source for re-introductions;
- providing employment;
- helping to achieve multiple use of land and water resources by integrating crocodile farming with fish or poultry production; and,
- providing a potentially highly lucrative tourist attraction.

Successful crocodile farming projects have been set up in a number of countries including India and Indonesia

Deer Farming

Deer farming is another possible source of employment and income generation and could make significant contributions to other industries in the private sector such as tourism, crafts and the leather goods. Spotted deer farming could be combined effectively with sustained yield harvesting from wild populations. It is recommended that these matters should be studied for feasibility in the follow-on phase by a captive animal breeding expert.

Captive deer, kept under cramped conditions at Karamjal Forest station opposite Mongla Port already attract over 50 000 visitors a year and it is recommended that this site be developed as a pilot wildlife breeding centre. Karamjal Animal Breeding Centre could provide opportunities for tourism, captive animal breeding studies, training and be the source of stock for deer farms. This will relieve pressure on wild animals and make a positive contribution to the economy.

Wildlife Management Plan

A plan aimed at protecting important species and improving their habitats should be prepared and implemented by the DFO Environment.

Legislation

The current definition of wild animal in the Wildlife Preservation Act of 1973 is not considered stringent enough. It is recommended that this should be looked into with aim of incorporating a definition of wildlife. The following could be considered: "Wildlife means: All plants and animals, which are wild by nature and are not domesticated; some feral populations could be included in special circumstances".

4.4.7.4 Apiculture

Future management should concentrate on the following :

- further research is required to assess the number of colonies, the effects of current harvesting practices on the ecology in general and the productive capacity of the bees in particular. The effects of current harvesting operations on honey production should be ascertained. Once the research is undertaken estimates of maximum sustainable production should be made and an annual allowable offtake set and controlled. Continuous monitoring of the bee population should be begun;
- the inflexible administrative procedure of only allowing entry on April 1st pays no heed to ecological conditions. It is found that frequently the Forest is entered too early in the flowering season thus causing honey collection

before it is ripe. This procedure should be replaced by one which is linked to the ripeness of the honey by area;

- the Beekeeping Manual (Zmarlicki, 1994) should be translated into Bangla and distributed amongst mowallis and small-scale honey producers who wish to improve techniques and production;
- honey production and processing affords one of the few avenues immediately available to assist disadvantaged social groups, women in particular. Since much of the honey collected in the SRF is badly handled and often incorrectly taken to be of inferior quality, the establishment of a pilot plant for processing honey and rendering beeswax established in the Khulna area.

The disparity in data on production and harvesting indicates a lack of control. FD monitoring is unable to take account of recent trends of multiple resource harvesting (Huda, 1995 pers.comm.). It seems unlikely that this trend will change and that new more participatory approaches will be needed to help regulate production and harvesting especially in the links between honey collectors, fishermen and shrimp fry catchers.

4.4.7.5 Tourism

For more details please refer to the ten year tourism development plan prepared by Moss (1994). This plan showed that profitable tourism could be established in the SRF. Ancillary small-scale industries such as crocodile farming, would generate substantial economic activity as well as employment opportunities.

The plan aims for environmentally friendly semi-permanent construction of camps and lodges linked to water-borne transportation and accommodation. This is felt to provide the best all-round prospects for sustainable tourism and integrated resource development. The plan is based on the concept of developing high value tourism with low numbers in key areas. This would generate substantial revenue but at the same time minimise environmental impacts. In other less sensitive areas high volume, low value tourism is recommended. The development criteria are set to optimise use of the wilderness asset with minimum disturbance to the environment - development without destruction - and these correspond with GOB policy on creation of enterprises, based on natural attractions.

The ten year has three phases:

Phase 1 **A transitional period** of two years during which time existing facilities at Katka and Nilkamal are extended and improved to international tourism standards and high quality Jungle Camps are constructed. During the same period a range of development sites and plans are considered and feasibility studies undertaken.

Phase 2 **A three year implementation period** during which time the proposals made and accepted in Phase 1 will be implemented, construction undertaken and operations started. This is a period of investment, development and promotion.

Phase 3 **A five year period** for profitable operating, product enhancement and diversification. During this time the Sundarbans will become an internationally renowned, prime destination taking a sizeable share of the special interest and ecotourism market. It will be acting as the catalyst for further developments of this nature at other locations in Bangladesh.

The plan recommends that the rights to run these high value low volume tourism ventures should be leased as concessions (with all the necessary safeguards and protection) competitively to the private sector. The Forest Department's role in implementing the plan would include:

1. control of entry and collection of Entry Permit fees;
2. calling for sealed bids or tenders for Concession Licenses;
3. regulation of methods and areas of tourist operations in accordance with pre-determined and agreed rules;
4. enforcement of Conservation Laws;
5. provision of properly trained Escort Guards and SRF Guides;
6. provision of interpretative literature, video tapes, maps etc for use by operators and the general public; and,

7. being the 'Executing Agency' during the first phase of the plan.

The plan makes the following recommendations that:

1. at the national level, the setting of standards, the regulation and monitoring should be a GOB responsibility and that the relevant departments should endeavour to enforce regulations to help improve performance within the tourism sector;
2. the Forest Department should be the regulatory and enforcement agency and should set up an administrative organisation to attend to conservation and wildlife matters in the sanctuaries;
3. the FD's tourism activities are properly funded, without which the development will be destined to failure;
4. the specialist action necessary to ensure personal security and prevention of dacoits should be determined through consultation with the Bangladesh Navy, the Divisional Commissioners, and the river police;
5. that overseas (if applicable) specialist training be provided for key staff involved in tourism (such as escort guards for wilderness trails and guides);
6. the escort guards, who will accompany groups on the wilderness trails, should receive in service training by experienced trail leaders working together for at least one season;
7. FD staff should not be allowed become involved in lodge management at any level other than providing dangerous animal escort duty or for specialist interpretative services, such as guiding round forest operations or Wildlife Sanctuaries; and,
8. study tours are organised for those who may be involved in the development of tourism.

4.5 The Institutional Position

The Forest Department is the sole management agency for the SRF, acting on direction from the Ministry of Environment and Forest. The broad functions of the department are as follows:

- a law enforcement body receiving its authority from the Forest Act, 1927;
- management of the various resources and selling the produce and the rights to harvest them on behalf of the nation;
- a planning, monitoring and research organisation.

The Forestry Masterplan (ADB, 1992) states that it is not rational to have the enterprise and law enforcement functions within any one organisation. Different internal rules and regulations are required.

It is generally accepted that the institutional framework of the Forest Department has a number of weaknesses. The organisation's work quality and effectiveness is hampered through of a lack of qualified manpower, deficiency in specific technical skills, lack of incentives and the lack of resources to be able respond to new demands (Rahman, 1995). It is therefore apparent that institutional reform is necessary if the SRF is to be managed more effectively.

Most of the current management deficiencies can be attributed to inadequate resources but some are intrinsic to the system itself. They are summarised as follows:

1. the technical management of the ecosystem is outmoded and continues to place most emphasis on timber and wood products and with little management or planning effort put into non-wood resources or the environment;
2. management focuses very largely upon revenue collection per se and not sustainability;
3. there is a lack of integration between the Forest Department and the other concerned agencies and departments which logically should participate where appropriate in the management of some aspects of the Sundarbans Reserved Forest ecosystem;

5. the system of management leads to confrontation between the Forest Department and those utilising resources;
6. the people who harvest resources are openly manipulated by various intermediaries and hardly feature in management plans;
7. despite the fact that the SRF contributes much more than it costs to the exchequer each year, it has not been possible to obtain essential capital and recurrent budgets to improve terms and conditions for staff and nearly all infrastructure and equipment now requires up-grading or replacement;
8. there is little continuity of management with key staff being transferred every second or third year;
9. the staff are poorly motivated with low pay scales and difficult, often dangerous, conditions of work;
10. the reporting and accounting procedures are inaccurate with poor data storage and retrieval facilities;
11. there is inadequate transparency and public accountability ;
12. the existing system does not provide the information base required for management planning.

4.5.1 Institutional development proposals:

To improve management various options for development are suggested. Whichever way is chosen, a feasibility study will be required beyond the scope of this plan. The goal is to reform management into a multi-sectoral organisation giving support to the FD and to the communities living in the border zone.

Assumptions are made which are common to all options. For example a silvicultural trial programme will cost the same whichever option is chosen and as such represents a separate sub-project included in plans for future investment. Each option assumes that current FD infrastructure, fleet of launches and vehicles and nearly the whole network of field offices require replacing. However, it is a corollary that further investment in development should only be contemplated if this will result in a more equitable return to disadvantaged user groups and to the Nation.

Common features are :

- that the change must be permanent and that the new organisation must be wholly supported by GOB or be self financing and not dependent on donor finance; new funding mechanisms will be devised;
- that by improving efficiency, accountability and transparency, the return from the resources of the SRF will be nearer the full economic value thus justifying the increased expenditure on management;
- that all the options must develop the capacity of the FD to continually collect data and monitor the resources so that an updated integrated database is available at all times for the preparation of management plans. Accurate data are essential if the resources are to be managed to the intensity required to ensure optimum use, sustainability and conservation.
- that the recommendations regarding changing the FD revenue system will be implemented to achieve the expected increase in revenue.

The first scenario - option 1- improves the existing management structure by up-grading the Department's technical capabilities and providing the capital investment for new infrastructure and equipment.

The second option supports the Forest Department as the pivotal organisation involved in managing and policing the reserve but at the same time it introduces a national steering committee and an Operational Unit (OPSUNIT) which will undertake inter-sectoral environmental monitoring, planning, research and capacity building functions. This option markedly differs from the first in that it draws in expertise of other departments and agencies where the FD is not traditionally skilled.

A third possibility is to introduce more radical adjustments but the consensus to date favours investment, cross-sectoral expansion of FD functions and improvement rather than total transformation which would probably be socially and technically untenable. In any case all reforms should be pragmatic in the context of the need to maintain stability within the system which has endured for a long time against increasing odds.

It is proposed that implementation of operational management plans would be through the Forest Department's greatly strengthened staffing structure with multisectoral collaboration and support.

It is considered that the department would have to recruit specialists to undertake management of an environmental research programme, fisheries, tourism and Border Zone livelihood projects and matters with regional dimensions such as marine zone protection and water pollution.

A National Mangrove Committee (NMC) - a steering committee at the highest level of Government, is proposed for policy formulation, development and establishment of better financial regulation, independent ecosystem audit, law reform and to increase the degree of co-ordination and integration with other concerned ministries, agencies and people's organisations. It would help the FD coordinate mangrove ecosystem management at all levels.

Management of the Sundarbans entails many technical functions including protection, management of production, monitoring and evaluation, research, management planning and implementation, all of which now require a practicable and realistic capacity for the FD to be modernised and become more involved in extension and education and to assist community development in the Border Zone.

Within the scope of the two options the Forest Department would be the main management agency for these functions In 2A and 2B the department will have support and direction from the NMC and the comprehensive inter-sectoral role of the Operational Unit. Both would rely on a local technical coordinating committee (the IMC). The second option clearly establishes a way forward within the FD for the proper integration of holistic resource management to meet new challenges.

4.5.1.1 Option I Improving the Status Quo

Rationale

The FD has not had the necessary funding or backing to cope with growing demands. Inflexibility of the funding system has prevented operations which yield much more than they cost. It is proposed that the FD is provided capital for new equipment and that a revolving fund of sufficient size is established to allow profit making silvicultural operations to be undertaken, such as thinning and improvement felling. The proceeds from which would replenish the fund. Other sources of sustainable long-term finance will also be considered to ensure sustaiability.

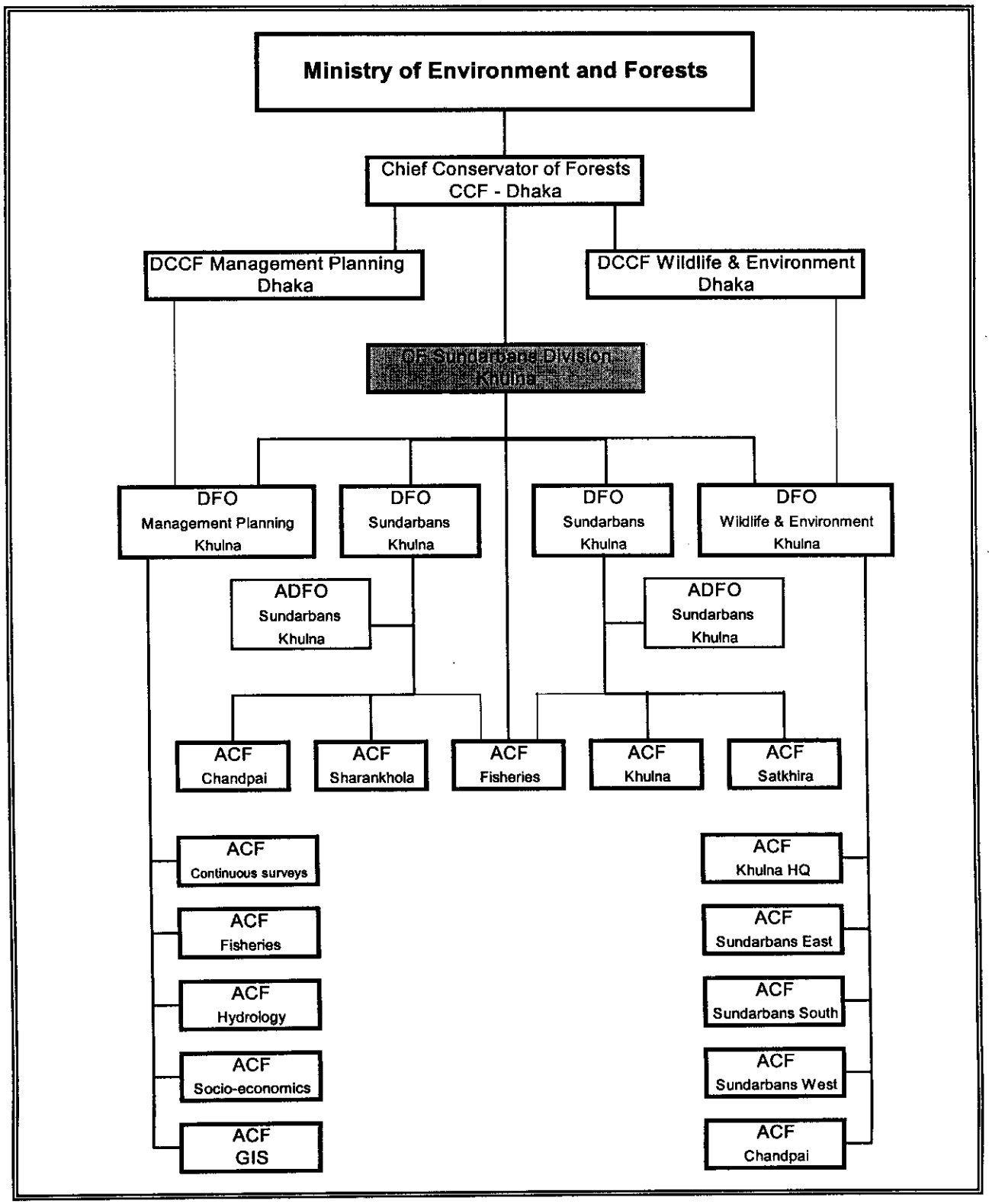
Proposed Structure

The proposed structure of option 1 is presented graphically as Figure 6. A new staff structure is proposed and the entire staffing position of the Sundarbans Division would be rationalised. For example there is an out of date establishment of about 550 boatmen who are no longer needed to operate boats and they could be re-trained to become speed boat drivers, forest guards, engine men or skilled labourers.

If the FD management is to re-orient its approach away from control by issuing permits, more towards development objectives where it lacks expertise in many areas such as fisheries management, marine biology, hydrology, tourism and wildlife utilisation, it will need to expand its capability in these specialised fields. New staff must be introduced at an early stage since further training of foresters from within the department is not viable; the skills are required immediately and it is a waste of funding if staff are trained twice.

The present system is unbalanced and there is too large a workload for a single DFO. In order to create a better balance it is suggested that the Sundarbans Division is split, dividing the four ranges equally between two DFOs. A fifth range, which will be responsible for the management of aquatic resources throughout the SRF will be established in association with the Fisheries Directorate. The Fisheries ACF will report directly to the CF, Khulna.

Figure 6 **Proposed Structure for Option 1**



In the present system, the DFOs responsible for Management Planning and for Environment and Conservation do not work directly to the CF Sundarbans but to two DCCFs based in Dhaka. There is already a lack of co-ordination between sections resulting in widespread inefficiency. It is therefore proposed that the CF should co-ordinate all staff and resources including the DFOs Management Planning and Environment, wood and NWFP functions and research including BFRI.

It is also required that the department increases its technical capacity. It is therefore proposed that under the direction of the DFO Management Planning there should be a new corps of specialists recruited that would collect data and would then be responsible for the preparation of management plans for all the resources. There should therefore be ACFs recruited, one responsible for each of the specific areas of data collection as follows:

- continuous surveys;
- aquatic resources and fish stock surveys with the Fisheries Directorate;
- hydrology with SWMC;
- community affairs and extension services;
- GIS and IDB management;

There should be both external training and international technical assistance to augment technical capabilities. Specialist training and new staff positions should be contractually linked to long-term appointments to the SRF Division to overcome the problems caused by the intra-departmental transfer system;

The Environment and Conservation division should be boosted by the addition of two extra ACFs, one to be posted as a staff officer to the DFO and the other to be stationed at Chandpai.

Investment in infrastructure, equipment and training

- The SRF field offices need replacing; 55 new permanent forest stations, 20 temporary forest stations, 5 permanent wildlife sanctuary offices and one nature conservation centre are required. It is estimated that the capital investment for new buildings would be about US$ 2.0 million.
- Nearly all the FD's boats are obsolete and must be replaced. There should be at least one launch per range, one for each of the DFOs and one for headquarters. At least 2 additional launches would be needed for surveys. The total replacement fleet is estimated at 9 launches, 5 survey vessels, 25 accommodation boats and 20 speed boats plus an estimated 11 new vehicles. The total transport funding required over a ten year period would be about US$ 6 million. This figure will be much higher if the Marine Zone is to be protected by the new organisation.
- Replacement firearms, an extended radio network, office furniture and computer equipment will be required at an estimated cost of US$ 1 million.
- Provision must be made for scientific and mensuration equipment and services, contractual services with the SWMC and new satellite imagery.
- There will be a need for additional overseas fellowships and training and also considerable on the job training. Short term international TA will supplement local requirements to provide advice, training and capaccity building (not to actually undertake field management work which should be the function of national staff).

The investment cost estimate for Option 1 totals about US$ 21 million over existing budgets for a ten year period.

4.5.1.2 Option 2 The Forest Department with the National Mangrove Committee and Operational Unit

Option 2 makes two similar proposals. 2A and 2B both propose continuity of the FD's role in implementing management operations but with realistic and practical changes to meet the demands of integrated resource management. The introduction of National Mangrove Committee (NMC), the Integrated Management Committee (IMC) and the Operational Unit (OPSUNIT) within the management structure

increases co-operation and collaboration with other agencies and provides policy co-ordination, direction and advice in other areas as required. It is a tenet of integrated resource management that experienced technical agencies with specific skills such as civil administration, law and order, sociology, fisheries management and hydraulics are involved in the formation of policy and the promulgation of the necessary legal reforms. In Option 2B the position of the OPSUNIT is clarified by including this as a direct responsibility of the CF Sundarbans Division and the role of the NMC is emphasised by indicating its position more clearly at the highest level of government as a National Steering Committee for the Sundarbans - Figure 8.

The OPSUNIT will be a semi-autonomous body concerned with research and monitoring, continuous surveys, inventories, socio-economic surveys, preparation of management and operational plans, data organisation and resource utilisation analyses. The OPSUNIT will be directed by an Integrated Management Committee (IMC) which will be chaired by the CCF and administered by the CF Khulna Circle.

Figure 7 **Proposed Structure of Option 2 A**

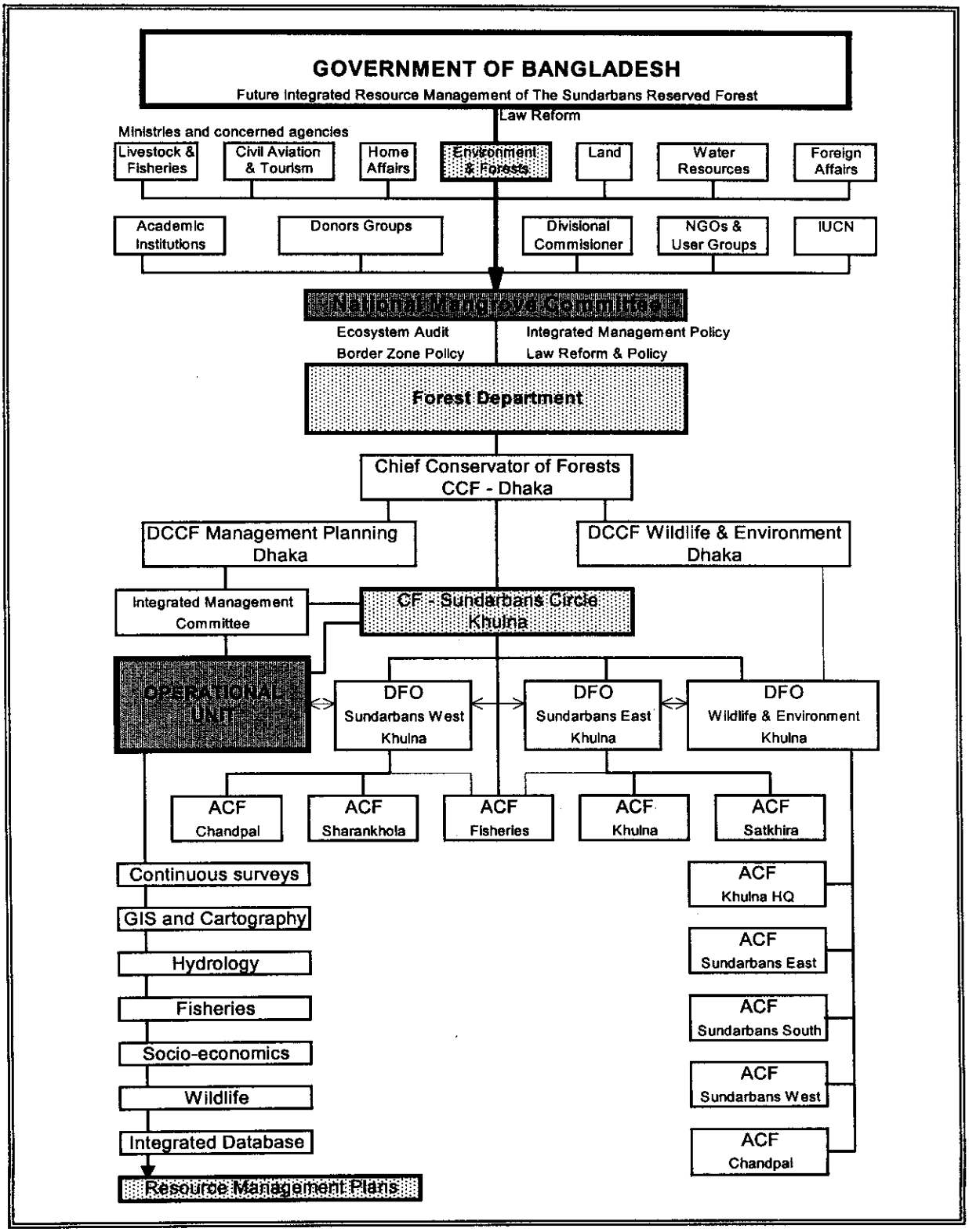


Figure 8 Proposed Structure of Option 2 B

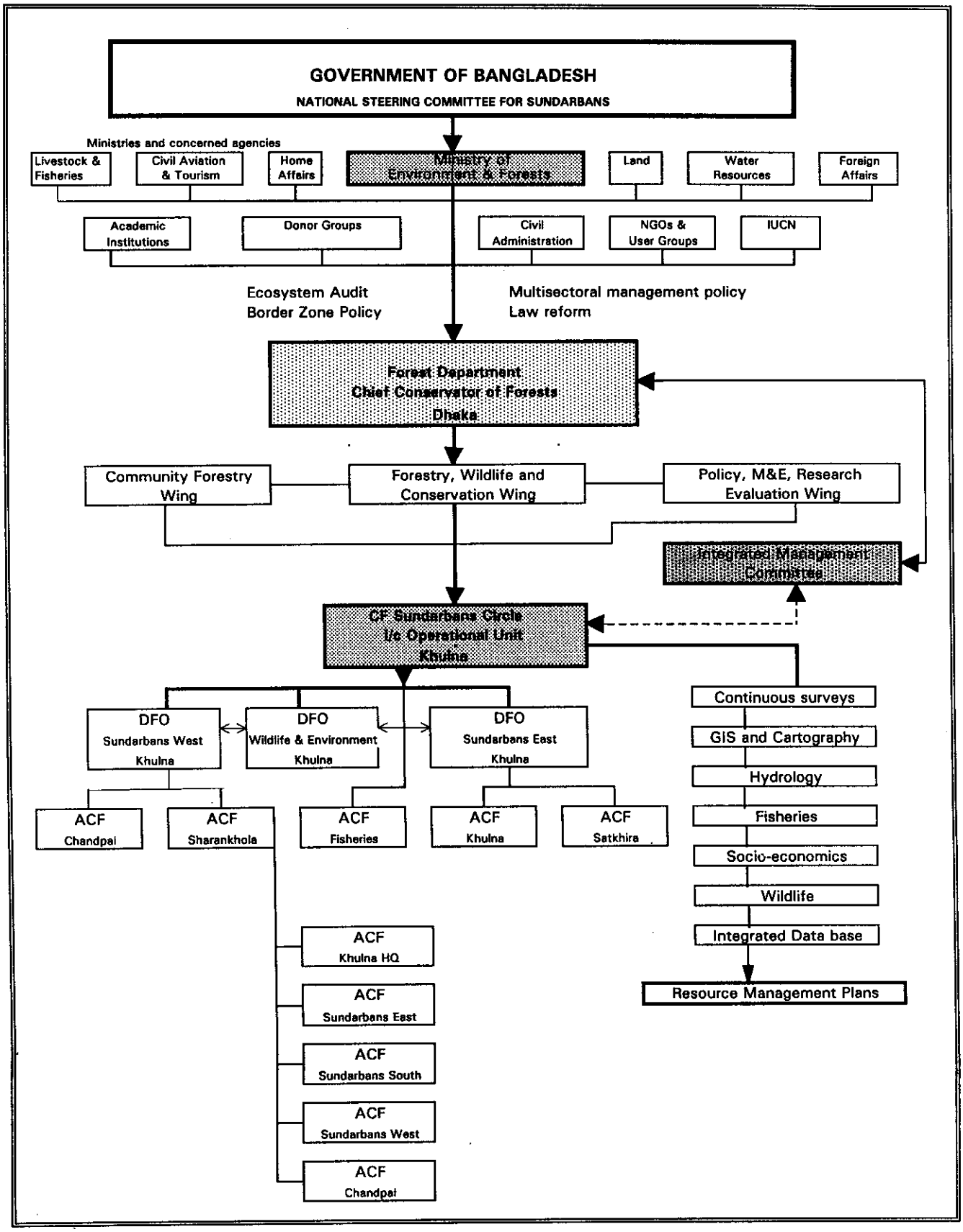
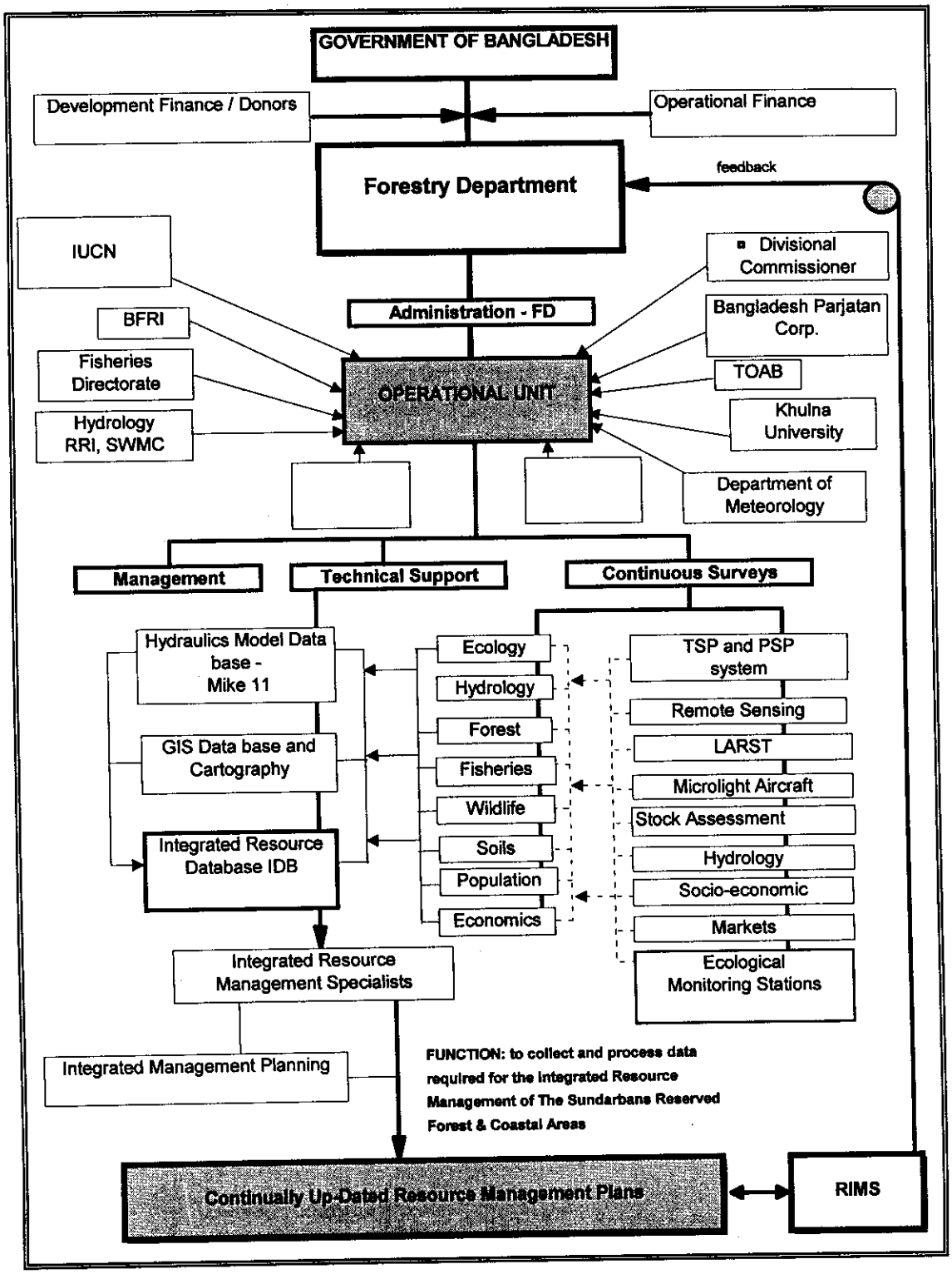


Figure 9 **Proposed Structure of the Operational Unit (OPSUNIT)**



By involving other institutions such as BFRI and Khulna University it will be possible to co-ordinate fundamental and applied research activities with long-term commitment and continuity avoiding duplication of effort. The Integrated Database (IDB) developed during the preparation of the IRMP, will provide for the storage and retrieval of data. This will become a platform for all research with many economies of scale. The Sundarbans has great research potential and given the resources of the OPSUNIT and the co-operation of the associated institutions, it should be possible to develop a worldwide centre of excellence for research and management of a threatened coastal zone resource.

Proposed Structure

The proposed structure of Option 2(A and B) are presented in Figures 7 and 8. The NMC would involve all concerned government agencies, headed by MOEF, including other stakeholders such as aid donors, NGOs and SRF resource user groups. The Divisional re-organisation is as for Option 1 with additional ACF's for the DFO Environment and Conservation

The proposed structure of the OPSUNIT is presented in Figure 9. The OPSUNIT would be organised by the Forest Department, initially funded by external donors. Its policies and functions would be set and directed by the Integrated Management Committee (IMC) which would be chaired by the CF Khulna under the direction of the CCF and would be made up of all concerned agencies at a local or divisional level. The IMC would guide technical policy matters subject to direction by the national steering committee.

The data and resource information generated by the OPSUNIT would be linked with the RIMS (Resource Information System) based at the Forest Department's headquarters. It is estimated that the cost to set up and fund the operational unit as part of option 2 for a ten year period is about US$ 13 million.

Key objectives of re-organisation:

- multi-sectoral integration, accountability and transparency; impartial monitoring and evaluation (MandE);
- independent ecosystem audit;
- consultation, communication and information arrangements with local stakeholders;
- reduction in confrontation;
- improvement and differentiation of management skills;
- wood and NWFPs will receive equal attention;
- resource conservation with higher economic returns.

User groups and NGOs will be represented in the NMC and the Integrated Management Committee directing the Operational Unit. It is hoped that all these factors taken together will usher in a new era of co-operation between users and managers.

Investment in Infrastructure and equipment

It is assumed that the FD's fleet of launches, vehicles and field offices will require replacement or upgrading. Additional specialist equipment will also be required, LARST satellite receiving station, Petrel Amphibian Microlight survey aircraft, and equipment for ecology research stations. The estimated costs are the same as for Option 1 except where specialist items have been included in the funding of the OPSUNIT. The estimated total investment required for Option2 is in the region of $ 27 million for a ten year period.

Investment in Infrastructure and equipment

The level of investment will be dependent upon whether marine and border zone activities are expended. Much will depend upon the findings of a feasibility study but the total cost be to the order of US$ 35 million.

4.5.1.3 The institutional option most appropriate for implementing the IRMP

The foregoing section outlines scenarios for an institutional framework to effect sustainable integrated resource management. Each has merits which will need careful review and to be measured against its ability to attain the nation's social, economic and environmental goals.

Issues which must be addressed:

1. Improvement of technical management

   Option 1 acknowledges deficiencies in technical management capacity of the FD and seeks to rectify this by expanding the staffing levels of the Management Planning Division, recruiting new ACFs with special skills, more training and employing international TA to undertake key activities, advising local staff and transferring equipment and technology etc. This approach seems unlikely to overcome the main problems due to the following:

   - the civil service pay scales are so low that it is unlikely that it will be possible to recruit people of a sufficiently high level of training and experience to fill the new positions;
   - training FD staff has in the past led trained staff to leave for better paid positions in the private sector or abroad, or they are promoted away from the position for which they are trained. Training would not solve the immediate skills deficit;
   - as the FD foresters will remain the managers it is probable that the non-wood resources will still not receive sufficient attention;

   foresters will still manage other resources such as fisheries, wildlife, tourism, honey and hydrology. These are highly skilled sectors in their own right and require specialist technical management; there are no independent checks to ensure the that the management plans are being implemented correctly.Option 2 - The level of technical management is increased through the introduction of the OPSUNIT, the use of training and by employing international TA to bolster key areas, directed by an inter-ministerial committee and local management steering committee. For implementation, monitoring and control, the constraints described for Option 1 remain although with a potential for a plausible degree of impartial control. The implementation staff would mostly be employed within the government pay structure. Some independent environmental audit could be arranged through the NMC which could be enhanced to perform these functions. The OPSUNIT should ensure a balanced approach to preparation of management plans.

2. Integration with other concerned agencies

   Traditionally the FD has resisted sharing any functions with other organisations and there is little to suggest that Option 1 will in any way change this entrenched position. Option 2 offer a good opportunity for involvement of other departments and agencies in integrated multisectoral management.

3. Realisation of the full economic value of the resources of the SRF

   Whichever form of institutional restructuring is introduced it must be agreed as a precursor that new revenue systems will be introduced and that there will be a new system for measuring and assessing removals. It is unrealistic to expect a complete change in attitude and even if new systems are introduced there will need to be sufficient incentive to ensure that revenue collection will be better than in the past.

   Introduction of the OPSUNIT will help promote proper measurement of removals and their monitoring and proper economic evaluation. Given suitable direction from tne proposed committees there is a realistic prospect for improvement in revenue collection and more equitable realisation of true economic values for resources. By introducing proper accountability and transparency of operations managed in separate divisions Option 2 will be the best avenue for eliminating practices which cause under-realisation of these values.

4. Confrontation between the managers and resource users

   Option 1 continues with existing institutional structures and even if management practices change, the deep rooted enmities are likely to remain. Involving local communities, traditional user groups and NGOs in the decision making process, proposed in both, could start the process of greater co-operation. In due course the law and order functions will need to be separated from management functions and by creating a better trained and better paid protection cadre, the managers of the forest could be accepted by the local population as guardians of resources in which all people are stakeholders having a vested interest in protection and productivity. If a participatory approach is also fostered by the FD through the

proposed re-structuring, especially the scope for fair access provided by free enterprise, the resulting co-operation will do much to ensure sustainablity.

5. Continuity of management

   It is obvious that any changes should be directed to ensure stability and minimum disruption to routine management. Option 1 retains most of the existing structure and offers a good basis for training and promotion within existing ranks. The major constraint to this is that key members of staff will continue to be transferred into and away from the management and technical positions. Options 2 offers a better degree of permanence and continuity for the professionals within the OPSUNIT.

6. Implementation of the Options

   Clearly Option 1 would be the easiest to implement. Changes would not be needed in the existing legislation. Options 2 requires some institutional adjustment, the setting up of the high level committees and development of new legally mandated institutional linkages.

7. Feasibility

   The proposals for reform and implementation of the goal of the IRMP include as many facets of this task as possible. No one option can possibly address all the issues raised throughout the plan. It is clearly impossible to design a panacea that will solve all the problems. Taking into account the main factors of technical efficiency, entrenched attitudes and growing social and economic imperatives, a thorough and objective feasibilty study should be commissioned by the Government to study each of the alternatives and the specific objectives.

Whichever avenue is chosen the IRMP has analysed the issues, identified the gaps, has provided guidelines to address them with adequate up to date information and provides policy makers with options to find a sustainable way to manage the Reserved Forest. All options will require substantial investment in staff organisation, technical training, infrastructure and equipment, for without the resources no option is viable.

4.6 Investment Profiles

The level of surplus FD revenue, provides ample justification for investment in reform in every sector and this strategy is backed by a set of investment profiles summarised below.

Whilst it may be argued that the government should itself invest further in the SRF from income derived from the forest, it is unlikely, in the face of higher national priorities, that even minimum investments will be forthcoming. Thus these investments will need to be considered by donors.

In this summary the projects are briefly described and the estimated total level of funding required is given without breakdown. Reference should be made to IRMP section 27 for more details.

4.6.1 Project 1: Investment in Institutional Reform Option 1

Title	Rehabilitation of The Forest Department - Sundarbans Division
Implementing Agency	MOEF and Forest Department with donors.
Location	Khulna
Duration	10 years
Estimated Cost :	US $ 21.03 million

For a description of option 1 please refer to section 4.5.1.1.

4.6.2 Project 2: Investment in Institutional Reform Option 2A/B

Title	The Sundarbans Integrated Resources Management Project
Implementing Agency	Forest Department, MOEF
Location	Khulna
Duration	10 years
Estimated Cost	US $ 26.54 million

For a description of option 2 please refer to section 4.5.1.2.

4.6.3 Project 3: Silvicultural Trials Programme

Title	Sundarbans Silvicultural Trials Programme
Implementing Agency	MOEF and Forest Department
Location	Khulna
Duration	5 years
Estimated Cost :	US $ 0.97 million

Background

The SRF been managed on a relatively low intensity system based on natural regeneration. There have been no scientifically and statistically valid trials. All areas of silviculture suffer from a lack of key data which makes management planning virtually impossible. Evidence from PSPs shows that managing endemic species more intensively could make considerable gains in productivity. Work should be done to see if indigenous or exotic plantations could increase the net production. The PSPs show that the current net productivity is around 0.8 m^3/ha/yr. Evidence from Thailand (FAO, 1994) shows that mangrove plantations can achieve a productivity of around 13 m^3/ha/yr. This indicates that plantations could have a major impact on the productivity of the SRF. Plantations in the past in the SRF have been damaged by browsing deer. No trials have been undertaken to see which types of fencing, if any, are cost effective. Due to the ban on hunting it has not been possible to protect the plantations by culling the deer in the plantation areas. Throughout the forest there are scattered areas, which from experience, would appear to require thinning and improvement fellings. In the past thinning has been undertaken but the results have never been monitored to see if the operations are cost effective. Clearly this needs to be studied.

Objectives

1. To undertake trials to gather essential silvicultural data necessary for planning.
2. To develop appropriate cost effective silvicultural techniques for the extension of the trial programme into future practical implementation phases.
3. To prepare future intensive forest management programmes for selected blank or depleted areas.

Description

In all options there is a need for international silviculture consultants to work with local silviculturists. Working together they will design the silvicultural trial programme. Once designed the trials would be implemented by the local silviculturists using contract labour and contract growing of seedlings. The consultant would return on short missions to help monitor the trials, assist in ensuring accurate measurement, and help write up the results. The results would then be used in preparing new management plans for implementation and a new research programme.

Outputs

Over a five year period an estimated total of 2 000 ha of plantations will be established, 75% of which will be as plantations of at least 20 ha in size. The remaining 25% of the plantations will be enrichment plantings within areas of poor natural regeneration.

The trial programme will, over the 5 year period, establish trials which will by completion already give good indications but will ultimately provide key information on: species/site selection, plantation spacing, weeding requirements, growth rates, planting techniques, survival rates, fencing types and requirements, protection from deer, costings, and thinning and improvement felling regimes.

4.6.4 Project 4: Wildlife Management

Title	Sundarbans Wildlife Management Programme
Implementing Agency	MOEF and Forest Department and private sector
Location	Khulna
Duration	5 years
Estimated Cost :	US $ 2.12 million

Background

The wildlife of the SRF represents a largely unmanaged and under utilised resource. There is a large population of spotted deer (approximately 90 000) which currently is not legally harvested. There has been little work done to see if the populations could withstand sustained yield harvesting. There is every possibility of setting up industries based on hunting and meat and other by products of a harvesting programme. Deer farming has been shown in other countries to be a commercial success. In Bangladesh illegally harvested deer meat sells above the prices of beef and mutton. Deer farms would also provide new employment opportunities and data to help assess the levels of sustainable harvest from the wild population.

The tigers of the SRF have not been studied in detail. Only rough estimates are available of population size and their ecology is not known. Every year there are at least 20 human deaths officially reported due to tiger predation (the actual total including unreported deaths is more likely to be around 40). The tiger is classified as by IUCN as endangered and this prohibits the trade in tigers completely. Tigers are being poached from the SRF. The estimated population of around 400 tigers is the only population of tigers in Bangladesh and probably represents the largest gene pool of ***Panthera tigris tigris*** anywhere in the world. Nothing is done to manage the population or to ensure its continued existence. A compoarative autecology study, which has international dimensions, is urgently needed.

Crocodile farming in other countries has proved a commercial success. There were originally 2 species of crocodile in the SRF, one of which is now thought to be extirpated. A commercial crocodile farm which could help in biodiversity conservation and reintroductions should be considered. If integrated with other enterprises such as fish culture or poultry production, this would also make a solid contribution to the local leather industry and tourism.

The loss of large animals from the SRF such as buffalo, hog and swamp deer, and rhinoceros must have had a negative effect on the ecology of the area. The scope for wildlife tourism would be increased substantially if these animals were re-established in empty niches as part of the SRF's natural fauna.

In many countries there are successful industries built up around wildlife by-products such as hides, antlers, bones and feathers. Bangladesh currently has no such industries but in other areas of handicraft production is seen to be very adept. It is therefore proposed that a feasibility study for consumptive utilisation on a sustained yield basis accompanied by a wildlife by-products industry, should be considered.

Objectives

1. To set up a commercially viable deer farm which would act as a breeding station and training centre in the long run for further private sector investment.
2. To improve the understanding and management of wildlife to allow sustained yield consumptive utilisation.
3. To undertake a Project Tiger - Global Tiger Forum study which investigate in detail the ecology of the tiger.
4. To undertake feasibility studies into other areas of wildlife management such as crocodile farming, re-introductions and the establishment of a secondary industry based on the by-products of wildlife harvesting from captive breeding programmes and natural surpluses.

Description

It is assumed that the various components of this project will be co-ordinated and assisted by either the OPSUNIT or the management planning wing of the FD in Khulna. If this institutional support is not forthcoming more resources will be required for implementation. The project overall contains a number of sub-projects, which will be co-ordinated by the wildlife specialist in the OPSUNIT in conjunction with the DFO Environment and Conservation.

During the first phase the project will undertake a feasibility study to design and cost the development of a deer farm at Karamjal (Animal Breeding Centre). This would be implemented as phase 2. It is estimated that the development would require fencing around 100 ha of forest, capturing live animals for stocking the area, monitoring and harvesting surpluses. During the development phase, training will be undertaken abroad and in-service. By the time the development phase is complete, the farm should be running on a commercial basis and should be self-financing - already at least 50 000 people visit the FD's mini deer enclosure at Karamjal annually.. The deer farm will also be used to train local entrepreneurs who are interested in setting up their own deer farms. The farm will be able to sell them the live animals required to start their own enterprise.

Outputs

1. During the project period a deer farm covering some 100 ha at Karamjal would be set up. After the initial investment and training period during the project life time the farm would become commercially viable through the sale of meat, tourism and through training and sale of live animals to private sector investors. The project would also provide essential information regarding the natural life cycles and fecundity of the spotted deer, which are still required in sustained yield management of the wild population in the Sundarbans.
2. A detailed study would be undertaken during the project which would provide all the information for management and the future consumptive utilisation of the deer (two species exist in the Forest) and wild boar populations. An implementation plan will be prepared which will set the level of harvest, how the harvest is to be undertaken, the possibilities of setting up hunting safaris, and the methodologies required to monitor the populations once sustained yield consumption has begun.
3. The Project Tiger programme would accurately assess the population of tigers, undertake detailed studies on its life cycle, physiology and habits and provide guidelines for future management. The study would investigate the occurrences of man eaters and try to find the reasons behind this behaviour. Possibilities of selling licenses to shoot man-eaters would be explored. Co-operation and dialogue with Project Tiger in the Indian Sundarbans will be established during this project.
4. The commercial viability of crocodile farming and the setting up of cottage industries based on wildlife by-products, deer and crocodile farming will be examined. The feasibility of increasing the biodiversity of the Sundarbans by reintroducing large mammals such as buffalo, hog deer, swamp deer and rhino will also be investigated.

4.6.5 Project 5: Development of Tourism

Title	Tourism Development Project
Implementing Agency	Ministry of Environment and Forests / Forest Department / Sundarbans Authority / Bangladesh Parjatan Corporation
Location	Sundarbans Reserved Forest
Duration	5 years
Estimated Cost	US $ 5.83 million

Background and Justification

Over the period 1986-87 to 1992-93 the average number of tourists visiting the SRF was around 5 300 but of those only 300 were foreigners. The average total income from fees paid by tourists was US $ 775 (Tk 31 000) per year. No accommodation, transport, interpretative services or specialist guides have ever been organised for tourists in the SRF. The only concessions have been the construction of two game viewing towers and the **ad hoc** use of the two rest houses at Nilkamal and Katka. Despite the lack of dedicated infrastructure there has been over the last seven years an average annual increase in the numbers of people visiting the SRF of 3.8%. It is also apparent that the level of fees recorded by the FD is not sufficient to cover the costs involved in administering the tourists and for the services rendered when estimates for overheads are included. From this it can be seen tourism is very underdeveloped in the SRF.

Based on its location, good winter climate, wilderness values and other unique features, the SRF offers a viable opportunity to develop culturally acceptable and environmentally friendly ecotourism for domestic and foreign visitors. The development of tourism is also a stated Government policy featuring in the Strategic Masterplan of 1988 for the ten year period from 1990. Moss (1994) has provided a ten year development model (TYDP) which if followed could establish a low volume, high value foreign exchange earning industry.

Objectives

The objectives of investment in tourism for the Sundarbans are to generate income and employment without damaging the environment. These are :

1. to conserve and utilise attractions base on unspoiled forest, wildlife and wilderness values;
2. to provide facilities which will cater for the low volume high spending segment of the market, usually, but not exclusively, international ecotourists;
3. to generate foreign exchange for the exchequer and revenue for sustainable management;
4. to provide business and employment opportunities both locally and nationally in the service industry by providing accommodation, food, entertainment, transport and the development of cottage industries producing handicrafts for tourists;
5. to encourage private sector investment in local and international in tourism in Bangladesh.

Description of the Project

The initial stage of the development of tourism will involve a detailed project design study which would expand the existing development proposals (TYDP). This study would include the preparation of drawings and specifications of the jungle lodges and cruise ships.

The scope of the implementation phase of this project would be to provide funds to the Government of Bangladesh so that jungle lodges could be constructed at a number of key sites in the SRF. At the same time 2 high quality tourist cruise ships to take the tourists to and from Dhaka and around the SRF would be commissioned. The right to operate these lodges and cruise ships could then be either auctioned or sold by sealed bid international tenders, following pre-determined guidelines and contractual obligations, for a given period of time. In order to make the operation of the jungle lodges and ships an interesting investment for potential bidders, it is suggested that exclusive concessions should be considered in selected parts of the SRF.

During the initial phase, whichever option for institutional development is chosen, it will be necessary for training of key FD personnel, who will be involved in providing escort and interpretative services. This will help develop the cadre of knowledgeable and highly professional staff required by high value ecotourism. Once trained this team will be recruited on a permanent basis and will form a small dynamic unit to regulate and provide services for the international tourism trade in the SRF.

Outputs

1. A detailed Project Design study into the development of tourism in the Sundarbans.
2. The construction of jungle lodges to cater for 24 up to 48 beds, and the construction of two high quality cruise ships plus the supporting infrastructure for ecotourism.
3. Auctions or sealed bid tenders of the rights to operate the lodges and ships by joint venture national/international tourism companies.
4. An increase in the numbers of high cost low volume ecotourists.
5. An increase in the numbers of low cost national tourists.
6. A substantial increase in the direct and indirect revenue collected.
7. A substantial increase in the amount of tourist dependent business providing new employment opportunities for women as well as men.

4.6.6 Project 6: Sundarbans Community Involvement Programme

Title	Sundarbans Community Involvement Feasibility Study
Implementing Agency	MOEF and Forest Department with people's organisations and other agencies
Location	Sundarbans + 10 Km Border Zone
Duration	7 months
Estimated Cost	US $ 1.65 million

Background and Justification

Within a 20 Km fringe of the SRF there is a human population of approximately 2 million with an average growth rate of 2.04%. This means that the population will double by the year 2025. A socio-economic survey (MARC, 1995) has shown that within this population there is a very high incidence of poverty and landlessness. It has been estimated that around half a million people access the reserved forest for some part of their livelihood during some part of the year. Further analysis undertaken (MARC and DDC, 1995) has shown that the people accessing the resource to extract mainly firewood and non wood forest products are themselves exploited by unscrupulous intermediaries.

This situtaion fuels over-exploitation of resources to cover the losses. However, even taking the extra removals into account the users are still only breaking even with little or no profit for their labour. Thus there is no contingency for accidents or even repairs and maintenance. This leads in most cases to dependence on money lenders and traders who in general charge high interest rates and expect that the produce should be sold to them at lower than market prices.

The net result is that the resources are harvested beyond sustainability (known as Maximum Social Yield) , and that the users are caught up in a never ending poverty trap. Added to this is the fact that the Nation itself is not receiving the full economic value of the resource. This in turn means that the SRF does not receive the necessary inputs and investment in management planning.

The levels of technology and techniques used in extracting forest esources are often at a very basic level. This results in high levels of waste, poor productivity and in some cases there is a high incidence of accidents.

Objectives

The objectives of the community involvement project is to make access to resources more equitable, to help reduce poverty and reduce unsustainable off-takes. At this stage it is only possible to recommend that a feasibility study is undertaken to design a project which will have the following objectives:

1. To provide capital to local user groups so that resources can be purchased without having to rely on middlemen and traders.
2. To provide education and training to the workers to reduce waste and the number of accidents and to improve productivity. This would also involve making available new tools and technology to the user groups at realistic prices.
3. To organize opportunities through proper consultative and participatory processes for traditional user groups to safeguard their interests;
4. To help the Nation receive the full economic benefits of the Sundarbans;
5. To develop livelihood projects and cottage industries based on the products of the SRF which will help to generate employment and thus help alleviate poverty.

Description of the Project

A detailed participatory feasibility study will be needed to help communities design a project that is both practicable to implement and acceptable to the proposed beneficiaries. The study must cover all aspects of the utilisation of all the Sundarbans Resources.

Outputs

1. A detailed Project Feasibility Study which will identify a project which will not only achieve the stated objectives but will be fully costed and shown to be economically viable and environmentally sustainable.
2. The Study should lead on to an implementation phase as soon as is possible.

4.6.7 Summary of Investment Profiles

Table 27 Summary of Investment Profiles

Investment Profile	Duration	Investments (US $ millions)		
		Foreign	Local	Total
Institutional Development				
Option 1	10	14.90	6.13	21.03
Option 2	10	15.33	11.2	26.53
Development Projects				
Silvicultural trials	5		0.97	0.97
Wildlife management	5	1.44	0.77	2.21
Tourism	5	3.40	2.43	5.83
Sundarbans Community Programme	0.5	1.21	0.44	1.65
sub total		6.05	4.61	10.66
Total by Option				
Option 1		20.95	10.59	31.54
Option 2		21.38	15.65	37.03

4.7 Ten Year Implementation Schedule

The IRMP analyses the status of the mangrove ecosystem and describes proposals for improvement in its management. The speed at which changes can be made is dependent upon GOB decisions, tangible commitments and the ability to attract the necessary finance.

It is obvious that substantial reform is needed to achieve the goals of sustainability, greater productivity and social equity.

As with any development programme there is a timebound design which focuses on the main issues and incorporates ideas for development in a unified scheme which will ultimately meet the environmental, social and economic targets.

The components of this scheme are discussed separately under each section relating to specific environmental factors or resources and introduced in a composite investment and implementation schedule as a Ten -Year Plan set out in Figure 9 The funding estimates are summarised in Table 27. readers should refer to volume 1 of the main IRMP for further details. Recommendations on development priorities fall into theree clusters:

1. Projects which concentrate on management issues within the SRF.
2. Projects which affect both the SRF and the Border Zone.
3. Projects which have regional or international dimensions.

As with any development plan, the successful implementation depends on the will of the government and those implementing the project. The first step will be for the Government of Bangladesh to decide how to strengthen the institutions which will carry out the work. Once this has been taken it will be necessary for a feasibility study to be commissioned and completed. Only then can the plan be actually put into action.

The Sundarbans Reserved Forest has been actively and successfully managed by the Forest Department for over a hundred years. The future of the forest depends upon improving management capacity and ensuring commensurate benefits in the surrounding countryside where the resource users reside. The decisions which must be taken are crucial to the very survival of the Forest in the face of strongly competing interests. The IRMP (volumes 1-3) represents a substantial contribution to understanding the system and its management. Hopefully the results and recommendations of the plan will help the decision-makers in shaping the future management of this unique ecosystem.

Figure 10 Ten Year Implementation Schedule