People's Republic of Bangladesh
Ministry of Irrigation, Water Development and Flood Control

Flood Plan Coordination Organisation

Southwest Area Water Resources Management Project

United Nations Development Programme
(BGD/88/038)

Asian Development Bank
(TA No 1498-BAN)

FAP 4

FINAL REPORT

Volume 7

Forestry and Navigation

August 1993

Sir William Halcrow & Partners Ltd.

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Danish Hydraulic Institute
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Forestry

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SOUTHWEST AREA WATER RESOURCES MANAGEMENT PROJECT (FAP-4)

FORESTRY

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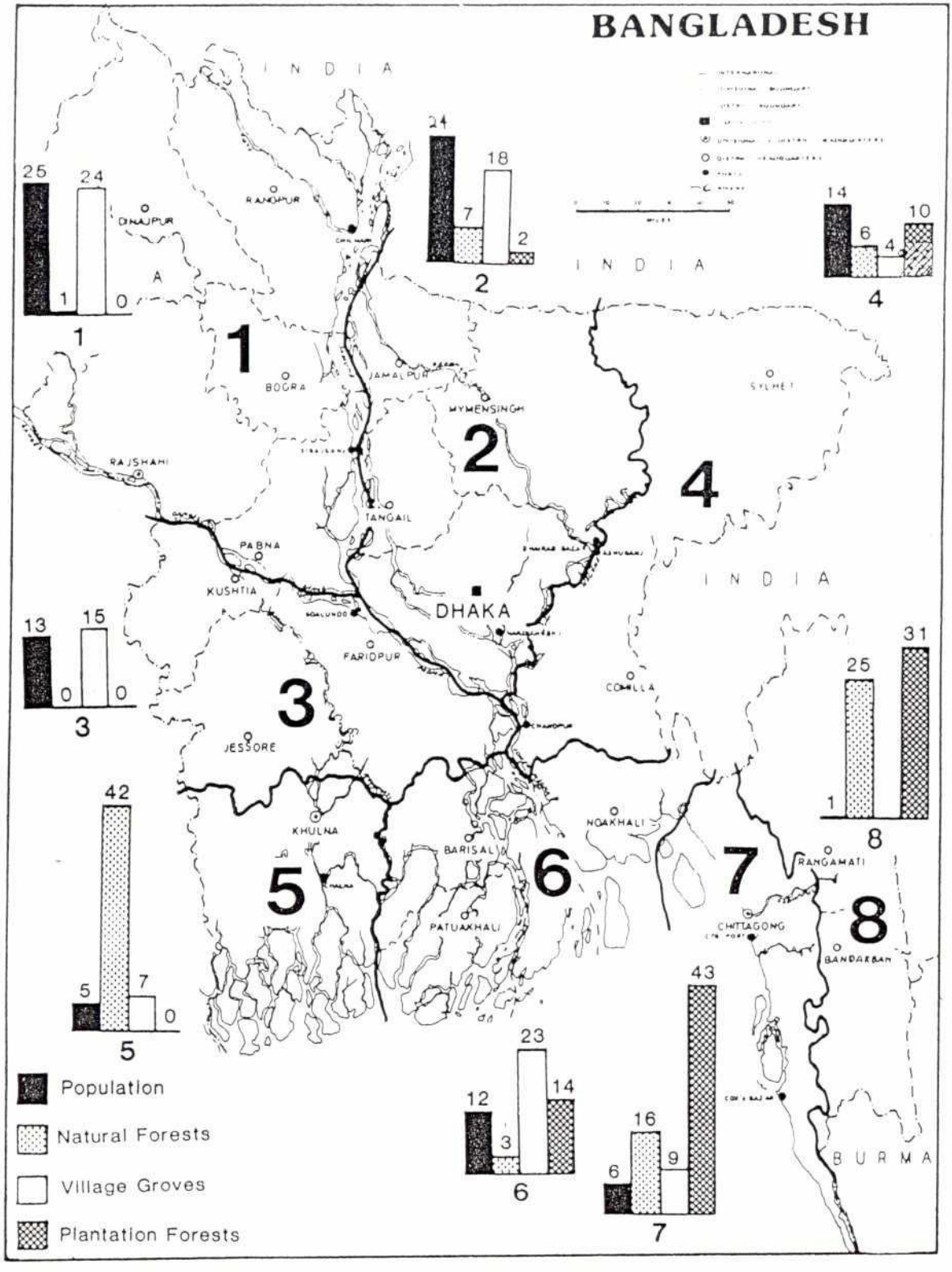
ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Rice Research Institute
BAU	Bangladesh Agricultural University
BFRI	Bangladesh Fisheries Research Institute
BGD	Bangladesh
BLRI	Bangladesh Livestock Research Institute
BTC	Bangladesh Tobacco Company
BWDB	Bangladesh Water Development Board
CARE	Cooperative for American Relief Everywhere
CARDMA	Coastal Area Resource Development and Management Association
CFGC	Community Forest Growth Centres
CERP	Coastal Embankment Rehabilitation Project
DAE	Department of Agricultural Extension
ERR	Economic Rate of Return
ESCAP	Economic and Social Council for Asia and Pacific
FAO	Food and Agriculture Organisation of United Nations
FCDI	Flood Control, Drainage and Irrigation
FD	Forest Department
FRI	Forest Research Institute
GDP	Gross Domestic Product
G-K	Ganges - Kobadak
GOB	Government of Bangladesh
GS	Growing Stock
IBRD	International Bank for Reconstruction and Development (World Bank)
IDA	International Development Agency (World Bank)
IUCN	International Union for Conservation of Nature
MAI	Mean Annual Increment
MBR	Madaripur Beel Route
NCS	National Conservation Strategy
NGO	Non-Government Organisation
NW	Northwest
ODA	Overseas Development Administration (UK)
PSP	Permanent Sample Plots
RHD	Roads and Highways Department
RIMS	Resources Management System
RRA	Rapid Rural Appraisal

SPARRSO	Bangladesh Space Resource and Remote Sensing Organisation
SAR	Staff Appraisal Report
SE	Southeast
SW	Southwest
SWA	Southwest Area
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USF	Unclassified State Forest
WCU	World Conservation Union

Figure 1.1



Map showing regional population distribution and regional disparities in natural forest resource area, resources of village groves and area of man-made plantations. Regions with the highest populations have the least resources (figures at the top of the columns are percentages)

Source : BGD/79/017 Field document4 Vol 1. Davidson,I. 1984

Regional Distribution of Forest Area

1 INTRODUCTION

1.1 Forestry in the Economy of Bangladesh

Forestry provided Bangladesh with Tk.28 billion or 3.5% of GDP in 1990 and employed 2% of the country's labour force. These figures do not represent the true importance of forestry in Bangladesh. A true measurement of its contribution to the economy would have to include:

a) The subsidies to state owned industries through controlled prices of wood raw materials.

b) Considerable quantities of fuelwood, poles, fodder, grass and other non wood forest products taken by villagers.

c) Illicit fellings

d) Protection and generation of fisheries breeding areas

e) Coastal protection against cyclones, wave action and tidal surges

f) Land reclamation from the sea and rivers

g) Protection of watersheds and irrigation structures against wind and water erosion

h) Improvement of the environment and microclimate

i) Nature conservation, wildlife habitat, ecotourism

1.2 The Land and Forest Resources of Bangladesh and the SW Area

The total land area of Bangladesh and SW Area is given in Table 1.1 together with the breakdown into forest, cropped area, fallow etc. and shown in Figure 1.1.

TABLE 1.1

Land Resources of Bangladesh and SW Area (1987)

Category	Millions Hectares		SW Area as % of the area of Bangladesh
	Bangladesh	SW Area	
Forest and plantation [1]	2.2	0.62	28%
Not available for cultivation	3.0	0.84	28%
Cultivable waste	0.3	0.02	7%
Current fallow	0.4	0.05	13%
Net cropped area	8.9	2.51	28%
Total cropped area	13.3	2.53	19%
Total land area	14.8	4.04	27%

[1] Not including village groves

Source : Forest Department 1987 and BBS 1991

Population and per capita land area

The population of the Southwest Area was 25 million (or 23% of Bangladesh's population) in 1991 living in 4.6 million households. At a population increase of 2.4% p.a. the projected population to 2010 would be

Year Persons millions	1991 25	2000 31	2010 39
Households millions	4.6	6.2	7.8
Land area/capita in ha	0.16	0.13	0.10
Government forest area/capita in ha	0.02	-	-

1.3 The Forestry Resource Type of Bangladesh and SW Area

Table 1.2 gives the forest type and category in SWA and Bangladesh.

TABLE 1.2

Forest Type by Area and Growing Stock (GS) Volume (1984/91 sources)

Forest type and category	Bangladesh		SW Area	
	Millions ha	GS millions m^3	Million ha	GS million m^3
A. Government forest				
Hill forest (50% tree cover 1.5m ha)	0.67	24.0[1]	-	
Sal (central & NW, 25% tree cover)	0.12	1.1	-	
Natural mangrove (75% tree cover)	0.57[2]	13.0[2]	0.40	13.0[2]
Plantation mangrove	0.10	12.5	0.04	5.0
Plantation other	0.05[3]	small	small	small
Bamboo				
B. Unclassified State Forest (USF)	0.73	(0.5 mill.t) small	-	-
C. Homestead village wood lots				
Homestead trees Bamboo (metric tonne)	0.27[4]	54.7[4] (5.0 mill.t[b])	0.10[6]	20.0[6] (1.3 mill. t[b])

1) Hill forest volumes uncertain but in the range 20 - 28 million m^3

2) Mostly Sundarbans Forest Reserve in SW region (gross forest area) but also a small area in Chakaria Sundarbans in Chittagong region (largely replaced by shrimp ponds). The net land area of Sundarbans is 0.40 million ha. Sundarbans growing

stock (G/S) ODA inventory 1985 is 13.0m m^3 (10m m^3 merchantable wood and 3m m^3 of branchwood and tops). Annual increment varies from <0.1 - 2.4 m^3/ha/yr depending on site quality.

3) Mostly plantation of long rotation species, poorly maintained in the Chittagong region.

4) Volumes estimated in the village inventory 1984 (UNDP/FAO BGD/78/020) but thought to be an underestimate of both area and volume. In 1990 Katebi estimated the area to be 0.72 million ha. Annual increment would be in excess of 15m^3/ha/yr for full stocking.

5) Forestry Master Plan 1992 survey giving supply in millions of culms converted to tonnes by 105.5 culms/tonne

6) Consultants estimates for SW Area based on an interpolation between the 1984 village inventory figure of grove area, Katebi's figure of 1990, field observations in April 1992 and taking SW groves area, as 28% of Bangladesh village groves and adding field crop tree planting.

The Forestry Master Plan estimates based on their 1992 survey is an annual SW Area yield of 1.9 million sawlogs and fuelwood and 135 million mature bamboo culms

Bangladesh deforestation rates are estimated at 8000 ha / year and 35 - 45% of forest lands are being cultivated or occupied (GOB 1987)

The distribution of the natural forest, the plantations and the homestead/village groves is not regular throughout Bangladesh. The highly populated areas of the northern and central regions have small areas of natural and plantation forests whilst the lesser populated regions including the south western have almost all the natural and plantation forests. On the other hand, the best village/homestead groves are in the northern and southern regions of the country (BARC 1992). Figure 1.1 reproduced from BGD/79/017. Field Document 4 Vol No.1 Davidson 1984 gives the situation graphically.

The village forests composed of woodlots, multipurpose fast growing trees, bamboos, canes, palms, shrubs and cropland trees is 0.27 million hectares (see also Table 1.2 and footnotes 4 and 6 above and section 3.6), countrywide, occupying only one tenth of the Government forest area, yet supplying over 80% of the sawlogs and about 90% of the fuelwood and bamboo consumption of the country (UNDP/FAO BGD/78/020). The South Western Region natural mangrove forest in the Sundarbans provides raw materials for the state forest industries at Khulna.

Katebi 1990 gave national homestead area as 0.72 million ha rather than 0.27 million ha from the village inventory 1984. This implies a greater growing stock than previously thought although no new figure was quoted.

2 THE WOOD CONSUMPTION, DEMAND AND SUPPLY

2.1 Introduction

Bangladesh has one of the lowest per capita consumptions of wood in the world - 0.1 m^3/capita/year of which 80% is fuelwood (Douglas 1981 FAO/UNDP/BGD/78/010). Annual wood production is estimated to be 9.5 million m^3 of which more than 85% comes from village forests and illicit fellings. In recent years the annual production from Government owned forests averaged 0.44 million m^3 of timber and 0.80 million m^3 of fuelwood and 90 million mature bamboo culms together equivalent to less than 15% of the total annual wood production, revealing the low productivity of the State Forests covering 2.2 million ha. The production from the Sundarbans was about 0.61 million m^3/year (merchantable wood including branchwood/fuelwood) in the early 1980s. By 1987 it was 0.30 million m^3 and following the 1988 ban on logging it fell to 0.20 million m^3 (from 1990 onwards).

Bamboo is extremely important in the rural areas for housing (some 250 mature culms/house with a life of 4-16 years), fencing, tools, drains, furniture, fuel, wind breaks, ladders. In the urban areas it is used for shuttering and industrial pulp.

Bamboos are found throughout the country except parts of the coastal saline belt of the SW region. They are most abundant in the highland areas and the hill tracts. The 1981 - 84 assessment by Choudhury put the national village growing stock at 190 million mature culms weighing 1.8 million tonnes (ADT) and 556 million immature culms and the Government forest 0.8 million tonnes of mature culms. These figures have been updated by the Forestry Master Plan survey 1992 giving the supply of mature culms as 5 million tonnes from the village forests and 0.5 million tonnes from Government forests. There is said to have been a gross over cutting including immature culms and destruction of bamboo root stocks to feed the brick burning industries. The 1992 assessment of regional bamboo supply and demand made by the Forestry Master Plan Study gives a national supply now of 656 million mature culms and a demand of 709 million and a forecast in year 2013 of a supply of 577 million culms and a demand of 902 million. With the rapid increase in population and the need for low cost housing, the loss of bamboo growing stocks is a serious matter. Minimal annual demands are estimated to be 25 mature culms per household per year.

The value of bamboo consumption is probably double that of wood at market prices.

2.2 Supply and Demand

There are few complete up to date estimates of supply and demand by forest source and end use, apart from the Forestry Master Plan studies of 1992. The FAO/UNDP study BGD/78/010 based on 1980's figures, published in 1986 (Table 2.1) characterised the forestry sector as:

- A small area of residual forest mostly under extreme pressure by agriculture and shifting cultivators in the hill tracts
- A village forest resource once thought to be in a state of equilibrium as a crucial source of timber, fuel, bamboo, fruit and fodder for 90% of the population, is now declining
- A significant industrial development including pulp and paper particle board and timber processing was expected to accelerate economic development but has not.

The apparently serious problems in the forestry sector include:

a) Production of the forest products industry is well below installed capacity

b) A continued decline in the Forest Resources growing stock and increment

c) A falling per capita consumption in forest products instead of a planned rise

d) An unsatisfactorily small contribution by the forestry sector to economic development despite substantial expenditure on forestry projects.

TABLE 2.1

Bangladesh National Domestic Supply and Demand (1980) of Wood Products by Source and Category from BGD/78/010 1986 (Drigo et al)

Supply Category source	Millions m^3 (Mm^3) and % of sub-totals							
	Fuel wood		Sawlogs & Ply logs		Pulp wood		Total	
	Mm^3	%	Mm^3	%	Mm^3	%	Mm^3	%
Village homesteads	6.20	89%	1.08	81%			7.28	86%
Natural forests *								
a) Hill forests	0.74	11%	0.26	19%	0.20	100%	1.20	14%
b) Sundarbans	0.39	6%	0.12	9%	0.04	20%	0.55	6%
c) Others	0.31	4%	0.14[1]	10%	0.16	80%	0.61[1]	7%
	0.04	small	small				0.04	small
Plantations	0.01	small	small		small	small	0.01[2]	small
Total	6.95	100%	1.34	100%	0.20	100%	8.49[3]	100%
% of total wood	82%		16%		2%		100%	

[1] Sundarbans production in 1987 reduced to 0.30 million m^3 of which timber 0.07 million m^3, fuelwood 0.05 million m^3 and pulpwood 0.18 million m^3, and for 1990 onwards reduced again to 0.16 million m^3 which pulp wood is 0.13 million m^3 and salvage sawlogs of sundri (Heritiera) 0.02 million m^3/year.

[2] Plantations currently have little production, since they are either long rotation and low stocking and quality (Chittagong) species or mangrove plantations which are planted primarily for coastal protection against cyclones and tidal surges and for consolidating accreted land. Timber production from coastal plantations, could, eventually, be selectively harvested to maintain tree cover and yields could reach up to 13 m^3/ha/year over 10 - 20 years rotation. With over 140,000 hectares planted up to 1993 this will give a potential annual production of more than 1.8 million m^3 from year 2020

[3] The 1991 figure for total wood production in Bangladesh is 9.5 million m^3 (IDA SAR 1992).

These figures have now been updated by the Forestry Master Plan Organization in 1992 through surveys. Their estimates of demand (D) and supply (S) demand for 1993 are shown in Table 2.2.

TABLE 2.2

Demand and Supply of Forest Products (1993) Eestimated by Forestry Master Plan 1992

Area	Millions m^3/yr							
	Sawlogs		Fuelwood		Poles		Total	
	D	S	D	S	D	S	D *	S *
BGD	5.15	1.43	8.17	6.05	0.27	0.20	13.59	7.68
SW	1.14	0.48	2.01	1.36	0.07	0.07	3.22	1.91

* Excluding pulp which is 0.32 million m^3 in Bangladesh of which 0.13 million m^3 /year is from the SW Area (Sundarbans)

D = Demand. S = Supply

Bamboo Bangladesh 576.9 million mature culms/year
Southwest 134.8 culms/year

Supply and demand projections 1992 - 2010 UNDP/FAO BGD/78/010 Forestry sector modelling for supply and demand scenarios began in 1981. Simulations to the year 2010 by BGD/78/010 (1984) - showed that :

- Village forests sustainable yields are probably in the order of timber 0.45 million m^3/year + fuelwood 0.51 million m^3 or total of 0.96 million m^3 compared with a reported rate of cutting of over 7 million m^3. This infers a gross over cutting of the growing stock and inclusion of illicit fellings from Government forests and possibly an underestimate of the extent of village groves and growing stock. A true continuous inventory of village forests is needed to clarify the position.

- Increased extraction of hill forest timber is possible but unlikely due to difficulty in access & security and costly investment in machinery, infrastructure and foreign exchange expenditure. The market is not favourable to lesser known species that would be supplied and to the high cost of extraction. Illicit logging is common. Plantations have been poor.

- 80% of the Chittagong plantations are teak and slow growing hardwoods whose yield will only bring 1% of the timber and <1% of fuelwood needs of Bangladesh by the year 2000. The coastal plantations may be able to supply some 1 million m^3 of fuelwood and poles by year 2000.

Projections to 2010 predicted

a) Great disparities in present supply and demand of wood in particular regions will worsen rapidly.

b) Per capita fuelwood supplies at current rates will supply only 25% of projected demand.

c) Sawn timber consumption per capita is expected to be 4 times current consumption whilst projected supplies will be only 1/6 of this.

d) Plantations in Chittagong will produce too little, too late and in the wrong place and are not economically justifiable.

e) Clear felling of National Forest in Chittagong Hill Tracts will incur high costs, especially foreign exchange and will add very little extra volume.

f) Newsprint and paper demand is likely to increase to 3 times the current demand but production would incur limitations due to high capital cost especially in foreign exchange. The industry would likely make a negative contribution to the national economy.

TABLE 2.3

Predictions for Wood Products to 2013

Area	Millions m^3							
	Saw log		Fuel wood		Poles		Total	
Bangladesh	D	S	D	S	D	S	D	S
Low	6.64	2.14	11.55	8.27	0.33	0.46	18.52	10.87
High	12	7.13	15.12	12.50	0.38	0.64	30.72	20.27
South West Low	1.50	0.67	2.81	2.13	0.08	0.17	4.39	2.97
High	3.24	0.67	3.67	3.67	0.10	0.17	7.01	4.51

Source: Forestry Master Plan BGD /88 /025, 1992

National pulpwood demands are 0.72 (low) and 1.07 million m^3 /yr in addition Bamboo demand is 901.5 million culms against a supply of 576.9 million.

D = Demand, S = Supply

The Master plan predictions are more optimistic about year 2013 supplies than the 1984 predictions for year 2010 (Table 2.3).

The high demand and supply figures reflect the situation where maximum effort is put into private production.

2.3 Biomass Supply and Demand for Energy

The most/recent figures available in the National Conservation strategy - Bangladesh "Towards Sustainable Development: Energy and Mineral Resources of Bangladesh" is based upon 1981 figures. Detailed tables of total energy balance and supply of biomass fuel in Peta Joules are given in Appendix 1. Total Energy consumption of 1981 in Bangladesh is shown in Table 2.4.

TABLE 2.4

Total Energy Balance of Bangladesh in 1981 in Peta Joules (10^{15} Joules) - Fuel Consumption

	Commercial Energy						Biomass Energy				
	Natural gas	Oil	Petroleum products	Coal	Electri city	Total	Agric residues	Fuel wood	Dung	Total	Total Energy
	30.1	0	54.3	5.5	6.3	96.2	317.3	83.6	77.7	478.6	574
% Total cons.	5%	0%	9%	1%	1%	16%	55%	15%	14%	84%	100%

Source: NCS

The prediction for energy/consumption to year 2000 showed two scenarios - 1) with kerosene substituting for fuelwood and agriculture residues and 2) without kerosene. The predicted proportion of biomass fuel : commercial fuels would change from 84% : 16% to 54% : 46% in scenario 1 and 59% : 41% in scenario 2 but the overall increase in biomass consumption would be 200% and 300% in scenarios 1 and 2 respectively, of which fuelwood would be a considerable part.

The proposed increase in fuelwood planting with fast growing tree species would also serve the purpose of diverting agricultural crop residues and dung to improving animal feed and fertilising crop land respectively.

The wood supply/demand situations are graphically illustrated in BGD/79/017 field document 4 volume 1 Davidson J. 1984 and reproduced here (Figures 2.1 and 2.2).

2.4 Supply and Consumption in Forest Resources in the Southwest Area

The SW Area forest resources are shown in Table 2.5.

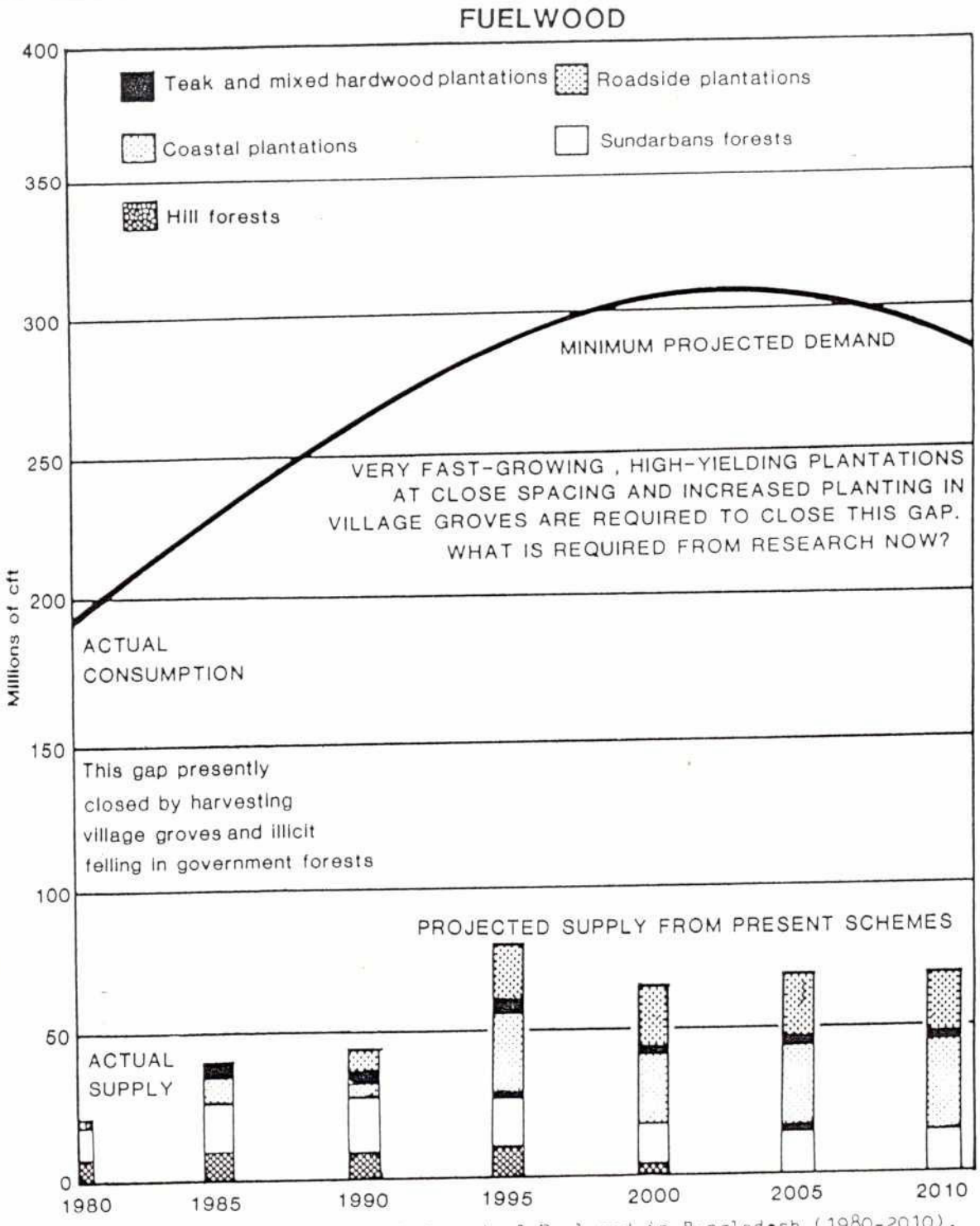
TABLE 2.5

The SW Area Forest Resources

	Area million ha	Est. GS Mm^3	Estimated MAI $m^3/ha/yr$
i) The Sundarbans mangrove ecosystem	0.40m ha Net land area	13.0	0.1 - 2.8
ii) Village/homestead groves	0.10m ha	20.0[1]	15[1]
iii) Coastal mangrove afforestation plantations	0.04m ha	5.0	13
iv) Bamboo	part of village groves	1.3 mt[2]	-
Total	0.54m. ha	38m m^3	

[1] Consultants estimates
[2] Included in village homestead groves. Estimate Forestry Master Plan 1992
See also Figure 1.1

Figure 2.1

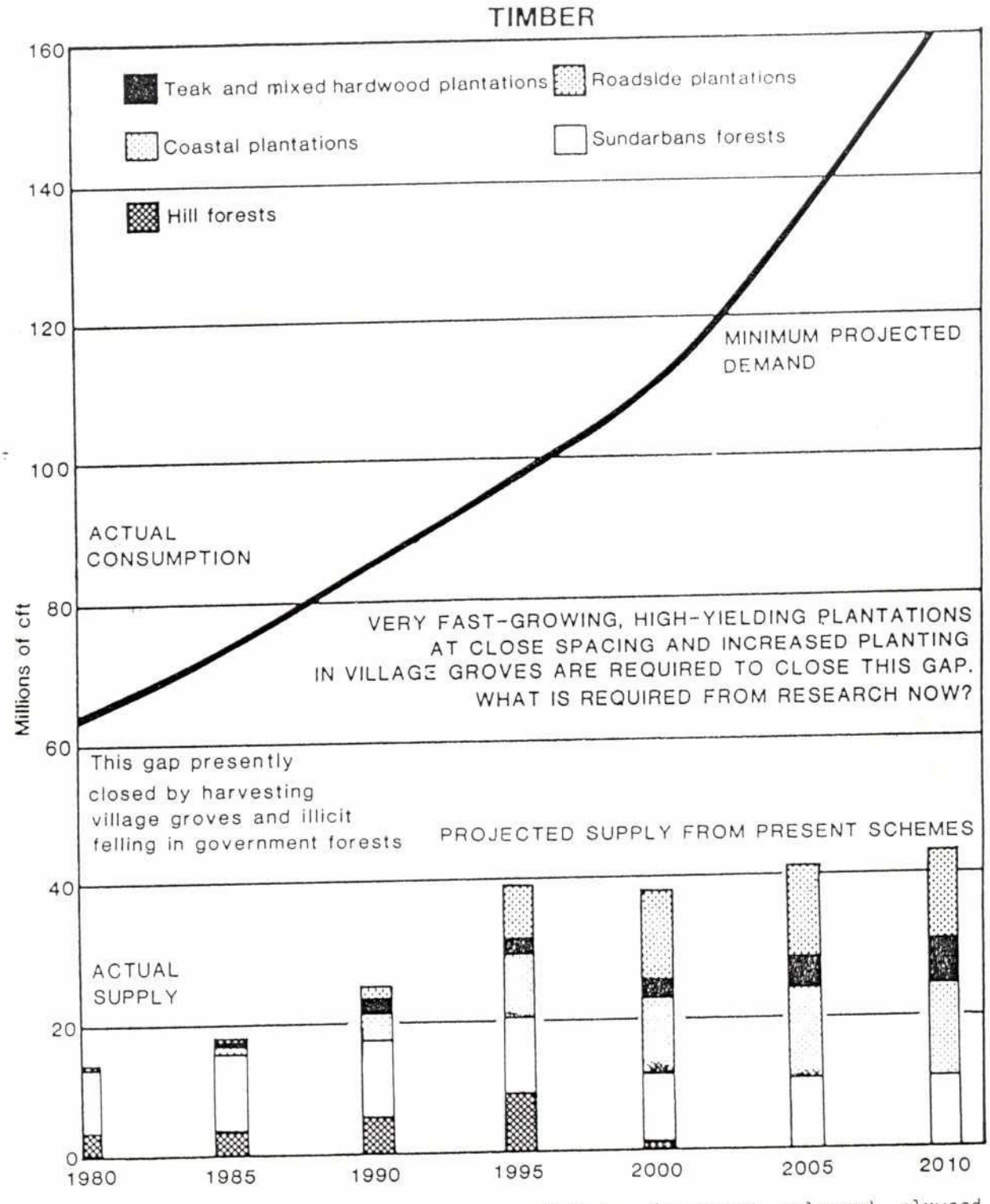


Projected supply and demand of Fuelwood in Bangladesh (1980-2010). During the early 1980s the huge gap between supply and demand is being filled by cutting from the village groves and illegal removals from government forests. Since government forests are being depleted and village groves are not keeping pace with population growth, means must be found to close the gap with new fast-growing exotic woodlots and plantations established expressly for fuelwood purposes (short rotation, close spacing). Farmers and homestead owners should be encouraged to plant fuelwood species as part of their farming land-use pattern and more attention should be given to using agroforestry techniques in farming systems.

Source : BGD/79/017 Field document4 Vol 1. Davidson, I. 1984

Fuelwood-Supply and Demand

Figure 2.2



Projected supply and demand of Timber (sawnwood, pulpwood, plywood and poles) in Bangladesh (1980-2010). During the early 1980s, the huge gap between supply and demand is being filled by cutting from village groves and illicit felling from Government forests. To help fill the widening gap, new initiatives are required such as planting fast-growing exotic and indigenous species in plantations and assisting farmers to plant fast-growing, preferably nitrogen-fixing, multipurpose trees on private land and homesteads.

Source : BGD/79/017 Field document4 Vol 1. Davidson, I. 1984

Timber – Supply and Demand

2.5 The Sundarbans

2.5.1 Introduction

The Sundarbans is a unique and valuable ecosystem providing a variety of benefits beyond simply wood products. These include a natural self regenerating biological barrier reducing storm, cyclone and tidal surge damage to the agricultural settlement hinterlands; a rich and diverse breeding ground for fresh and seawater fish and crustacea; a wild life habitat for unique animal species and resident and migratory birds. Any assessment of the Sundarbans should be an ecosystem assessment valuing these other benefits and their environmental and potential ecotourism contribution as well as the wood and non wood forest products.

Most of the information relating to the Sundarbans is concerned with its history and its forest productivity. Over 300 years ago the mangrove Sundarbans extended to twice its current size stretching from the Hoogly river (India) to Sandwhip (Bangladesh) and far to the north of its current boundary. Since then, a combination of deltaic changes in river morphology and fresh water river flow, tidal intrusions, flooding, tectonic movements and human agricultural activities have had a profound influence on the forests' extent, composition and quality (generally detrimental). The current borders of the forest were defined and brought under forest management in 1883, since when 3 inventories (1933, 1960 & 1983) of its growing stock have been carried out giving evidence of its exploitation and decline. The Indian part of the Sundarbans forest has a land and water area of 4262 km^2. The Bangladesh part of the Sundarbans with a land area of 0.58 million ha (0.395 ha forest and 0.006 million ha scrub & grass) can be classified into 3 zones of descending order of productivity per unit area (see Figures 2.3 to 2.11).

- The fresh water zone dominated by Heritiera fomes (Sundri) a valuable sawlog species which is declining due to dieback currently affecting 17% of the growing stock. See Figure 2.7.

- the moderately saltwater zone dominated by Excoecaria agallocha (Gewa) the second most exploited species, used mainly for matchwood and pulpwood logs for the Khulna newsprint mill.

- the saltwater zone dominated by Ceriops decandra (Goran) used for fuelwood and tannin.

These dominant species together with others may be found in varying proportions in each zone. Sonneratia apetala (Keora), a pioneer short lived species is exploited for fuelwood. The industrial wood raw materials are supplied at highly subsidised prices to the forest industries.

2.5.2 Wood Products

The forest is managed on the selection system with a rotation of 100 - 135 years (50 years for Sonneratia) and felling cycles of 20 to 30 years depending on species and site quality. The mean annual increment (MAI) of Heritiera is up to 2.8 m^3/ha/year and Excoecaria up to 2.4 m^3/ha/year. Overall MAI of the whole forest is 1 m^3/ha/year due to over cutting of all age classes affecting recruitment of these to future harvests.

In the early 1980s volumes of merchantable wood removed exceeded 0.6 million m^3/year. The inventory of 1983/84 estimated the exploitation had exceeded the allowable cut by over 40% and annual removals have sharply declined. A logging ban was imposed in 1989 and only Excoecaria (Gewa) 0.13 million m^3 per year and top died Heritiera (Sundri) 0.02 million m^3 per year are currently supplied to Khulna newsprint mills and the construction

industry respectively. About 0.05 million m^3 of Ceriops (Goran) is extracted for fuelwood per year. The future predictions are that Excoecaria will not be able to sustain an industrial supply at the current level of exploitation and fuelwood will be curtailed. Some parts of the forest will be taken out of the commercial working circles due to low timber availability (logging not economic).

Growth and forest species composition monitoring through 120 permanent sample plots should have been regularly recorded since 1985 for a proper basis of forest management but these have been neglected.

The Sundarbans forest decline can be attributed to overexploitation of wood resources and also a reduction of the freshwater flushing action caused by upstream barrages and poldering, increased adjacent agriculture and shrimp farming, increased silt deposition, increasing salinity in some places and tectonic uplifting effects. Degradation is exacerbated by illegal felling.

Due to the strong commitment of the Government to conserve the Sundarban mangrove forest, so far no major encroachment has taken place. But with increasing human population and foreign exchange earnings possibilities (shrimp export) the ecosystem will be under increasing threat for use as agriculture land and shrimp farms.

2.5.3 Other Forest Products

The annual non wood forest products recorded in 1988 were:

Nypa fronds	80,000 tonnes (t)
Fish	6,000 t
Honey	200 t
Wax	60 t
Shell for lime	360 t
Grass	13,000 t
Hental (Phoenix) fronds	8,000 t

The Sundarbans contributes 50% of the Forest Department revenue (in spite of the large subsidies given to forest industry for wood raw material). It supports 224,000 fishermen. Some 600,000 persons or about 5% of the greater Khulna and Barisal districts depend directly or indirectly on the Sundarbans for part of their livelihoods, though few live in the forest.

The ecosystem animals including the Bengal tiger, deer, monkeys, 35 species of reptiles, 8 species of amphibians, 5 species of marine turtles, crocodiles, wildpig and 186 species of bird, many of which are endemic to the Sundarbans may be managed for conservation and ecotourism on a commercial scale. Wildlife sanctuaries require management plans,staffing and equipment. The Indian Sundarbans Tiger project and bird reserve adjacent to the Bangladesh Sundarbans have been functioning under management for 10 years. Cooperative projects with India on wildlife management in both Sundarbans has been advocated. The Integrated Sundarbans Development and the WB Forestry projects will be assisting with wildlife management plans and development.

The $ 3.3 million UNDP/FAO BGD/84/056 3 year project "Integrated Resource Development of the Sundarbans" which began in 1992 is aimed at integrated multiple use resource management development with increased opportunities for peoples participation in wood and non wood cottage industries including the opportunity for organised tourism and recreation and is expected to contribute directly to the overall objective of socioeconomic development envisaged in the national 5 year plan.

2.6 Village Homestead Groves SW Region

There is little available data on the extent, growing stock or growth rates of village homestead groves in the SW region. Based on the country figures of the village forest inventory of 1984 which gave a national growing stock of 54.7 million m^3 and 1.8 million tonnes mature bamboo on 0.27 million ha. The Forestry Master Plan survey of 1992 gave a SW Area annual supply of about 2 million m^3 of wood. The 1991 SW land classification for F0 land is 0.68 million ha. All these figures plus field observations in travelling through the SW area, aided the consultant to estimate the SW village resources as 20 million m^3 wood and 1.3 million tonnes mature bamboo culms on 0.10 million ha of homestead and field planting. Homestead wood is a product of an essentially agroforestry system.

There is extensive use of fuelwood and bamboo roots for kiln burning of bricks and pottery (national consumption is about 1 million m^3/year. Source - Towards sustainable development. Energy & Mineral Resources of Bangladesh in 1985. Islam MN 1991. IUCN/WCU), in spite of the ban on fuelwood for this purpose. The main bamboo growing areas of the SW are Kushtia, Rajbari and Jessore. Elsewhere bamboo is becoming scarcer and is not suited to the saline coastal areas.

Agroforestry has long been practiced in Bangladesh. In all agroecological zones, trees, crops livestock and fish are integrated into the homestead production system, where women play the predominant role. In some areas particularly on rainfed agricultural land, trees are intentionally planted or retained by farmers either along field borders or directly in fields as well as in multistoried tree stands (BARC 1991). Recent developments and initiatives have involved agroforest production with landless families on denuded forest land, khas (Revenue Department) land and marginal land such as strips along roads, railways and ponds.

A number of Government and Non-Government organisations are promoting agroforestry in the homestead areas based on the fact that this is the priority location for future wood supplies and that 60 million out of 110 million Bangladeshis are considered landless (ie having <0.2 ha of land), and need income earning opportunities. Agroforestry projects are being coordinated and developed by BARC, BARI, BFRI, BLRI, BAU, Forestry Department, BRAC, PROSHIKA, USAID, CARE, FORD FOUNDATION, Bangladesh Tobacco Company (BTC) and other NGOs (Appendix 2 lists their programmes). The Asian Development Bank (ADB) $ 44 million and UNDP/FAO $ 2 million are financing the countrywide 5 year " Upazilla Afforestation and nursery development project 1989-93 " with the aim of arresting tree resource depletion in Sal forests, increasing tree planting in homesteads, compounds, marginal and fallow wastelands including strip plantations along railways, roads, canals and flood embankments with fast growing multipurpose trees including traditional fruit trees. Proforma benefit sharing agreements/memoranda of understanding have been drawn up between landless persons, the Forest Department and the Roads and Highways Department (RHD) and the Bangladesh Water Development Board (BWDB) to plant strip plantations with specified tree species along roads and berms and slopes of embankments. See Appendix 3.

The upcoming ADB Coastal Embankment Greenbelt project will carry out afforestation along the coastal regions for several km inland. The mode of operation will be similar to the Upazilla project

2.7 Coastal Mangrove Afforestation Plantations

Coastal mangrove plantation establishment on newly accreted mud flats along the Bay of Bengal from the 1960s has been very successful in consolidating and building up the riverine and coastal accretions. To date 0.105 million ha have been established, with mainly Sonneratia species (Keora) a short lived (50 years) pioneer mangrove species, for fuelwood, poles and sawlogs.

Almost all plantings to date have been done with minimal applied forestry research.

Originally there was an agreement between the Ministry of Lands and the Forest Department that the latter would acquire the accreted land for tree planting for 10 years, after which it would revert to the Lands Department for allocation to agriculture. More recently the agreement was extended to 20 years. After the experience of the 1990 cyclone and devastating coastal damage to life and property it was realised that the mangrove plantations had provided a measure of protection to the hinterland that was not afforded to unprotected areas. There is therefore a general feeling that the plantations should be retained in whole or in part. The added accretion of silt over the years, eventually, renders the sites unsuitable for Sonneratia (Keora) growth and following the natural succession of the mangrove ecosystem, other mangrove species would replace Sonneratia probably commencing as an underplanting and releasing the first crop for harvest. The rotation of Sonneratia has been tentatively fixed at between 10 and 20 years and it is no longer considered advisable to thin the crop but rather to plant at a wider espacement. The factor in this decision is the high incidence of Cossid borer attack (45% trees affected) which degrades the trees value as poles or sawlogs.

From 1980 the IBRD (IDA) UNDP/FAO began financial support ($ 11 million over 5 years) to the mangrove afforestation project which had between 1960 and 1980 planted 32,000 ha. The Forestry I Project (IDA) planted an additional 30,500 ha area and in 1985 a $28 million Forestry II project planted a further 35,000 ha up to 1991. In addition to the 1992 planting of a further 8000 ha the planned Forestry III IDA credit $49 million aims to include a further 33,000 ha of mangrove plantation within its programme covering the whole forest sector for 1993 - 1999. Total coastal planting from 1960 to 1999 should exceed 140,000 ha.

Of the total 0.11 million ha planted to date, 0.04 million ha are in SW region. (See Appendix 4 mangrove plantations of the SW region by district, area and year of planting). Of the 33,000 ha due to be planted 1993 - 1999 the proportion in the SW region will only be decided by the acquisition of accreted land.

Productivity of mangrove plantations is forecast at MAI of up to 13 m^3/ha/year. Likely theoretical southwest region production from existing plantations and say a further 0.02 million ha would not exceed 0.75 million m^3/ year before the year 2000. With the need to preserve a cyclone barrier, the production would be less.

The Forestry III project would support the planting of 27000 ha of Industrial plantations between 1993-99 in Chittagong, Cox's Bazar, Sylhet and Khulna (Sundarbans). Of this total 13,500 ha would be short rotation (10 - 17 years) fast growing species of which a large proportion may be in the SW region at/near Khulna industries. Volume production from these is likely to be in the order of 9 - 17 m^3 /ha/year or about 0.175 million m^3/year after year 2006.

2.8 Bamboo

Information on bamboo from BARI and Swiss Development Corporation survey of 1989 covering 16 districts in central, northwest, west and southwest regions and 180 households indicated that bamboo is found in all districts but is more plentiful in the upland well drained areas of the north and west above Jessore and up to Dinajpur and the hill country of the Northeast and hill tracts. It is not well grown in the saline coastal lands.

According to the Forestry Master Plan survey of 1992, bamboo demand over current supply is expected to increase by 40% by year 2013 (in the SW Area by 60%), from the 6 million tonnes of mature culms/year (1992) and it would be expected that 80% would come from

homesteads. The main use is for low cost house construction and a multitude of household and farm uses.

The supply is dwindling rapidly due to disease, neglect and over exploitation. The distance of supply to market is increasing. The average number of mature culms/household studied, varied from 30 - 3000. Construction of a house requires 250 culms and with a life of 10 years, the annual replacement should be 25 culms. As a field crop, with its low production cost, the net return on 1 ha of bamboo surpasses most agricultural crops but is not as profitable, by far, as Jackfruit, mango and banana in the homestead or bananas/tobacco in crop fields (BARI, SDC 1989).

Bamboo growing currently suffers constraints of : subsistence farmers are not oriented to the bamboo market; there are no modern techniques of improvement of growing stock available; neglect is exacerbated by grubbing out of bamboo rootstocks to sell to brick making kilns; no new planting material or extension advice on growing and maintenance; applied field research on productivity improvement is lacking.

The bamboo growing stock in the SW region, based on the Forestry Master Plan survey 1992 is about 1.3 m ton and rising consumption will require over 2 m tons by 2013.

2.9 Brick Kiln Burning

Though a ban was introduced on burning fuelwood for brick making in 1984, the supply of coal and gas to substitute for fuelwood was curtailed from 0.27 million tons in 1981 to 0.067 million t. in 1985 and natural gas was reduced to nil. Fuelwood continues to be used for brick burning and has in fact been increased in quantity.

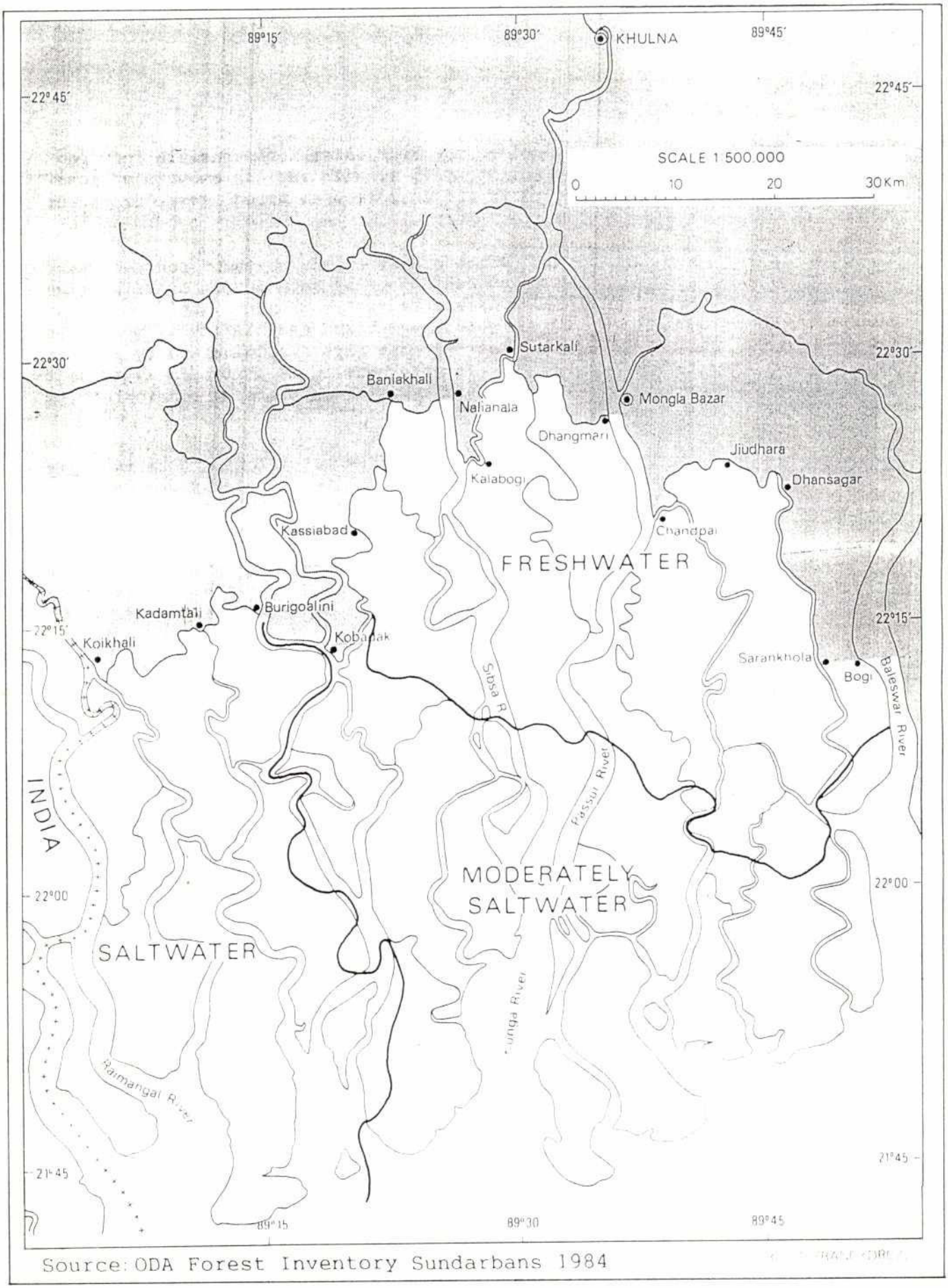
Thus the planned and actual brick making fuel supply of 1985 was

Source	Planned Peta Joule	Actual Peta Joule used
Coal	7.03	1.8
Gas	2.75	nil
Fuelwood	7.49 = 1/2 million m^3	15.6 = 1 million m^3 +

Source:

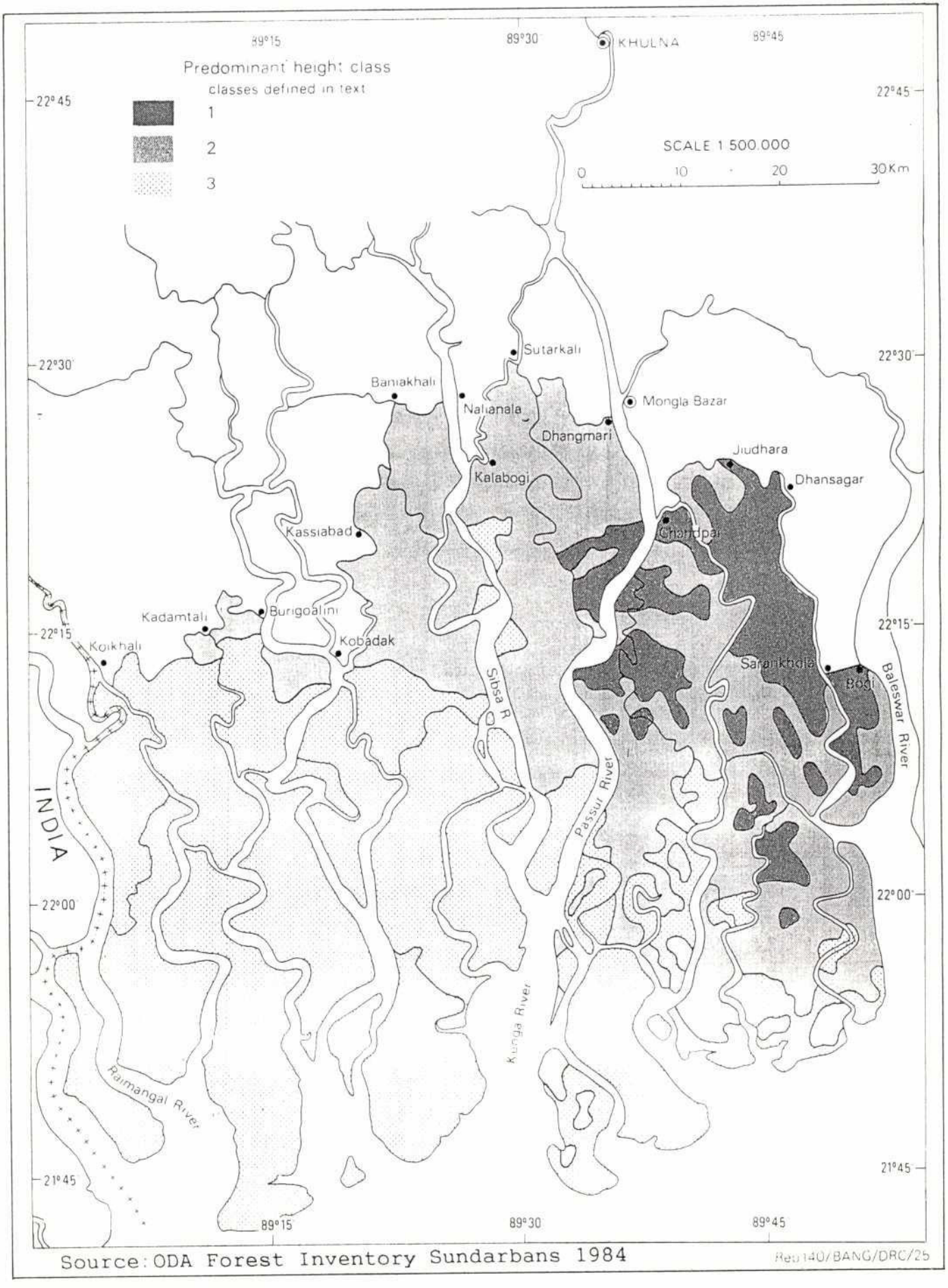
Since fuelwood is scarce there is and will continue to be a run on bamboo resources to fill the gap and a nominal 0.2 million m^3 of fuelwood would be used in the SWA (assuming 20% of the brick making capacity there) of which an increasing amount may be bamboo.

Figure 2.3



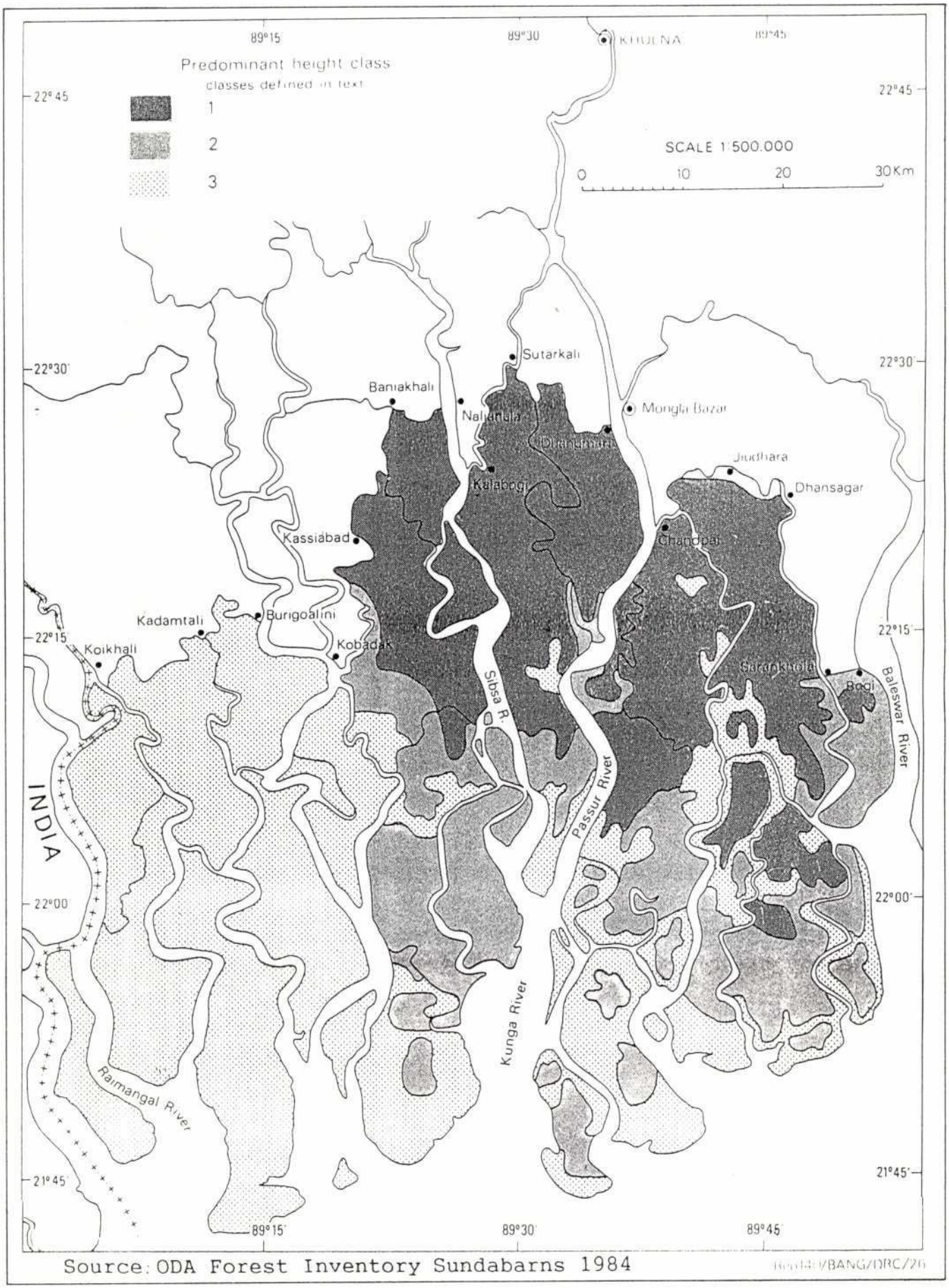
Sundarbans – Ecological Zones

Figure 2.4



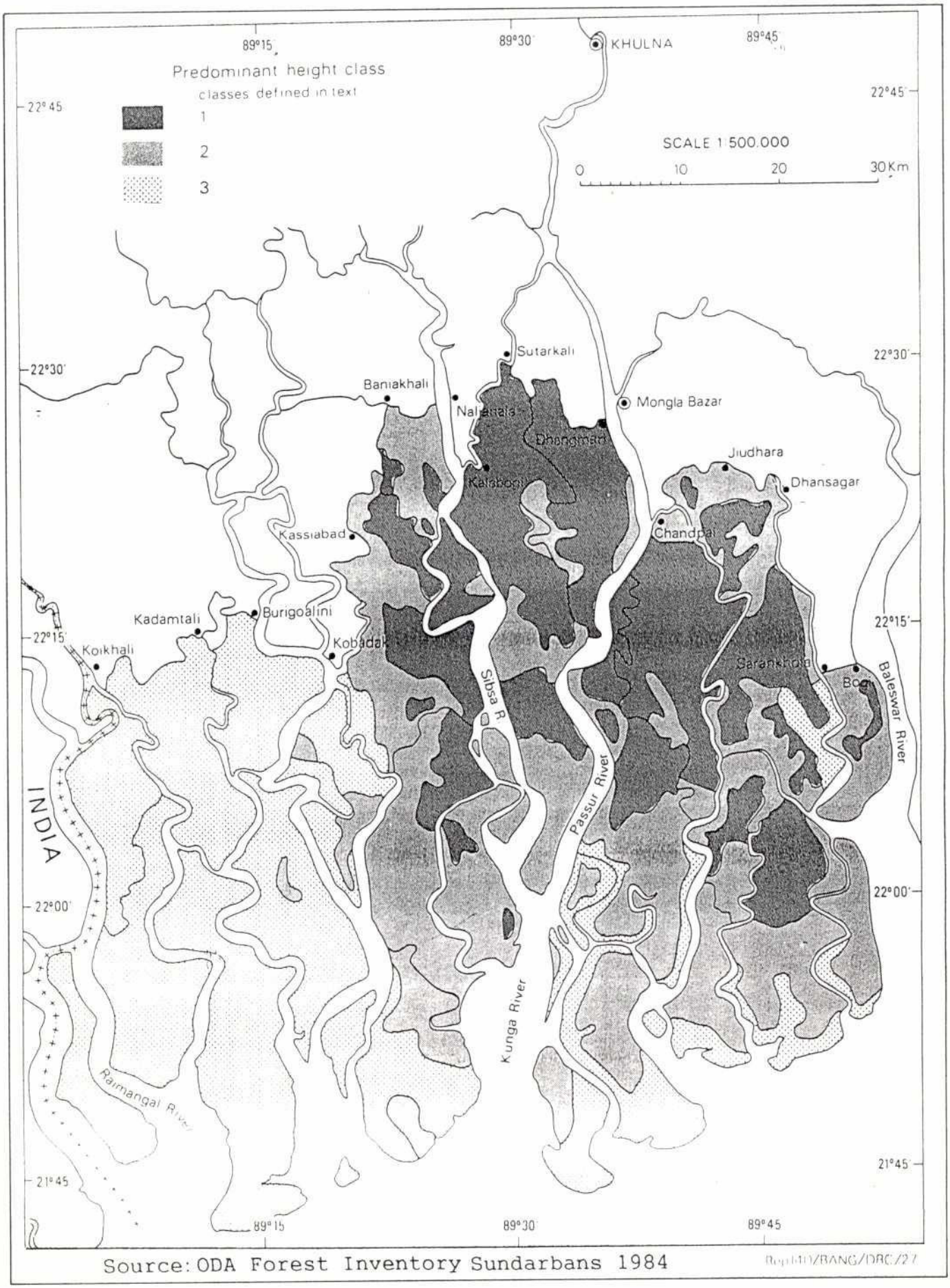
Sundarbans–Height Classes from Curtis (1933)

Figure 2.5



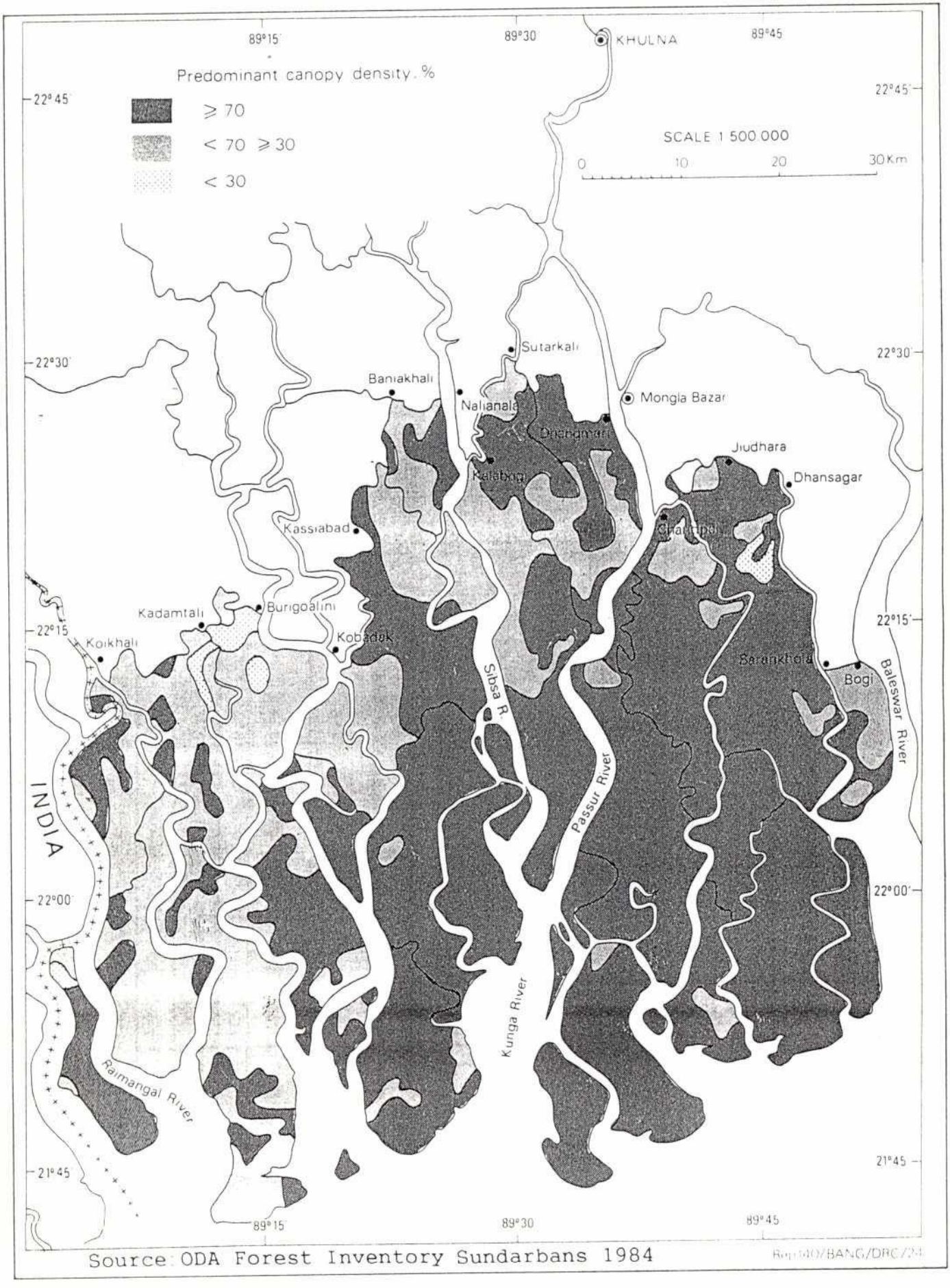
Sundarbans—Height Classes from Forestal (1960)

Figure 2.6



Sundarbans–Height Classes 1983

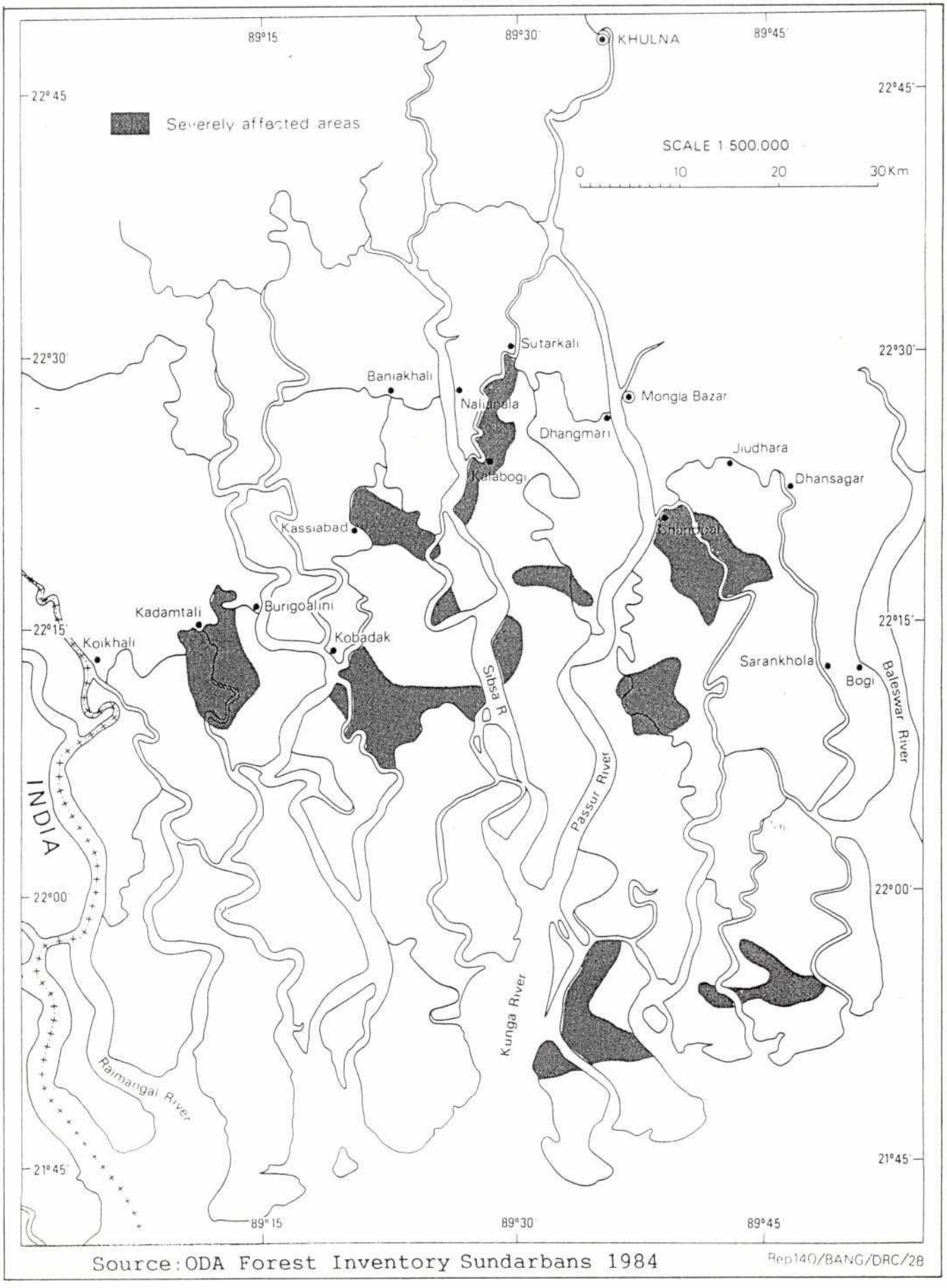
Figure 2.7



Source: ODA Forest Inventory Sundarbans 1984

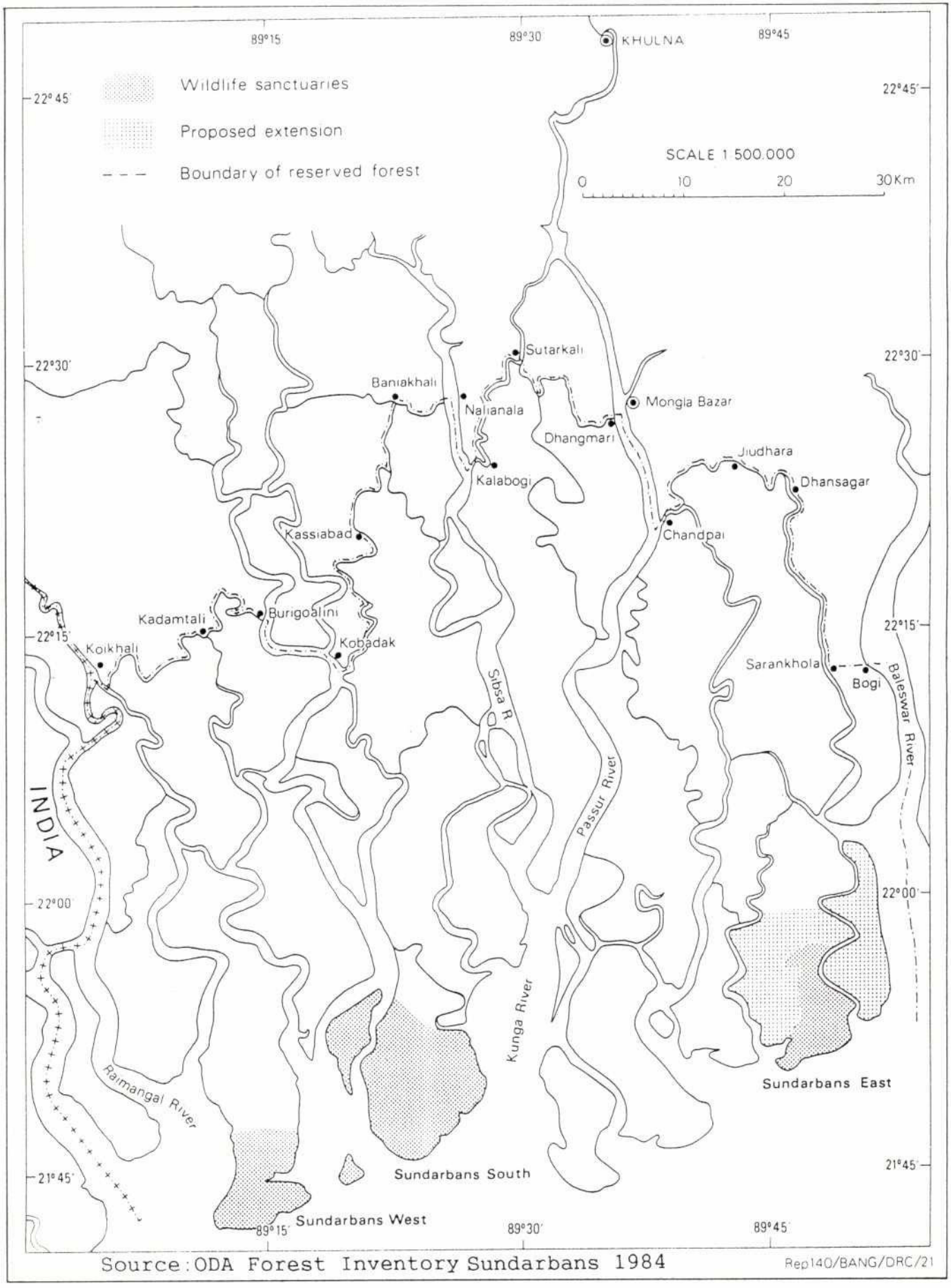
Sundarbans–Canopy Density 1983

Figure 2.8



Sundarbans—Sundri Top-dying 1983

Figure 2.9

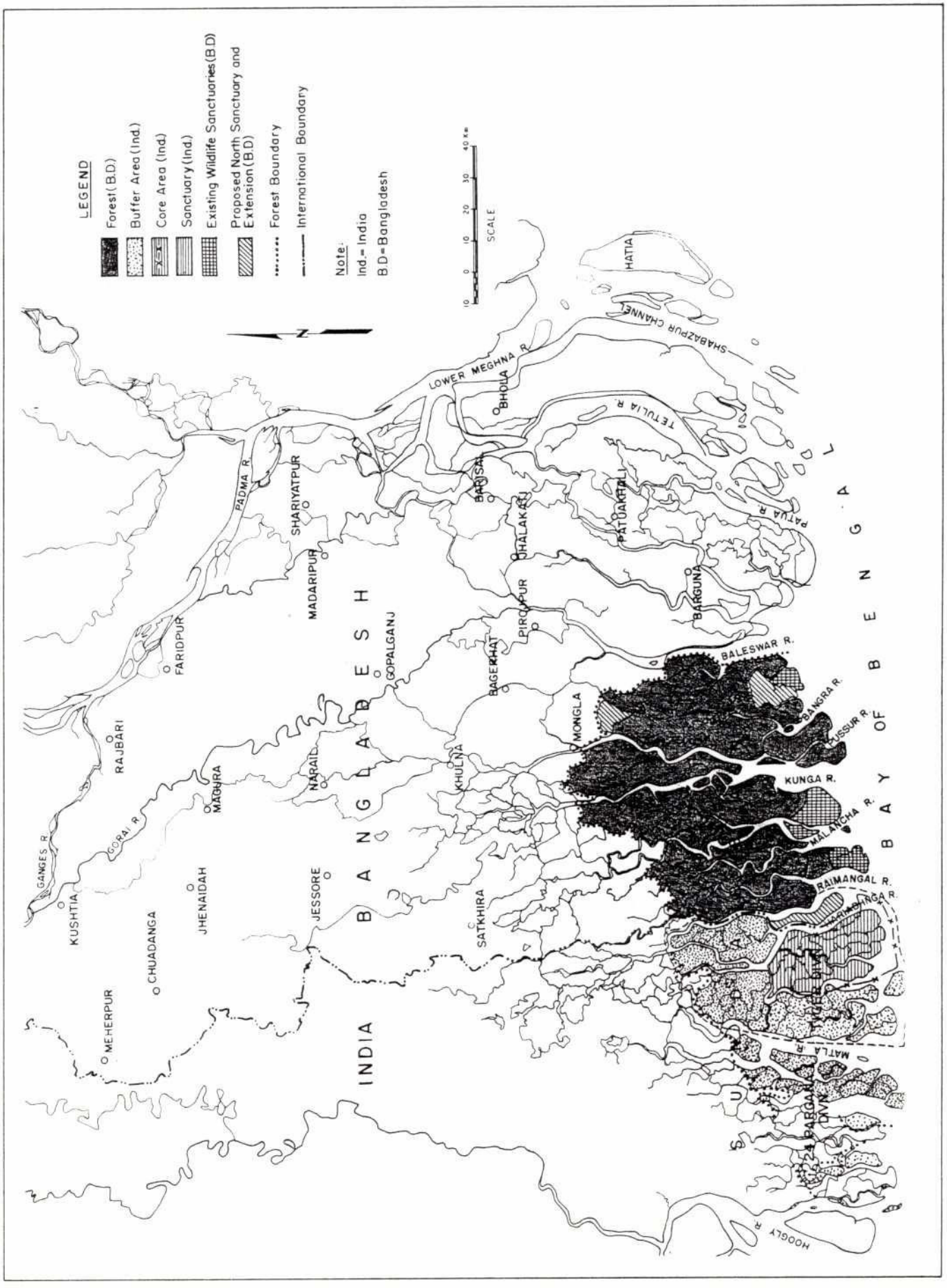


Source: ODA Forest Inventory Sundarbans 1984

Rep140/BANG/DRC/21

Sundarbans– Wildlife Sanctuaries 1983

Figure 2.10



Existing and Proposed Wildlife Reserve Areas in the Sundarbans (Bangladesh & India)

3 ECONOMIC BENEFITS OF FORESTRY IN THE SW AREA

3.1 Introduction

Economic benefits are considered under 4 categories

- Village homestead groves
- The Sundarbans ecosystem
- The coastal mangrove afforestation
- Social or community forestry

3.2 Village Homestead Groves

Village homestead groves supply 80% of the country's saw logs and 90% of its fuelwood and bamboo consumption. Yet these trees also produce in addition large quantities of fruit, fodder for livestock, crop protection, shade and enhanced environment.

The contribution to the regions fruit production is important. Table 3.1 shows an extract of 1988 production of 4 village tree species fruit production.

TABLE 3.1

Southwest Area Production of Selected Fruit Trees, 1988

Fruit tree	Area in SW region Ha	% of Bangladesh crop by area	Production of fruit Metric tonnes	% of Bangladesh production
Coconut	22046	28%	62050	68%
Mango	8942	18%	29350	18%
Jack fruit	5164	21%	5020	20%
Litchi	1273	33%	2930	29%

Source: B.B.S. 1991

Mango provides the most popular saw logs in the region. The village groves contain an intimate mixture of coconut palms, date palms, Areca palms, Borassus palms, mango, jack fruits, litchis, papayas, bananas, guavas, Samanea (rain tree), Swietienia (mahogony), Dalbergia (sissoo), Erythrina, Anthocephalus, Eugenia, Eucalyptus Acacia, bamboos and others. In addition to the groves, multipurpose trees are planted on field crop borders or in intimate mixtures with field crops.

The consultant estimated some 0.10 million ha of village groves and field plantings of multipurpose trees in the region with a growing stock of about 20 million m^3. Annual wood production is well in excess of sustainable production.

The value of multipurpose trees in crop patterns may be judged from Table 3.1 to 3.3 and the optimum economic models of homestead agroforestry for different farm categories at Chuadanga in the southwest region (Abedin,Z Husain,S. Quddus,A. and Hocking,D 1990 are shown in Appendix 5.

TABLE 3.2

Returns per ha of Various Crops in Full Production

Land use/crop pattern	Yield t/ha or numbers	Gross return 000 Tk/ha p.a.	Production cost 000 Tk/ha p.a.	Net benefit 000 Tk/ha p.a.
1. Homestead				
Bamboo mature culms	1250 (Nos)	50	5	45
Banana	100,000(fingers)	75	10	65
Jak fruit	2000 (Nos)	300	20	280
Mango fruit	20 tonnes	400	20	380
Coconuts fruit	20,000 Nos	60	20	40
Turmeric	10 tonnes	30	10	20
2. Crop field				
Bamboo mature culms	2250 (Nos)	90	10	80
Sugarcane	75 tonnes	80	30	50
B. Aus/chickpea	1.8 + 1.2 t	20	10	10
B. Aus/mung bean	1.9 + 0.7 t	20	10	10
B.Aus/cauliflower	1.9 + 20 t	80	35	45
Jute/lentil	2.2 + 0.8 t	25	13	12
T. Aus/Tobacco	2.8 + 1.4	72	25	47
Banana	185,000(fingers)	150	50	100
Turmeric	16.8	45	75	30

Source - Abedin M Quddus, M. supply, demand and cultivation of bamboo in Bangladesh RRA. On Farm Research Division BARI 1990.

3.3 Wood Prices

Most towns have one or more sawmills which consist of a single bandsaw (5 cm blade) operated by 6 persons with a daily capacity of 3 m^3 sawn output, but operating at 50% of this. The most common woods and their value as logs and sawn wood are shown in Table 3.2. The mill owner buys logs in from the groves and sells the sawn wood off the saw or keeps a small stock in hand. Some pit-sawing is done in villages.

Table 3.3 gives the purchase price of sawlogs and sawn wood in the SWA.

TABLE 3.3

Purchase Price of Saw Logs and Sawn Wood in SW Area
in 1992 based on samples from Kushtia and Jessore

Species	Sawlog sale price village Tk/m^3	Sawnwood sale price town sawmill Tk/m^3 or market
Timber		
Group 1. Mango Sissoo	{ 2120 to 2650	{ 4240 to 4945
Group 2. Eugenia	4945	9430
Group 3. Jak fruit Neem	{ 5120 to 5650	{ 11475 to 16770
Fuelwood/m^3		880 to 1410
Palm logs		Cut to customers order, not generally stocked
Bamboo culms/each roots/maund		50 to 80 700

Source: Consultants estimate

Sawnwood prices are well above world market prices reflecting the shortage of wood in the country.

3.4 The Sundarbans

The Sundarbans ecosystem covering a gross area of 0.58 million ha of which 0.40 million ha is natural mangrove forest and scrub and the remainder river channels and creeks, is managed exclusively by the Forest Department with headquarters in Khulna and 16 Forest stations throughout the forest. The staff number 18 professionals, 145 technical officers, 875 boatmen and labourers. In addition to managing the forest for industrial wood and fuelwood production, they protect the fish breeding grounds, license and control the activities of 224,000 fishermen, license the collection of non wood forest products such as nypa fronds, honey and beeswax, shell for lime, thatching grass and the management of three wildlife reserves. As well as these tangible products there is the considerable protective benefit afforded to the inland agricultural farms and settlements, by the forest against cyclones, storms and tidal surges, at a relatively low annual maintenance cost. The alternative cost if the forest was removed would be high capital and annual maintenance cost of man made protective structures. An approximate value of the production, royalty received, the wood extraction costs to government and the auction revenue and consumer prices of wood and other products is given in Table 3.4.

TABLE 3.4

Sundarbans Estimated Annual Production of Wood and Non Wood Forest Products (based on records 1986-90)

Product or Service	Annual production and units	Royalty collected Tk millions (Revenue)	Wood extraction to auction site Sundarbans. Tk millions (Expenditure)	Auction sales Tk millions (Revenue)	Sale price to consumer Khulna (Private enterprise and Govt)
Wood					
1. Sawlogs	0.02 M^3		23.0	118.0	300.0
2. Fuelwood	0.05 M^3		9.0	30.0	44.0
3. Pulp/hardboard	0.13 M^3		30.0	83.0*	344.0 (70.0*)
4. Transmission poles	21000 Nos		4.0 Khulna	13.0*	27.0
Non wood					
5. Nypa palm fronds	80,000 tons	11.0			78.0
6. Hental fronds	6573 tons	0.3			2.0
7. Honey	208 tons	0.6			8.0
8. Wax	52 tons	0.2			2.0
9. Shell	2382 tons	0.1			1.0
10. Grass	13 tons	0.1			<1.0
11. Fish	6000 tons	12.8	60.0 catching		195.0
Services					
12. Fish breeding protection	Tk 3553[1] million				
13. Coastal protection	Tk 320[2] million				
14. Wildlife reserves	?				
15. Potential ecotourism	Tk 40[3] million				
16. Environment enhancement	?				

Source: Nuruzzaman, 1990

* Subsidised price paid by Khulna industries - 20% of market price

12 and 15 based on figures from Environment component report, World Bank III Preparation Report 1991 updated for fisheries from fisheries statistics 1989/90 in 1992 :

[1] Based on Bangladesh annual offshore fish catch 231,000 mt valued at Tk 7000 million and 30% of this from breeding and nursery stock in the mangroves and the Sundarbans representing 80% of all mangroves forest natural plus man made in the country or Tk 1680 million. Shrimp post larvae collections for Satkhira, Bagerhat and Khulna shrimp industry estimated at 0.8 billion/year at Tk 0.7 each = Tk 560 million. Shrimp farms depending on the Sundarbans shrimps for 50% of their requirements, supply 83% of Bangladesh's shrimp export market from 79000 ha of ponds around Khulna, Bagerhat and Satkhira or 15,000 mt/year valued at Tk 175/kg or Tk 2,625 million. Thus Tk 1313 million attributable to Sundarbans stock.

[2] Based on coastal cyclone / flood embankment defenses of 2200 km costing over Tk 16 billion and an annual maintenance of Tk 320 million in lieu of the natural forest defence.

[3] Estimated annual capacity of 8000 tourists paying Tk 5,000

3.5 The Coastal Mangrove Afforestation

There are over 0.043 million ha of mangrove plantations planted in the SW region between the 1960's and 1991. A further 0.02 million could be planted by year 2000 in the Southwest region should there be enough accreted land by then. Originally, planted primarily for production, they are now scheduled primarily for coastal protection and secondarily for wood production. Production from these plantations is unlikely to exceed 0.75 millions m^3 from year 2000 onwards. The IDA Forestry III project SAR 1993-99 gives the costs and benefits of these plantations and also those for short and long rotation industrial plantations. The ERR for mangrove afforestation on accreted land is 24% and for industrial plantations 22%. The auction prices at forest depot and the stumpage financial and economic prices/m^3 of various products are given in the same report (1992) and are shown in Table 3.5.

TABLE 3.5

Plantation Wood Prices at Forest Department Depots and Stumpage Prices and Economic Stumpage Prices, 1991

Product	Auction price FD depot Tk/m^3	Stumpage price Tk/m^3	Economic price Tk/m^3
Fuelwood			
Mangrove	636	247	201
Industrial	848	388	318
Poles			
House	4237	2472	1271
Transmission	5650	3884	
Peeler logs	6709	4237	2048
Saw logs			
Short rotation	8300	5473	2612
Long rotation	12360	9181	4414

Source: FD Personnel communication and consultants estimate

3.6 Social/Community Forestry

The Upazilla afforestation and nursery development project BGD/84/054, coordinates and finances the work of social and community forestry undertaken by a number of NGOs, assisting the poorest members of society and the landless planting trees on embankments, road sides, canal banks and marginal forest lands. It further encourages such people to raise trees for sale in small nurseries. The 1989 Appraisal Report of the project contains an appendix on fiscal rate of return and benefit sharing, with financial and economic prices of fuelwood, sawlogs, bamboo, agro forestry crops , fruit and vegetables. Extracts from this appendix are reproduced at Appendix 3.

The Bangladesh Tobacco Company (BTC) have promoted a number of private fuelwood plantations of Leucaena on the G-K irrigation project canal banks to provide fuel wood for tobacco curing. Relevant production estimates and benefits per ha of trees, planted 2m x 2m (5 rows width along 1 km of canal) were:

	Tk millions
Income	0.30
Expenditure	0.05
Net benefit	0.25

Estimated production over 5 years	$110m^3$
Mean annual increment	$22m^3$/ha/year
Net benefit per m^3	Tk 2275

Being a coppice crop it will regrow and be capable of cutting again in 5 years or less with enhanced production and minimal maintenance. Cropping may be repeated for 6 or more cycles.

Many of the embankments, roadsides, canals and railway embankments have already been planted and many more remain to be done. The total length of flood embankment in the southwest regions is estimated to be about, 4462 km. With an average planting width of 20m, including the berm this would give about 9000 ha.

4 MAJOR PROJECTS IN THE FORESTRY SECTOR

4.1 Introduction

There has been an increasing commitment of outside assistance to forestry programmes in Bangladesh since the late 1970s. Technical assistance programmes from UN and bilateral agencies and investment programmes assisted by the World Bank (IDA), ADB and UNDP have entered second phases and IDA is about to commit Forestry III beginning 1993. A selected list of these project is found in Appendix 6.

Projects ongoing and imminent and of relevance to the southwest region are:

- The Forestry Master Plan 1992-93 UNDP/FAO/Sandwells
- IDA Forestry III 1993 - 99
- The Sundarbans Integrated Development Project 1992 - 1994 UNDP/FAO
- The Upazilla Afforestation and Nursery Development Project 1989-93 ADB/UNDP/FAO.
- Tree and Palm Plantation for Establishment of a Greenbelt along Coastal Embankments of Cyclone prone Areas ADB 1992 - 97
- Coastal Embankments Rehabilitation Project (CERP).WB 1992 - Afforestation component.

4.2 Project BGD/88/025 UNDP/FAO Forestry Master Plan, $ 0.77 million 14 months 1992-93

The Bangladesh Forestry Master Plan is meeting the forestry sector planning objectives by designing programmes to address the problems of:

- environmental degradation caused by deforestation
- unproductive and shortsighted land use practices in sensitive areas, especially major catchments
- increased scarcity of forest/tree products for domestic use, fuel, fodder, fruits, construction material and non wood forest products
- declining products for industrial use
- inefficient and wasteful uses of scarce natural resources

The programmes will be designed for a 20 year period and a portfolio of immediately required studies/projects will be prepared and some implementation begun. The project will be closely linked with IDA Forestry III and is providing a wide range of technical consultants in the fields of participatory forestry, institutional organisation, research, resource economy, environmental planning, land-use planning, silviculture, bamboo cultivation, harvesting, non-wood forest products, marketing and investment.

4.3 IDA Forestry III 10377-BD 1993-99 $ 49.6 million IDA

Forestry I and II from 1980 - 1992 supported development of a Resource management system (RIMS), coastal mangrove afforestation, industrial plantations, mangrove research,

education and training. Forestry III continues this support but is now adding environment and nature conservation, forest land use and people's participation in sector development. Forestry III will invest in:

Head	% of budget
Forest Resources Management (RIMS)	15%
Forest Resources expansion (60,000 ha mangrove and industrial plantation)	49%
Nature conservation	5%
Institutional development of Forest Department	31%

Forest Resources management will update forest management plan and silvicultural treatments. Industrial plantation will be planted in Chittagong, Sylhet and coastal plantations of mangrove will be raised in the Bay of Bengal and river estuaries. The 3 wildlife reserves in the Sundarbans will have management plans and the IDA will assist with obtaining donor funding for their operation. The Forest Department will set up a new Environment Management wing to monitor environment in all forestry sectors - Chittagong, Hill Tracts, Madhupur sal forest, coastal plantations, Chakaria Sundarbans and the Sundarbans. The branch will aim at ensuring long term productivity of forest lands through maintenance of biodiversity, soil quality and modulated water flows in the forest. It will develop procedures for achieving environmental standards and monitor compliance with them.

Mangrove research will concentrate on BFRI at Barisal and Khulna to support coastal mangrove planting and work in the Sundarbans in conjunction with the new Integrated Sundarbans Development Project 1992-94.

4.4 Sundarbans Integrated Development Project BGD/84/056 1992-94 $ 3.3 million UNDP/FAO

The aim of the project is to bring together all interests in a sustained development of the Sundarbans ecosystem multiple resource management,through studies and trials. It will :

- develop a physical data base and study the dynamics of the ecosystem management
- set up a socio - economic data base for policy guidelines on improvement of income and employment in cottage industries
- develop strategies for increased production for wood, non wood products and fisheries
- study the possibilities for commercial wildlife farming, ecotourism and recreation
- enhance the environmental and protective role of the forest for coastal croplands and homesteads

The project will be closely linked with IDA Forestry III project

4.5 **The Upazilla Afforestation and Nursery Project Development BGD/84/054 1989-93 $ 44 million ADB and $ 2 million UNDP/FAO**

The Upazilla Afforestation and nursery development project followed directly from the 1st Community Development Project 1982-91 which concentrated on NW Bangladesh and was financed by ADB $ 11 million and UNDP $ 1.8 million. That project offered components -

- replenishment of village homestead woodlots
- establishment of strip plantations
- establishment of demonstration agro-forestry plantations
- establishment of new and rehabilitation of existing Community Forestry Growth Centres (CEGCs)
- institutional support to the Forestry Extension circle of the Forest Department
- Promotion of woodfuel energy saving stoves

Target beneficiaries were the disadvantaged, landless and marginal farmers.

The new project follows the same strategy but is country wide. It is involving a number of Government organisations such as DAE, Forestry Department, BARC (Homestead Agroforestry Research and Extension Project), BFRI and NGOs such as USAID, CARE, Ford Foundation, BRAC. It will :

- Review the baseline survey of the 1st community project for updating socio-economic data, wood consumption and crop and species preferences
- Promote 17,750 km of roads and embankment (RHD & BWDB) and 800 ha of block plantings with fast growing trees and conduct publicity campaigns for tree planting
- Rehabilitate 40 nursery extension training centres
- Raise 70 million seedlings in 346 nurseries
- Train 4000 DAE and 76,000 village personnel in forest nursery and plantation techniques.
- Production of wood, fruit, vegetables and bamboo

4.6 **Tree and Palm plantation for Establishment of a Greenbelt along Coastal embankments of Cyclone prone Areas. ADB Study 1992 $ 0.3m followed by investment by bank of $ 30 -40 million 1993 - 97**

The aim of the project is to plant a greenbelt of palms and trees on the coastal embankment areas stretching several kilometers inland from Cox's Bazaar round to Noakhali covering the cyclone prone coast. The primary benefits will be coastal protection. The secondary ones will be income earning opportunities, fruit,fuel and rebuilding material.

The four month study commencing in 1992 will assess :
The role of the embankments; appropriate planting techniques; scale of planting; Appropriate tree and palm species;design model(s) embankments' planting mixing trees and palms; priorities planting areas; institutional alternatives and constraints; incentives, credits to participating farmers; social and environmental factors.

A project proposal suitable for immediate funding will be the study outcome. The investment and implementation will follow.

4.7 Coastal Embankment Rehabilitation Project (CERP) World Bank Proposed 1992 onwards

Involves 21 polders of which 3 are in the SW Area - P/35/1, P40/2 and P48. Work will be restructuring old embankments and constructing new ones. Afforestation in the SW would be 560 ha of foreshore of embankment and 100 ha of embankment.

4.8 Coastal Area Resource Development and Management

The resources of the coastal zone including forestry have been viewed in an integrated resource development and management plan with a proper understanding of coastal ecology and the long term implecitions of upland development activities and possible sea level rise in the coastal environment.

Coastal Area Resource Development and Management Association (CARDMA), an NGO, has taken a unique initiative to bring together peoples' representatives, scientists and policy makers to discuss the above issues. The subject matters were presented and discussed in workshops held in Dhaka in 1988. The action research and monitoring of priority areas, needed in order to establish a necessary data base for the preparation of a long term strategy of coastal resources development and management in Bangladesh, were recommended.

These recommendations have been further reviewed by UN/ESCAP. Coastal Environment Management Plan for Bangladesh 1988 and UNDP project Coastal Area Resource Management, Identification/Project Formulation mission 1991. Implementation of the recommendations would make a positive contribution towards development of a forestry sector in the region.

5 IMPACTS OF MEDIUM/LONG TERM WATER RESOURCE OPTIONS ON FORESTS IN THE SW AREA

5.1 The Sundarbans Natural Mangrove Ecosystem

The environmental setting of a mangrove locality is a function of both physical and biological processes. These are (1) geological - tectonic processes, covering a spectrum of scales from local to global (2) geomorphic - regional and local land form characteristics, sedimentation and erosion, soil geochemistry and other substrate conditions (3) hydrological - local and synoptic weather impacts, climatic characteristics and variability, rainfall and runoff patterns, groundwater flow and storage, estuarine circulation and dispersion, tidal inundation, sea level variability, coastal current and waves and other relevant oceanographic processes, (4) biological - reproductive biology, species competition, succession etc.

All of these processes have an impact on the development, structure and function of the mangrove ecosystem, but several of them are closely interrelated and difficult to separate. However hydrological systems along with geomorphic process dominate the resultant environmental setting more than any other process.

In the southwest regions of Bangladesh mangrove forests are linked with three hydrological systems depending on the dry season fresh water flow. These include:

i) Eastern system: This area bounded by the Tetulia river on the east and Baleswar river in the west. The area receives freshwater from the lower Meghna river through Abupur, Hizla and Ramdashpur offtakes and circulates freely through the channels keeping their salinity level among the lowest in the study area. Coastal mangrove plantations are mostly restricted to this system.

Central system: The area receives a small amount of freshwater from the Ganges through the Gorai - Madhumati system. The area is bounded in the east by the river Baleswar and the Sibsa river in the west. Salinities in the region begin to increase with the decreasing discharge of fresh water at Kamarkhali. The dry season net flows are now so low that there is a net upstream flux of salt during the dry season. The best productive forests of existing natural mangrove occur in this system.

Western system: The area is bounded in the east by the Sibsa river and to the Indian border in the west. It has no major external sources of fresh water. The limited amount it receives comes from its own drainage basins and the possible spill of Nabaganga - Gorai water through the connecting channels at Chalna. The very small input of freshwater leaves these western estuaries very high in salt content. The western part of national mangrove forests of the Sundarbans is connected with this system. This forest is least productive in terms of wood volume.

Information so far obtained suggest that the mangroves of the Sundarban are housed in a complex environment as different parts of the forest are linked to different hydrological regimes. It is evident that salinity of the river water, groundwater and soil show identical spatial gradients and are linked with the amount of freshwater flow from upstream. Increased salinization influences the species association pattern and also affects the plant growth. Some species growing luxuriantly in the low saline zone become stunted when they grow in the high saline zone. The growth of Heritiera fomes (Sundri) which constitutes the largest tree volume of the forest is completely dependent on the availability of a freshwater supply from upstream.

Table 5.1 below illustrates the reduction of timber volume of the forest with the increase of salinity in the Sundarbans.

TABLE 5.1

Timber Volume Correlation with Soil and River Salinity

Blocks	Total merchantable wood volume m^3/h	Soil salinity ppt	River salinity ppt
4	59.5	4.6	3.4
1	53.0	7.1	3.4*
5B	36.6	8.0	19.0
2	34.9	6.1	13.0
3	23.6	9.3	12.5
7	21.6	13.2	21.0
8	19.5	12.0	23.0
5A	18.0	14.0	19.0
6	17.0	10.0	21.0

* Range 3.4 - 10 ppt

Source: 1. ODA Forest Inventory, 2. Karim 1988

It has also been documented that each mangrove species responds to a critical level of inundation or hydroperiod as a result of change in land elevation produced by microscale geomorphic settings. Table 5.2 summarizes the change in composition of plants with the change in salinity and hydro period.

Appendix 7 lists the major species of mangrove found in the Sundarbans.

5.2 Sundri Top Dying

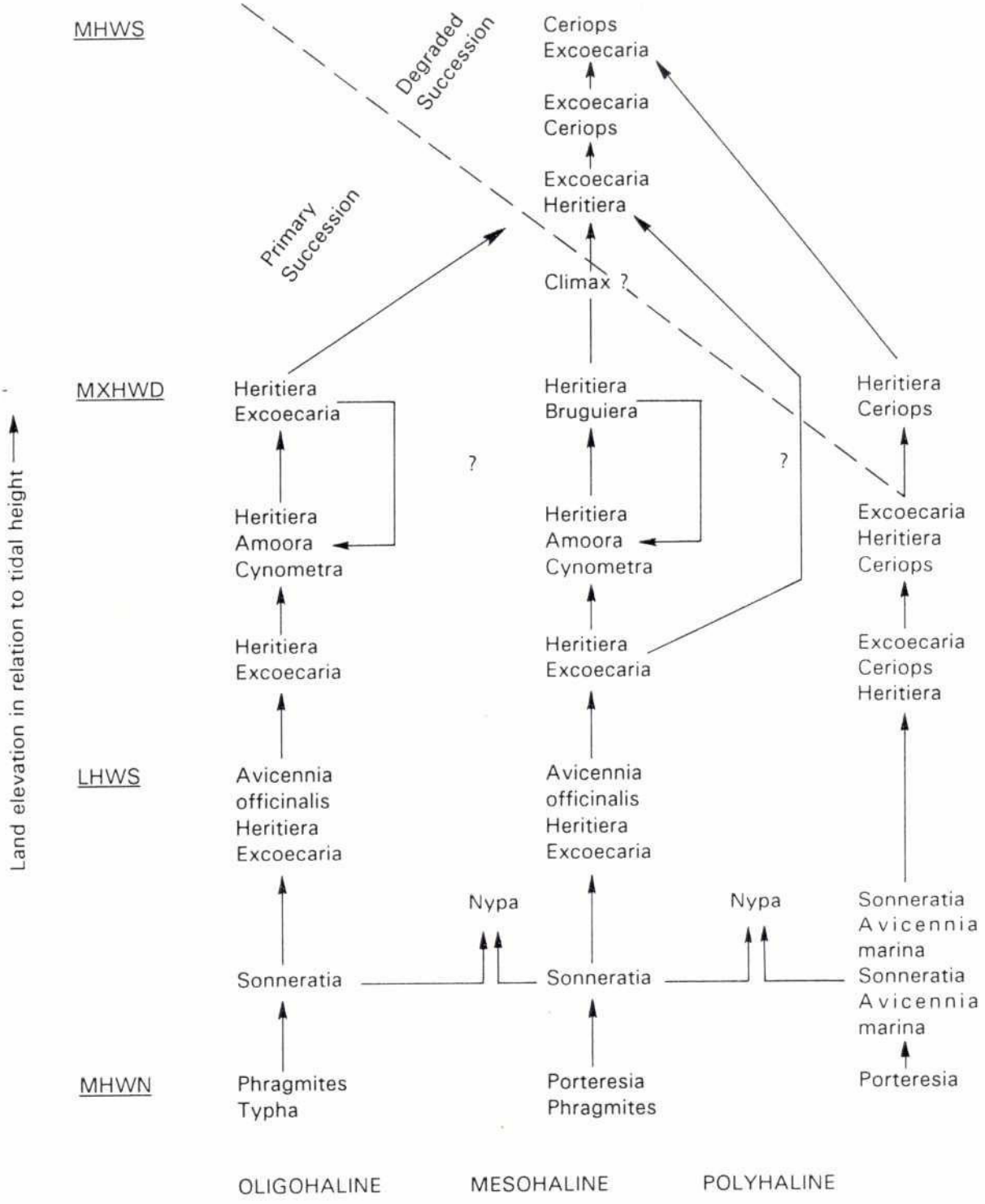
Top dying of Sundri, a disorder causing death of the trees from the top downwards has been viewed as serious threat to sustained forest productivity. A wide range of arguments and hypothesis have been put forward as to its cause. It has been argued that an increase in river salinity as well as soil salinity causes top dying but its occurrence in the less saline soil does not prove this hypothesis. The occurrence of excessive sediment deposition causing drowning of the pneumatophores can not also be considered as conclusive evidence of the cause of top dying. In depth analysis of the etiology and research results indicate that trees could be exposed to stress conditions due to a single factor or a combination of factors, including :

1) salinity
2) reducing the critical level of inundation
3) loss of canopy due to cyclonic storms
4) water logged condition in the soil.
5) excessive sediment deposit on pneumatophores

The association of canker formation and fungal leaf attack (Chrysocoa and other infectious fungi) are apparently secondary infections arising from these stress conditions.

TABLE 5.2

Successional Model for Mangrove Vegetation in the Sundarbans



Source: Karim, 1988

MHWS = Mean high water of spring tide
MXHWD = Maximum high water during dry season
LHWS = Lowest high water of spring tides
MHWN = Mean high water of neap tides

Although there exists considerable concern about sundri topdying little progress has been made, so far, which can draw conclusive and confirming evidence as to the cause of topdying. The Bangladesh Forest Department, through FRI Chittagong, conducted pathological and entomological studies of the disorder without a conclusion. The extent of loss of timber volume of the tree due to top dying was inventoried by ODA (1983), who also surveyed the physicochemical characters of the soil in top dying areas, although the survey was not designed to obtain conclusive evidence on the cause of top dying. The few research reports which attempt to relate salinity to the cause of sundri top dying present results which are contradictory and conflicting.

Recently an attempt has been made to study the salinity and mineral status of plant soil-groundwater interrelationships with the sundri top dying through a BARC project. The study is in the final stage of report preparation and indicates that there is no linear relationship of top dying of sundri with the salinity and mineral status of the soil. It was observed that sediment deposition raised land elevation above the maximum high water of the spring tides during the month of April and is quite common in the areas where trees are dying out in patches. Etiology of the topdying trees varies in different trees. Some tree groups develop symptoms of chronic stress condition such as reduction of leaf size, gradual thinning of the canopy and other trees lose their crowns due to windbreak and continue with the remaining part healthy for sometime and ultimately get infected with disease organisms. It was also observed that top dying is not an instantaneous response to a sudden change in environmental condition of the site, rather it is a chronic phenomenon which requires close monitoring in the field.

Recently a salvage sanitation felling began by the Forest Department which harvests affected sundri trees. Currently, however, there is no Forest Department research plan in force to study sundri top dying. Now would be a good time to monitor the sundri top dying status under a properly conducted research project. Such information may otherwise be lost which is badly needed to find out the future changes of vegetation composition as well as sundri top dying. The matter should be taken up by the Integrated Sundarban Development project BGD/84/056 Project on a priority basis.

5.3 Coastal Afforestation

The coastal afforestation project in the southwest region of Bangladesh is being carried out in the coastal lands which are among the most dynamic and changeable of geomorphological settings. The area is in a tectonically active deltaic plain. The geomorphological development of the existing plantation land and future land formations is naturally linked to the delta building process of the rivers of the eastern system.

The plantations in these newly accreted lands occur as either mud flats outside the protective river embankments or as new islands. Mangroves accelerate the rate of sedimentation in the planted areas and elevate the land level. The elevated land also changes the critical hydroperiod which is plant specific. Under such condition of geomorphological variability and varied inundation regime the choice of species should have been on the clear understanding of the autecology of the mangrove plants of the region for the success of these plantations. Most of the problems that have cropped up for plantation failures is the result of the lack of understanding of the suitability of crop on different geomorphic settings and hydrological regimes. It is unfortunate that past forestry research efforts in two forestry assistance project's could produce little new information on plantation silviculture and techniques from that generated before the commencement of those projects. However a good start has been made to remedy this with a small under planting programme of secondary succession species which needs further intensification with adequate manpower and resources.

In the eastern rivers system the availability of newly accreted land is very limited for extension of future mangrove afforestation. However multipurpose use of the existing river embankments (some 9000 ha) has great potential for future fuelwood and fodder plantations, and should continue to be brought under the upazilla afforestation programme.

An attempt has been made in the past to address land stability conditions and future changes in these conditions at both existing and potential planting sites under UNDP/FAO Project BGD/85/085. Like many other studies in the past this study on prediction of suitability of land for plantations has been terminated with a report only. Lack of continuity of observation and monitoring the changes in permanent sample plots is a serious constraint for future plantation programmes.

So during future pre-feasibility study of the water management structure the following information should be incorporated in the planning process and a close institutional linkage with RIMS of forest department should be established for maintaining a permanent data base.

1) General index of vegetation quality
2) Stream bank vegetation condition (present or absent)
3) Width of mudflats along embankment

5.4 Homestead Vegetation and Village Bamboo Groves

Since availability of the new land for raising plantations and improvement of growing stock of the existing plantations and natural forest is limited the homestead plantations and the raising of village bamboo groves with their potentially high incremental growth rates should be intensified. This sector has the greatest potential for raising multipurpose and timber trees with the participation of women and marginal farmers as well as big landowners. Existing experience of raising trees for commercial purposes in the southwest region needs to be explored further with the participation of people both at the level of governmental and non governmental organisations.

Any increase in the quantity of FO land (land category with minimal seasonal flooding) arising from water management activities, should generally be beneficial to overall village forest production.

5.5 Proposed Water Management Options and Effects on Forestry

(i) Increasing fresh water river flows in the Gorai and/or the Arial Khan - MBR

The enhancement of dry season water flows through the Gorai or the Arial Khan river systems to the extent of 250cumec to improve the irrigation potential of agricultural schemes north of the Sundarbans and depress the saline front would likely deliver an increased freshwater supply to the Pussur and Sibsa rivers improving the diversity and productivity of part of the forest and possibly alleviating Sundri dieback. The river systems carry a sediment and nutrient burden, which in the right quantity and place are beneficial to the mangroves. Too much sediment in the wrong place upsets the ecosystem causing a quality deterioration. This is what is occurring in the northern part of the Sundarbans, partly as a result of poldering to the north reducing the old tidal spill area. The ideal river salinity during the time of minimal freshwater flow to ensure good quality Sundri dominated forest is < 5 ppt. (range 3 - 10 ppt). Simulated increased freshwater flow in the Gorai river, without additional abstraction en route, appears to reduce the salinity in the northern part of the Sibsa and Pussur Sundarbans rivers from 19 - 20 ppt to 10 - 16 ppt. However

midway between the northern forest boundary and the sea, the salinity of these two rivers remains unchanged. Further simulations would be needed to show flows necessary to decrease salinities to a lower level.

Monitoring of the river flows into the Sundarbans for flow, salinity and sediment transportation for evaluation of changes to the forest and remedial action is required.

(ii) Rationalizing the polders' drainage layouts

The 43 polders located in Satkhira, Khulna and Bagerhat catchments north of the Sundarbans were constructed mostly between 1960 - 70, bringing some positive agricultural benefits through reducing the soil salinity. However the empoldering has reduced the tidal spill area and caused excessive sediment deposition in the river channels including those in the Sundarbans and also rendering many channels unfit for navigation at low tide. Siltation of the Sundarbans rivers and drainage creeks has caused elevation of the ground thereby reducing the frequency of inundation and increasing the forest floor's exposure to sunlight, especially in the dry season and subjecting the vegetation to excessive evapotranspiration and soil salinisation. Restoration of the drainage channels of the Sundarbans is essential to improving the deterioration of the forest. Rationalizing the polder drainage to create large spill areas may assist the Sundarbans forest. Continued empolderment will exacerbate the siltation of the Sundarbans rivers.

(iii) Improving the navigation to Mongla Port

Increased flows to the port would require an increase in flow of the Pussur river and possible closing of side channels to/from the Sundarbans forest. This action would mean the east west exchange of saline and fresh water would reduce and siltation of internal Sundarbans creeks would ensue and drainage become impeded. The consequent raising of the ground level would convert the forest to a saline scrub forest. The adjacent forest is already being adversely affected by the dredging and dumping of silt from the Port channels and oil pollution from shipping.

5.6 Village Forests

(iv) Expansion of FCDI in the SE region subject to limitations on the supply of fresh water to Bhola Island

Abstracting freshwater from the Meghna causing further saline intrusion north would adversely affect tree species growing in freshwater habitats along and within polders. The coastal mangrove plantations would be affected by increased sediment deposits over the present deposit rate depending on sedimentation flow. Many of the current plantations already need a change of species due to the increased elevation of the sites.

(v) Flood control of the Ganges - Padma rivers.

When the flood control embankment gate structures are complete the proportion of FO ground in the SW Area will be considerably increased. Tree planting schemes should be vigorously pursued both inside and outside the embankments to create additional embankment stability and tree products for income.

(vi) Promotion of project level improvements in operation and maintenance of water

management and mixed shrimp /fish /agriculture and making maximum use of beels and joint use of ground and water resources.

Expansion of fisheries and shrimp ponds along the Sundarbans northern boundary may encourage conversion of the Sundarbans forest to shrimp ponds, in spite of the fact that there may be an area equal to the present 79,000ha of shrimp ponds available in Bagerhat district. There is an increasing demand for conversion of part of the Sundarbans for salt pans in Khulna and Satkhira districts, especially in the northwestern Sundarbans with its low income villages.

Increased freshwater fisheries and shrimp developments should provide the opportunity to incorporate the planting of freshwater swamp trees like Baringtonia, Pongamia and palms along the fisheries embankments for stability and tree products.

(vi) Non structural measures to mitigate flooding

The promotion of tree planting to protect flood embankments and homesteads in the cyclone prone areas is being followed up by the ADB cyclone protection greenbelt project. The project should be extended westward to the eastern boundary of the Sundarbans.

6 RECOMMENDATIONS FOR MONITORING AND EVALUATION OF SW AREA FORESTS

6.1 Introduction

The main forest concern is the deterioration of the Sundarbans, apparent from the changes in species diversity, dieback of Sundri,increased salinization of rivers and soils and excessive siltation.

6.2 Sundarbans

To provide an adequate database on which to make decisions about water and forest management it is recommended that a continuous monitoring and evaluation of the ecosystem begin soonest. This would require an integrated effort on behalf of Government Ministries involved in and around the Sundarbans, including Ministries of Forest and Environment, Agriculture, Fisheries, Irrigation and Flood, Shipping and Mongla Port Authority. Monitoring and evaluation would be undertaken by the UNDP / FAO Integrated Sundarbans Development project BGD/84/056, supported by IDA Forestry III and the Environment wing of the Forest Department on a continuous basis,in perpetuity. Funding would be sought from bilateral sources. It would involve the setting up of a chain of monitoring stations at major river junctions in and to the north of the Sundarbans forest supplementing those already in existence. These stations would measure river cross sections, flow rate, salinity and sediment transportation characteristics at different periods of the year. At the same time the 120 forest Permanent Sample Plots (PSPs) set up in the major forest types in the Sundarbans in 1986 and since neglected should be reactivated. Observations would be made at 2 year intervals. The execution of a programme of continuous assessment requires a permanent research team with necessary transport and equipment. Lack of these in the past has meant that measurements are neglected and evaluations are non existent. PSPs would be the basis for silvicultural and forest management plans and the key to improving forest productivity. They would record changes in forest types, canopy density, height, volume, numbers,regeneration, growth rates, ground vegetation, soil characteristics and salinity, sediment deposition, and wildlife. Work already begun with SPARRSO on timber volume inventory in the Sundarbans using aerial photography and remote sensing would be pursued to complement the ground survey work. A similar monitoring and evaluation of fisheries and crustacean resources, regeneration and sustainable supply of breeding stock would be made under the auspices of the Fisheries experts. The relationships between various forest types and qualities and fish/crustacean breeding stocks would be ascertained. Fisheries management would take steps to improve extension services to educate fishermen in non wasteful collection of juvenile stock and rotation fishing areas.

The assembly of a Sundarbans database with these elements will be the basis of planning water management supply options to Sundarbans rivers.

Contacts and exchange visits of foresters and scientists should be made to the Indian Sundarbans forest which is contiguous to the Bangladesh Sundarbans forest. The Indian side is further advanced in wildlife management and social forestry in degraded natural mangrove management. Socio economic surveys should be undertaken to provide the basis to involve forest fringe dwellers in cottage industries, participation in ecosystem management and other income producing activities. Initiating agroforestry activities on the Sundarbans boundaries would help to act as a buffer against forest encroachment. Badly depleted forest areas within the Sundarbans should be planted to appropriate mangrove species.

A note on the Indian Sundarbans is given in Appendix 8.

6.3 Village Homestead Forests

It is recommended that the forest development on village homesteads and FO land present the best possibility to increase both the area and the productivity of SW forests. Current productivity is about 15m^3/ ha /year. and could be increased to about 25m^3 /ha/year within 20 years on 0.1 million ha of homesteads. Additional planting would take place by expanding existing planting on FO land including crop field boundaries, in lieu of agricultural crops (especially bamboo) and agroforestry on embankments. The best means to achieve this would be through the DAE ,ADB /NGOs Upazilla project and the ADB coastal cyclone zone greenbelt projects. The latter should be approached to extend its mandate to include the coastal zone of the SW Area from Noakhali to the east boundary of the Sundarbans.

Future prefeasibility studies of water management structures should include a data base of the site's general index of vegetation quality, stream bank vegetation conditions (present or absent) and width of mud flats along embankments. This will be coordinated with RIMS of the Forestry Department for planning tree planting.

6.4 Coastal Plantations

It is recommended that an intensive review be made of the SW Area plantations with a view to rehabilitating them in the light of the changed land elevation due to siltation. Research and development should be speeded up to find the correct mangrove successional species to underplant or replace the pioneer species that are now deteriorating. Plans should be prepared to manage the plantations primarily as cyclone protection barriers but with a secondary wood production function which will not impair their primary use. Production could eventually supplement the industrial wood supply.

6.5 Wildlife Conservation

The recommendations made in the environment report submitted to preparation of the World Bank Forestry III project 1992 should be the basis of developing the conservation and wildlife sanctuaries of the Sundarbans. These are basically to extend the wildlife sanctuaries to cover the various ecosystem types not yet represented under the current situation. These include a new sanctuary on the north boundary of the Reserve (Figure 2.9) and cooperative wildlife development with the West Bengal Indian Sundarbans Wildlife Reserves and scientists. Other wetland wildlife areas in the SW Area should be considered for conservation in overall water management planning.

6.6 Coastal Area Resource Development and Management

The initiatives undertaken by the UN/ESCAP, UNDP and NGOs such as CARDMA in 1988, described in Section 4.8 above, on an integrated resource development and management of coastal areas should form the basis for all the above recommendations.

APPENDICES

APPENDIX 1

Total Supply of Biomass fuels in Bangladesh in 1981 in Peta Joule (10^{15} Joule)

Type of Fuels	Class of Land					Other Sources		Total	Percent
	Cropped area	Village forest	Forest	Fallow	Area not available for cultivation	Dung	Recycle Biogass		
Agri. Residues									
Plant Residues	212.41	-	-	3.79	-	-	25.78	241.98	50.49
Husk and Bran	56.91	-	-	-	-	-	-	56.91	11.87
Bagasse	19.16	-	-	-	-	-	-	19.16	4.00
Sub-Total	288.48	-	-	3.79	-	-	25.78	318.05	66.36
Wood Fuel									
Fuelwood	-	42.36	10.25	3.07	1.15	-	3.52	60.35	12.59
Twigs and Leaves	-	23.19	-	-	-	-	-	23.19	4.84
Sub-Total	-	65.55	10.25	3.07	1.15	-	3.52	83.54	17.43
Dung	-	-	-	-	-	77.72	-	77.72	16.21
Total Biomass	288.48	65.55	10.25	6.86	1.15	77.72	29.30	479.31	100.00
% of Total Biomass	60.19	13.68	2.14	1.43	0.24	16.21	6.11	100.00	
% of Total Land Area	58.83	2.10	15.33	5.73	18.01				

Source: GOB 1987

Total Energy Balance of Bangladesh in 1981 in Peta Joule (10^{15} Joule)

Description	Commercial Energy						Biomass Fuels					Total Energy
	Natural Gas	Crude Oil	Petroleum Products	Coal	Elect.	Total	Agri. Residues	Tree Residues	Fuel Wood	Dung	Total	
I SUPPLY												
Primary Production	49.4	-	-	-	2.3	51.7	317.3	23.6	60.0	77.7	478.6	530.3
Imports	-	54.0	21.4	6.0	-	81.4	-	-	-	-	-	81.4
Exports	-	-	-9.5	-	-	-9.5	-	-	-	-	-	-9.5
From Stock	-	0.3	3.0	-0.5	-	2.8	-	-	-	-	-	2.8
Total Primary Supply:	49.4	54.3	14.9	5.5	2.3	126.4	317.3	23.6	60.0	77.7	478.6	605.0
Percent of Total Energy Supply	8.2	9.0	2.5	0.9	0.4	21.0	52.4	3.9	9.9	12.8	79.1	100.0
II TRANSFORMATION												
Refinery	-	-54.3	51.9	-	-	-2.4	-	-	-	-	-	-2.4
Thermal Power Station	-18.3	-	-10.1	-	7.3	-21.1	-	-	-	-	-	-21.1
Losses and Own Use	-1.0	-	-2.4	-	-3.3	-6.7	-	-	-	-	-	-6.7
Total Final Supply:	30.1	-	54.3	5.5	6.3	96.2	317.3	23.6	60.0	77.7	478.6	571.8
III CONSUMPTION												
Domestic	3.5	-	16.2	-	1.1	20.8	241.6	23.6	41.3	77.7	384.2	405.0
Industrial	7.7	-	12.3	5.0	3.7	28.7	75.7	-	16.9	-	92.6	121.3
Commercial	1.5	-	-	-	1.2	2.7	-	-	1.8	-	1.8	4.5
Transport	-	-	20.8	0.5	-	21.3	-	-	-	-	-	21.3
Agriculture	-	-	1.4	-	0.1	1.5	-	-	-	-	-	1.5
Others	-		-	-	0.2	0.2	-	-	-	-	-	0.2
Non-Energy Use	17.4	-	3.6	-	-	21.0	-	-	-	-	-	21.0
Total Final Consump.	30.1	0	54.3	5.5	6.3	96.2	317.3	23.6	60.0	77.7	478.6	574.8
Percent of Total Energy Consumption	5.2	0	9.4	1.0	1.1	16.7	55.2	4.1	10.5	13.5	83.3	100.0

CONVERSION FACTORS			
Natural Gas	1 MMCF = 0.00099PJ	Electricity	1 GWh = 0.0036PJ
Crude Oil	1000 Tonne = 0.0427PJ	Agri. & Tree Res.	1000 tonne = 0.0125PJ
Petroleum Products	1000 Tonne = 0.0427PJ	Fuel Wood	1000 tonne = 0.0151PJ
(Average Coal	1000 Tonne = 0.027PJ	Dung	1000 tonne = 0.0116PJ

Source: GOB 1987

APPENDIX 2

Extract from Bangladesh Agroforestry Plan 1990 - 95 "An agenda for policy, research and action"

4 INSTITUTIONAL SETTING

4.1 Agroforestry Projects and Activities

A BARC-Winrock working paper on "Agroforestry in Bangladesh: synthesis of research and development efforts" (Lai 1990) described the current status of agroforestry work by 10 organisations or programmes. Five organisations (BARC, BARI, BFRI, BLRI and BAU) are involved in agroforestry research within the national FSRD network. The Forest Department is establishing agroforestry modules with landless families on denuded lands in the sal (Shorea robusta) forest zone. BRAC and Proshika are carrying out a number of homestead and roadside agroforestry projects, as are many NGOs. Through local NGOs in North Bengal, SDC is supporting agroforestry action research in farmers' fields. And a successful khas (Revenue Department) land agroforestry project is being implemented by formerly landless settlers in Betagi, near Chittagong.

Survey responses provided updated information on completed, ongoing and proposed projects, details of which are presented in Appendix IV. A brief synopsis of each responding organisation is presented below:

4.1.1 BARI

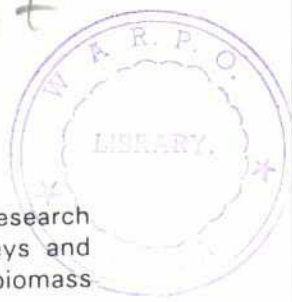
BARI, mainly through the On-Farm Research Division (OFRD) and FSR sites, has completed surveys and studies on: different homestead and crop-field agroforestry systems; household fuel situation; women's role in homestead production; bamboo supply, demand and cultivation; and economic and tenurial aspects of agroforestry.

Its ongoing agroforestry work focuses on testing of: fast-growing fruit trees and MPTS on homesteads at different FSR sites; border plantings of MPTS on the Barind tract; cropping patterns in agroforestry modules on forest land; fertiliser management for date palms; and tree-crop interactions in existing agroforestry systems. Proposed research projects will include experiments on: silvo-pastoral modules in existing jackfruit and shishu orchards in the High Ganges River Floodplain; optimum spacing of babla shishu and jackfruit on crop lands; and resource utilisation in Madhupur tract agroforestry systems.

4.1.2 BFRI

Among BFRI's list of ongoing projects, four have distinct agroforestry components. They are: (1) socioeconomic study on Betagi and Pomora community agroforestry project; (2) agroforestry research on forest and marginal lands: (3) FSR trials at BFRI Headquarters, Chittagong and Bandarban hills; and (4) underplanting of cane and medicinal plants in forest plantations.

Proposed projects include continuation of the above work as well as the following: surveys of traditional agroforestry systems and indigenous multipurpose trees and shrubs; socioeconomic analysis of agroforestry and farming systems; testing of tree management practices for sustained fodder and fuelwood production; development of suitable nursery and propagation techniques; and training and extension of bamboo and agroforestry technologies.



4.1.3 BAU

Agroforestry component research is carried out under BAU's Farming Systems Research and Development Programme (FSRDP). Completed projects include: tree surveys and monitoring on FSRDP sites; biomass fuel use monitoring; Leucaena fodder and biomass plantings; and Sesbania as a relay crop in aus rice systems.

Current work emphasises the above themes, and also: multilocation testing of Sesbania rostrata; pigeon pea hedgerows around banana orchards; and further MPTS testing. Proposed projects include a series of experiments utilising Sesbania in different cropping systems as well as spatial and temporal arrangements. Other future research interests include terrace planting of trees on homesteads in haors (low-lying, flood-prone areas), and seed collection from haor areas to select flood-resistant tree varieties.

4.1.4 IFCU

The Institute of Forestry at Chittagong University has no agroforestry project activity. However, agroforestry courses have been introduced in the syllabus, and some students are conducting review work on agroforestry-related topics.

4.1.5 ADAB

ADAB has completed a project in which they channeled funds from EZE (a German church-based organisation) to 18 NGOs in northern Bangladesh, and organised training on nursery development.

In the 1990-93 plan, ADAB proposes to organise an agroforestry/social forestry training course for 25 NGO participants each year, in collaboration with relevant government agencies and resource NGOs. A nursery development training course will be offered to 10 NGO participants each year. ADAB will also collaborate with World Food Programme and other donors to provide necessary nursery development inputs.

4.1.6 BRAC

BRAC's ongoing work features programmes in: nursery development, roadside plantation and agroforestry; homestead agroforestry; sericulture and ericulture; Leucaena plantings for fodder production; and agroforestry demonstration trials. Proposed projects include expansion of all the above programmes. The sericulture programme will be expanded to produce 20 metric tons of silk annually.

4.1.7 Proshika

To date, Proshika's social forestry and agroforestry programme has achieved the following: (1) established well over 200 km of roadside agroforestry; (2) collected over 1,200 kg of babla, pigeon pea, Sesbania and Leucaena seed for direct seeding and seedling production; (3) developed about 225 nurseries (over 50 financed with group members' own savings; and half of nurseries run by female groups) that produce about 2 million seedlings annually; (4) protecting over 1,400 acres of degraded sal forest areas; and (5) planted about 300,000 trees annually on homesteads.

Proshika proposes to expand these activities, and also enter into a collaborative arrangement with the Forest Department for agroforestry development on denuded sal

forest sites, where Proshika staff have identified about 200 acres of potentially suitable sites.

4.1.8 CARE-International

In the CARE LIFT (Local Initiatives for Farmer Training) programme, an agroforestry component has been recently introduced to complement the bio-intensive gardening (BIG) technology by emphasising nitrogen-fixing trees (for green manure), live fencing and improved management of homestead trees. The ongoing pilot demonstrations are located at LIFT sites in Kishoreganj Upazila (Nilphamari District) and Kasba Upazila (Brahmanbaria District). Training is provided to CARE and DAE staff, and to participating farmers. Once the agroforestry component is well developed, it will be fully integrated into the LIFT programme. Proposed expansion areas include Greater Noakhali and Patuakhali Districts.

4.1.9 Ford Foundation

As a donor organisation, the Ford Foundation currently supports the Proshika social forestry and agroforestry programme. Future project support includes the Forest Department pilot agroforestry project in the Dhaka-Tangail-Mymensingh sal forest zone, where 300 acres of experimental agroforestry systems will be established with the participation of organised groups. Ford Foundation also wishes to support the development of agroforestry research and training.

4.1.10 Bangladesh Tobacco Company (BTC) in GK project

The consultants visited the plantations undertaken by landless persons, promoted by the BTC along canal banks of the GK irrigation project Kushtia, in southwest region. See main text para 5.11.

PRO-FORMA BENEFIT SHARING AGREEMENTS
MEMORANDUM OF UNDERSTANDING

BETWEEN

FOREST DEPARTMENT AND ROADS AND HIGHWAYS DEPARTMENT

Memorandum of Understanding (MOU) between the Roads and Highways Department (RHD) and the Forest Department (FD), Government of the People's Republic of Bangladesh, for raising tree plantation along the roads and highways, its protection, maintenance and disposal of the produce.

1. This MOU shall take effect from the ..... 198.. and will remain in force till the RHD requires the land or a portion therefrom for its own use.

2. RHD agrees to allow FD for productive use of the land through induction of a especially trained target group/groups selected by FD. The cropping pattern should contribute towards stabilization of the slopes and beautification of roads.

3. RHD agrees not to charge any rent FD for using the land.

4. If RHD needs any of the land put under use by FD, RHD should give a month's notice to FD to facilitate disposal of produces already grown and compensate the inducted target groups at a rate to be decided jointly by RHD, FD and the inducted target group, provided such land is required before the seventh year of its formation.

5. FD shall have the full right to use the land on existing flat bottom (including burrow pits), road slopes for raising crops as agreed earlier.

6. FD shall take due care not to damage the land in any way but any avoidable damage caused shall be repaired by FD. FD shall, however, not be responsible for any damages due to force majeure (like natural calamity or civil commotion).

7. FD shall avoid planting on the inner side of the curve of road; on the approaches of bridges and near railway level crossings.

8. FD under intimation to RHD, may construct temporary huts, where necessary, for temporary accommodation of staff or member of target group (not family accommodation) engaged for plantation and protection works. These huts should never be constructed on the verge of the road.

9. RHD may extend its cooperation to protect the plantation.

In the event of any wilful damage to plantations caused by anybody, the inducted target group shall have the right to seek assistance of law-enforcing agencies and FD may render assistance to the target group to obtain such assistance.

10. RHD agrees not to lease to any person or agencies the land handed over to FD without FD's consent.

11. RHD will make available to FD a detailed mileage of roads indicating their names for a seven-year period, hand over targeted section one year ahead of raising plantations.

12. FD shall be allowed to collect earth from nearby burrow pits for construction of huts and for filling up rat-holes to protect the trees and slopes as and when necessary.

13. FD shall be responsible for repairing rat-holes periodically, especially before the rainy season and in raising of intercrops, will ensure that no damage is done to the embankment in any way by the target group.

If any damage is caused to the embankment by anybody other than the members of the target group and FD, the same should at once be reported to RHD or to the nearest police station.

14. The target group will be permitted to collect free of charge all intermediate products; when the crops are finally harvested the produce will be distributed in the proportion of 10 per cent to RHD, 5 per cent to the Union Parishad, 65 per cent to the target group and the remaining 20 per cent will be retained by FD towards the partial recovery of plantation formation cost.

15. The crops -- short-term, mid-term and long-term -- to be grown on RHD land by the target group must be agreed upon by all parties and must not cause any damage to the roadsides and its berm-slopes.

16. The rotation of the fuelwood trees is expected to be 5-7 years and that of timber and fruit trees 30-40 years. After the first rotation of seven years, the area shall again be planted up by FD if mutually agreed and the process will continue.

In the event of RHD requiring the land at the end of seven years or desiring the retention of any trees, the value of the same will be calculated on the basis of market price and the same distributed in the proportion indicated in item no. 14.

17. RHD and FD will execute this MOU.

18. The terms and conditions of this Memorandum of Understanding can be altered/modified by mutual discussion between RHD and FD.

AGREEMENT BETWEEN WATER DEVELOPMENT BOARD AND THE FOREST DEPARTMENT, GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH FOR RAISING PLANTATION, PROTECTION AND MAINTENANCE AND DISPOSAL OF PRODUCTS

This Deed of Agreement for raising plantations and intercropping, its maintenance, protection and disposal, made on the ..... day of ..... 198...

BETWEEN

The Water Development Board, a body corporate -- established under the Bangladesh Water and Power Development Board Order, 1972 (PO No. 59 of 1972), hereinafter called the 1st Party

AND

The Government of the People's Republic of Bangladesh, acting through its Forest Department, hereinafter called the 2nd Party.

Whereas the 1st Party is the sole owner of the land situated on both sides of Water Development Board embankment and Road as described in the schedule;

Whereas the 1st Party has agreed to allow the 2nd Party for productive use of the land through induction of a especially trained target group/groups selected by the 2nd Party; the cropping pattern should be as per agreement reached between the 1st Party and the 2nd Party and which shall contribute towards stabilization of the embankment;

And whereas the 1st Party has agreed not to take any rent from the 2nd Party for using the land;

NOW, THEREFORE, the Parties hereby agree to conclude this Agreement on the terms and conditions hereinafter contained.

1. This Agreement shall take effect from the ..... 198.. and shall remain in force till the 1st Party requires the land or a portion therefrom for its own use.

2. If the 1st party needs any of the land put under use by the 2nd Party, the 1st Party should give a month's notice to the 2nd Party to facilitate disposal of produces already grown and compensate the inducted target group at a rate to be decided jointly by the 1st Party, the 2nd Party and the inducted target group, provided such land is required before the seventh year of its formation.

3. The 2nd Party shall have the full right to use the land on existing flat bottom, slopes of embankments for raising crops as agreed earlier.

4. The 2nd Party shall take due care not to damage the land in any way but any avoidable damage caused to the embankment shall be repaired by the 2nd Party. The 2nd Party shall however not be responsible for any damages due to force majeure (like natural calamity or civil commotion).

The 1st Party will permit the use of any vacant available accommodation but if such accommodation is needed or is not available, the 1st Party will permit the 2nd party to construct temporary huts on the innerside of the embankment in such manner which will not cause any damage to the embankment.

6. The 1st Party may extend its cooperation to protect the plantation.

In the event of any wilful damage to plantations caused by anybody, the inducted group will have the right to seek assistance of law-enforcing agencies and the 2nd Party may render assistance to the target group to obtain such assistance.

7. The 1st Party agrees not to lease to any persons or agencies the land handed over to the 2nd Party without the 2nd Party's consent during the ..... of the Agreement.

8. The 1st Party will make available to the 2nd Party a detailed schedule of embankments for a seven-year period and hand over annual sections a year in advance of the plantation program.

9. The 2nd Party is allowed to collect earth from nearby burrow pits for constructing huts and for filling up holes to protect the trees and the embankment as and when necessary.

10. The 2nd Party will be responsible for repairing of rat holes and crab holes periodically, especially before the rainy season and in raising of intercrops, will ensure that no damage is done to the embankment in any way by the target group.

If any damage is caused to the embankment by anybody other than the members of the target group and the 2nd Party, the same should at once be reported to the 1st Party or to the nearest police station.

11. The target group will be permitted to collect free of charge all intermediate products, such as vegetables, fruits, grasses, intercrops, fuelwood and pulse from Arhar raised as live-hedge. When the crops are harvested, the produce will be distributed by the 2nd Party in the proportion of 10 per cent to the 1st Party, 5 per cent to the Union Parishad, 65 per cent to the target group and the remaining 20 per cent will be retained by the 2nd Party towards the partial recovery of plantation formation cost.

12. The rotation of the fuelwood trees is expected to be 5-7 years and that of timber and fruit trees 30-40 years. After the first rotation of seven years, the area shall again be planted by the 2nd Party if mutually agreed and the process will continue.

In the event of the 1st Party requiring the land at the 3nd of seven years or desiring the retention of any trees, the value of the same will be calculated on the basis of market price and the same distributed in the proportion indicated in clause II.

3. The 2nd Party shall grow:

(a) Ipil Ipil, Date Palm, Sisso, Australian Acacia, Koroi, on the outside slope and berm of irrigation canal banks;

(b) Dhaincha, Hijal, Mandar, Murta and Ipomea in the burrow pits of flood embankments;

(c) Sisso, Date Palm, Koroi, Koroch, Hijal, Mandar, Acacia auriculiformis, Murta, Ipomea on the berms of the countryside and the riverside of flood embankments; and

(d) embankment crest width and slopes of irrigation canal banks shall not be available for plantation of trees.

IN WITNESS WHEREOF, the Parties hereto have their respective hands and seals hereunder on the date and year first above written.

Signature of Witnesses

_____ Signature of 1st Party
Witness of 1st Party

_____ Signature of 2nd Party
Witness of 2nd Party

Table 1: Financial and Economic Prices Used in the Appraisal

			FUELWOOD				POLES/SMALL LOGS		
			Financial Prices	Conv. Factor e/	Economic Prices		Financial Prices		Economic Prices
Retail prices a/		Tk/md g/	38.1 b/			Tk/rft g/	14.2		
Minus: cost of splitting			3.1	0.75	2.3	handling	3.0		2.2
profit			3.8	0.80	3.0		1.3		1.0
Depot price			31.2		32.8		9.9		11.0
Minus: cost of transport farmgate - depot			6.6	1.2	7.9		2.1		2.5
felling, cross-cutting			6.2	0.75	4.6		2.0		1.5
handling			1.8	0.75	1.3		1.0		0.7
Farmgate price	1988	(Tk/md)	16.6		19.0	1988 (Tk/rft)	4.8		6.3
				0.80	15.2			0.80	5.0
	1995	c/(Tk/md)	17.2		15.9	1995 f/ (Tk/rft)	5.3		5.5
	1995	(Tk/cu m)	344.0 d/		318.0	1995 (Tk/cu m)	1,892.0		1,941.0

a/ All prices are averages based on observations at four project locations (Dinajpur, Dhaka, Mymensingh and Faridpur/Barisal) and are those during 1988.

b/ Price of split fuelwood.

c/ Assuming 0.5% p.a. price increase between 1988 and 1995.

d/ Assuming specific gravity of (solid) fuelwood of 0.75.

e/ Specific conversion factors were 0.75 for unskilled labor and 1.1 for transport. SCF = 0.8

f/ Assuming 1.0 per cent p.a. price increase between 1988 and 1995.

g/ Conversion factors:
1 maund (md) = 37.3 kg = 1.56 cu ft (cft) (sp. gr. 0.85)
1 cft (sawlogs, poles) = 0.028 cu m = 0.64 md (sp. gr. 0.85) = 0.024 mt
1 cft fuelwood (solid) = 0.028 cu m = 0.56 md (sp. gr. 0.75) = 0.021 mt
1 running foot (rft) = 0.1 cft = 2.4 kg (p.gr. 0.85)

h/ same conversion factors assumed in e/

Table 1 (continued): Financial and Economic Prices Used in the Appraisal

SAWLOGS			Financial Prices	Conversion Factor	Economic Prices
Retail price of sawwood a/ b/		Tk/cft e/	167		
minus cost of sawing			7	0.8	6
handling			3	0.75	2
profit			19	0.8	15
Depot price of sawwood			138		144
Depot price of sawlogs c/			107		109
		Tk/cu m	3,777		3,848
minus 20% quality discount			755		770
cost of transport farmgate to mill			208	1.2	250
felling/crosscutting			151	0.75	113
handling			45	0.75	34
Farmgate price of sawlogs	1988	(Tk/cu m)	2,616		2,681
				0.8	2,145
	1995 d/	(Tk/cu m)	2,880		2,359

Other Prices (Tk)

Product	Unit	Financial Prices	Economic Prices (1995)
Bamboo	(piece)	22	17.6
Pigeon pea sticks	(mt)	132	106.0
Sesbania (as fuel)	(cu m)	55	44.0
Fodder	(mt)	330	264.0
Fruit (mango equivalent)	(mt)	3,300	2,640.0
Lentils	(kg)	5.5	4.4
Groundnut	(kg)	10	8.0
Pigeon pea	(kg)	4	3.2
Mustard	(kg)	10	8.0
Sugar cane	(mt)	550	440.0
Inputs			
DAP fertilizer	(kg)	6	9
Urea	(kg)	5	7
TSP	(kg)	5	6
MP	(kg)	4	5
bullock hire	per day	27	30

a/ All prices are averages based on observations at four project locations (Dinajpur, Dhaka, Mymensingh and Faridpur/Barisal and are those of 1988).
b/ Assuming 40/34/25 division of output among species group I (e.g. jackfruit, mahogany), group II (e.g. neem, Acacia lebbek) and group III (e.g. mango).
c/ Assuming 65/35 division between sawwood and milling waste (sold as fuelwood).
d/ Assuming 1.0 per cent p.a. price increase between 1988 and 1995.
e/ See previous page for conversion factors.

Table 2: Derivation of Economic Price of Fuelwood
By Reference to Kerosene Prices

		Middle of 1988 a/		1995 b/
Kerosene, FOB Singapore	US$/mt	137 a/	US$/mt	186
Freight, insurance (Singapore-Chittagong)		16		16
Landed price, Chittagong		153		202
Handling, distribution to Project locations, profit		28		28
Ec. price of kerosene	US$/mt	181	US$/mt	230
Taka equivalent	Tk/mt	5,701	Tk/mt	7,245
	or Tk/kg	5.7	Tk/kg	7.2

Conversion factors assumed:
1 kg of kerosene = 10,000 kcal
1 kg of fuelwood = 3,500 kcal
Thermal efficiency of kerosene: 40%
Thermal efficiency of fuelwood: 10%

Economic value of fuelwood if fuelwood perfectly substitutable for kerosene:	Tk 0.47/kg c/	Tk 0.60/kg
	or Tk 353/cu m e/	Tk 449/cu m
[Economic prices in the appraisal d/]	[Tk 310/cu m]	[Tk 318/cu m]

a/ Source: Petroleum Economist, September 1988 (US$ 0.445/US gallon)
b/ Projections based on World Bank (January 1988) Price Forecasts. Kerosene prices assumed to exactly parallel those of crude.
c/ Equal to $53.6 \times (\frac{10}{40} \times \frac{3,500}{10,000})$
d/ Derived from financial prices using conversion factors (see Appendix 12, Table 1).
e/ Assuming specific gravity of fuelwood of 0.75.

Location:	Dinajpur			Dhaka			Mymensigh		Faridpur/Barisal		Other economic farmgate prices:	Unit:	Fin. prices Tk/unit:	Ec. prices Tk/unit
	fuelwood	Poles	Sawlogs	fuelwood	Poles	Sawlogs	fuelwood	fuelwood	Poles	Sawlogs				
Retail prices	Tk/md:			Tk/md:			Tk/md:	Tk/md:						
Selling price c)	35			47			40	[illegible]			Bamboo	piece	22	17.6
minus econ.cost of:											Pig.pea sticks	mt	132	105.6
transp. farmg.to outlet	8.40			9.60			7.20	[illegible]			Sesbania fuelwood	cu m	55	44.0
splitting	2.00			3.00			2.25	[illegible]			Fodder	kg	0.33	0.3
profit (10% sell.price)	2.80			3.76			3.20	[illegible]			Fruit (mango equiv.)	kg	3.3	2.6
sub-total	21.80			30.64			27.35	[illegible]						
Wholesale/mill operator		Tk/rft:	Tk/cft:		Tk/rft:	Tk/cft:			Tk/rft:	Tk/cft:	Lentils	kg	5.5	4.4
Selling price		13	165		16	208			13	160	Groundnut	kg	10	8.0
minus econ.cost of:											Pigeon pea	kg	4	3.2
handling		1.50	2.25		3.75	2.25			1.50	2.25	Mustard	kg	10	8.0
splitting/sawing			5.25			6.00				5.25	Sugarcane	kg	0.55	0.44
profit (10% sell.price)		1.04	13.20		1.44	16.60			1.04	12.80				
sub-total		10.46	144.30		12.81	182.65			10.46	139.70				
			sawlogs:			sawlogs:				sawlogs:				
			Tk/md:			Tk/md:				Tk/md:				
			168			214				164				
minus econ.cost of:														
transp. farmg. to mill		2	10		2.4	13.2			2.4	9.6				
handling	1.5	1	1.5	1.5	0.75	1.5	1.5	[illegible]	0.75	1.5				
felling,crosscutting	4.5	2	4.5	5.25	1.5	6	4.5	[illegible]	1.5	4.5				
		5			7				5					
Farmgate econ.prices:														
(end of 1988)	Tk/md	13	64	122	19	82	155	17	[illegible]	58	118			
SCF = 0.8	Tk/cu m	250	1448	2748	378	1844	3496	338	[illegible]	1313	2675			
	Tk/cft	7	41	78	11	52	99	10	[illegible]	37	76			
	$/cu m	8	47	89	12	59	113	11	[illegible]	42	86			
Farmgate econ.prices:														
(1995)	Tk/cu m	262	1578	2995	397	2009	3811	355	[illegible]	1431	2915			

Notes: a) weighted average of different species and grades, assuming a 70:30 division b.sawwood and milling waste (sold as fuelwood)

sawwood type:	% output	Dinajpur	Dhaka	Far./Bar.	Average
jackfruit,mahog.	50	200	250	190	213
neem, Ac.lebbek	25	150	190	150	163
mango	25	110	140	110	120
w.average (sawnw.only)		165	208	160	178
w.average (incl.waste)		126	159	124	136

Conversion factors:
1 maund (md) = 37.3 kg = 1.56 cu ft (cft) (sp.gr.0.85)
1 cft (saulogs,poles) = 0.028 cu m = 0.64 md (sp.gr. 0.85) = 0.024 mt
1 cft fuelwood (solid) = 0.028 cu m = 0.56 md (sp.gr. 0.75) = 0.021 mt
1 running foot (rft) = 0.1 cft =

b) project sawlogs are assumed to command 80% of the price of corresponding species supplied by the private market on account of quality differences.

c) following conversion factors used to derive economic prices:
transport: 1.2 handling,splitting,etc.: 0.75 SCF : 0.8

APPENDIX 4

Area of Coastal Mangrove Plantations in the Southwest Region of Bangladesh 1966-1992

Project Title		Bhola (Barisal)	Patuakhali	Total
Coastal afforestation project (CAP)	1966/67		339.3	339.3
	1967/68	106.7	344.1	450.8
	1968/69	151.8	293.5	445.3
	1969/70	91.1	323.9	415.0
	1970/71			
	1971/72	36.4		36.4
	1972/73	4.0		4.0
	1793/74	66.8		66.8
	1974/75	427.1	494.0	921.1
	1975/76	844.9	1183.3	2028.2
	1976/77	1034.8	876.5	1911.3
	1977/78	850.2	506.1	1356.3
	1978/79	1542.2	1332.1	2874.3
	1979/80	1283.4	1230.8	2514.2
	subtotal	6439.4	6923.6	13363.0
Mangrove afforestation project (MAP)	1980/81	1735.6	1022.3	2757.9
	1981/82	1619.4	1012.1	2631.5
	1982/83	2024.3	1255.0	3279.3
	1983/84	3036.4	1012.1	4048.5
	1984/85	2595.1	1255.0	3850.1
	subtotal	11010.8	5556.5	16567.3
Forestry II project Mangrove afforestation component (MAC)	1985/86	830.0	1214.5	2044.5
	1986/87	1214.5	1214.5	2429.0
	1987/88	2526.3	1012.0	3538.3
	1988/89	809.7	566.8	1376.5
	1989/90	1012.1	647.8	1659.9
	1990/91	404.9	688.3	1093.2
	1991/92 target	810.1	409.7	1219.8
	subtotal	7607.6	5753.6	13361.2

Source: FD 1987 and Consultant's assessment during field visit (1992).

APPENDIX 5

Optimum economic model of homestead agroforestry for different farm categories at Chuadanga

Parameters	Landless	Marginal	Small	Medium	Large	Average
1. Objective	Maximum profile					
2. Constraints						
a) Land availability (ha)	0.061	0.049	0.029	0.145	0.175	0.070
b) Capital availability (Tk)	275	811	854	1197	2397	1011
c) Minimum fruit requirement (q)	0.168	0.051	0.017	0.069	0.048	0.035
d) Minimum fuel requirement (q)	0.683	0.726	0.235	0.980	0.689	0.490
e) Minimum fodder requirement (q)	0.237	0.220	0.119	0.569	0.316	0.197
f) Minimum timber requirement (q)	0.298	0.081	0.026	0.109	0.077	0.054
3. Optimum model						
a) First option (without bias)						
i) Specified Trees and numbers						
Mango	-	-	-	-	-	-
Jackfruit	5	-	-	1	-	-
Coconut	-	-	-	-	-	-
Betelnut	-	42	62	-	91	43
Lemon	-	-	-	-	-	-
Guava	-	-	-	-	-	-
Date palm	-	-	-	-	-	-
Shishu	15	18	1	84	83	31
Babla	-	1	1	3	2	1
ii) Net profit (Tk)	5738	6591	4632	17309	23254	9301
b) Second option (Farmers' choice)						
i) Specified Trees and numbers						
Mango	1	1	1	1	1	1
Jackfruit	4	1	1	1	1	1
Coconut	1	1	1	1	1	1
Betelnut	-	5	5	5	5	5
Lemon	-	1	1	1	1	1
Guava	-	1	1	1	1	1
Date palm	-	15	6	2	32	13
Mahogany	-	-	-	1	1	-
Shishu	13	7	-	69	72	21
Babla	-	1	-	2	1	-
ii) Net profit (Tk)	5456	5195	2625	16200	20726	8508

Extract from "Optimisation of Agroforestry Systems in Bangladesh at Household and National Levels". On Farm Research Division, Bangladesh Agricultural Research Institute (BARI) and Swiss Development Corporation, September 1990.

APPENDIX 6

Bangladesh Foreign Aided Forestry Projects

Project No.	Title	$ millions	Duration Years	Actual start/ finishing date	Foreign funding agency
BGD/81/028 BGD/84/054	Community forestry NW Upazilla Afforestation and nursery project	44.9 1.9	5	1982 - 87 1990	AsDB UNDP FAO
Forestry I	Assistance to the Forestry Sector	11.0	5.5	1980 - 85	World Bank (IDA)
Forestry II	Assistance to the Forestry Sector	28.0 10.6	6	1986 - 91	World Bank (IDA) UNDP FAO
Forestry III	Assistance to the Forestry Sector	49.6	8	1992	World Bank (IDA)
AsDB	Afforestation and Resettlement in USF Chittagong hill tracts	1.8	10	1979 - 89	AsDB
BGD/79/017	Inventory of the Chittagong hill tracts	2.7	4	1981 - 85	UNDP FAO
ODA	Inventory of the Sundarbans tidal forests	1.0	3	1982 - 84	Overseas Development Administration (UK)
SIDA BGD/81/020	Forestry Development Training Centre Kaptai	- 1.9	4 4	1977 - 81 1982 - 86	SIDA UNDP FAO
BGD/78/020	Village Forests inventory	0.7	1	1984	UNDP FAO
BGD/83/010	Assistance to 2nd Agricultural Research	2.2	5	1985 - 90	UNDP FAO
BGD/84/046	Tree planting Bangladesh Mosque Society	0.2	2	1985	FAO
RAS/86/120	Research Application to Management Mangroves Asia Pacific	1.2	3	1987	UNDP UNESCO
RAS/86/048	Forest Industries Development Group	2.4	3.5	1987 - 92	UNDP FAO
BGD/88/022	Coastal Areas Research Management Planning	0.2	?	1988	UNDP FAO SMF LDC
BGD/88/025	Forestry Master Plan	0.8	1	1992	UNDP
GCP/RAS/131/ NET	Regional Wood Energy Development	?	?	?	FAO NETH Development
RAS/89/?	Sea level rise Coastal zone management	?	?	?	UNESCO
ODA/EEC	Rehabilitation tea gardens and factories	35.0 + TA	?	?	ODA EEC
NTFAP	Formulation of National TFAP	?	< 1	?	FAO
FORD FDN	Agroforestry Research and Demonstration	0.2	?	?	FORD Foundation
National Conservation	National Conservation Strategy	?	?	?	?
Comprehensive energy	Energy Plan	2.1	?	?	?

APPENDIX 7

Sundarbans Flora

Prain 1903 reported 334 species from the Sundarbans and the adjacent area and suggested at least 58 of these are sea introduced species. Since then no systematic account of the Sundarbans flora has been done. Chaffey and Sandom (ODA Inventory of the Sundarbans 1985) collected 67 macrophytic species from the Sundarbans, of which Karim 1988 encountered 34 species as common for the Sundarbans forest.

Out of the 20 cosmopolitan mangrove genera, the present Sundarbans flora is represented by 14 genera. This includes 13 major species in 8 genera and 8 minor species in 6 genera. Since the limits of the back mangal (back swamp) are imprecise and no taxonomic survey has been made in recent times it is difficult to include a comprehensive list of all plants that might be encountered. Below is a list of macrophytic plant species collected from the forest during 1982 - 84 ODA survey. It includes 17 species out of 60 cosmopolitan mangrove associate species in addition to the mangrove elements.

LOCAL NAME	SCIENTIFIC NAME
Abetaa	Flagellaria indica L.
Achet	Drypetes sp.
Agusha	Hoya sp.
Amur	Hoya sp.
Baen	Amoora cucullata Roxb.
Ban jam	Avicennia officinalis L.
Bari a ghash	Eugenia fruticosa Roxb.
Batla, batul	Blumea sp.
Batla, bharal	Excoecaria indica (Willd). Muell. Arg., syn. Sapium indicum Wild.
Bhaela, bharal	Intsia bijuga (Colebr.) O. Kuntze, syn. Afzelia bijuga A. Gray
Bhola	Hibiscus tiliaceus L.
Bon bakul	Ixora sp.
Bon ghash	Blumea sp.
Bon lichu	Lepisanthes rubiginosa (Roxb.) Leerh.
Bon notoy	Mallotus repandus (Will.) Muell. Arg.
Bowali lota	Sarcolobus globosus Wall.
Chanda katta	Dalbergia spinosa Roxb.

Chanda lota	Dalbergia candenatensis Prain
Choyt barai	Salacia chinensis L.
Choyla	Sonneratia caseolaria (L.) Englet, syn. S. acida L.
Dagor	Cerbera manghas L., syn C. odolam Gaertn.
Deki lota	Stenochlaena palustris (Burm.f.) Bedd., syn. Acrostichum scandens L.
Dhalchaka	Aegialitis rotundifolia Roxb.
Dhanshi	Myriostachya wightiana (Nees ex Steud.) Hook. f.
Dhundul	Xylocarpus granatum Koenig, syn. Carapa obovata Bl.
Doyal	Mucuna gigantea (Willd.) DC.
Gab	Disopyros peregrina Guerke, syn. D. embryopteris Pers.
Garjan	Rhizophora mucronata Lam.
Gewa	Excoecaria agallocha L.
Gila lota	Derris trifoliata Lour., syn. D. uliginosa Benth.
Golgoti lota	Tetrastigma? bracteolatum Planch.
Golpatta	Nypa fruticans Wurmb.
Goran	Ceriops decandra (Griff.) Ding Hou, syn. C. roxburghiana Arn.
Gura, gurae, gural	Kandelia candel (L.) Druce
Gwalae lota	Derris trifoliata Lour., syn. D. uliginosa Benth.
Hantal	Phoenix paludosa Roxb.
Hargoza	Acanthus ilicifolius L.
Hingal	Aglaia sp.
Hoda, hodo	Acrostichum aureum L.
Jam, jam gash	Eugenia fruticosa Roxb.
Jermani lota	Thunbergia sp.
Jhanna	Rhizophora mucronata Lam.
Jhao	Tamarix indica Willd.

Jir	Ficus sp.
Kali lota	Derris trifoliata Lour., syn. D. uliginosa Benth.
Kankra	Bruguiera gymnorhiza (L.) Lam.
Karanj, karanja	Pongamia pinnata (L.) Lam.
Keora	Sonneratia apetala Buch. - Ham.
Kewa katta	Pandanus foetidus Roxb.
Khalisha, khalshi, khulsha	Aegiceras corniculatum (L.) Blanco. syn.
Kirpa, kripa	Lumnitzera racemosa Willd.
Kucha	Cyperus javanicus Houtt., syn. Mariscus albescens Goud.
Kumb, kumba, kumbi	Barringtonia racemosa (L.) Spreng.
Kusha	Cyperus javanicus Houtt., syn. Mariscus albescens Gaud.
Kutum katta	Caesalpinia crista L.
Lota sundri	Brownlowia tersa (L.) Kost., syn. B. lanceolata Benth.
Narikili	Petunga roxburghii DC.
Nol gash	Eriochloa procera (Retx) C.E. Hubb.
Nol kagra	Phragmites karka (Retz) Trin. ex Steud.
Nona jhao	Tamarix indica Willd.
Ora	Sonneratia caseolaris (L.) Engler syn. S. acida L.
Passur	Xylocarpus mekongensis Pierre, syn. Carapa moluccensis Lam. var. gangetica Prain
Porgassa	?Dentrophthoe falcata (L.f.) Dans. Macrosolen cochinchinensis (Lour.) van Teigh.
Sadda baen	Avicennia alba Bl. or A. ?marina (Forssk.) Vierh.
Serpoli, setpoli	Premna ?corymbosa Rottler
Shamu lota	Viscum monicum Roxb. ex DC.
Shingra	Cynometra ramiflora L., syn. C. mimusoides Wall.
Sitka, sitki	Clerodendrum inerme (L.) Gaertn. and/or Flueggia virosa (Roxb.) Baill.

Soyla	Sonneratia caseolaris (L.) Engler syn. S. acida
Sundri	Heritiera fomes Buch. - Ham.
Sundri lota	Brownlowia tersa (L.) Kost., syn. B. labceolata Benth.
Tiger fern	Acrostichum aureum L.
White baen	Avicennia alba Bl. or A. ?marina (Forssk.) Vierh.

APPENDIX 8

Indian Sundarbans

The Bangladesh Sundarbans should not be considered in isolation as it is bounded on the western side by a continuation of the natural mangrove forest in the Indian or West Bengal Sundarbans (see Figure 2.10). Both forests were at one time under a single management system, but separated in 1947. Much may be learnt from activities on the Indian side where the forest has been more degraded than in Bangladesh but where rehabilitation and people's participation in management of the resource is probably more advanced.

The Indian Government set up the Sundarbans Biosphere Reserve in 1989 to contain 9630 km² of coastal area including 2.4 million people of which 0.3 million are on the forest fringe. The area is divided into two main parts - reclaimed land with embankments (Sundarbans Development Board) and the mangrove forest plus water bodies of 4262 km² to seaward. The forest area east of the Matla river up to the Bangladesh border is under the Tiger Project Division (core 1330 km², buffer 892 km², and sanctuary 362 km²) and the forest to the west of the river is administered by the 24 Parganas Forest Division.

Tidal amplitude is 2.1 m and on average 35% of the area is submerged in the intertidal zone. Rainfall is between 1640 and 2000 mm between June and September. Reclaimed areas produce only one low yielding paddy crop as pump irrigation is ineffective due to high saline water table (4m). Shallow canals are dug to store fresh water in the wet season for use in the dry season. As on the Bangladesh side, local people depend for much of their income on fishing, aquaculture, honey and wax collection and wood cutting. Post larval tiger prawn seed collection is an important business especially in the closed Tiger Reserve area. Forest closure has resulted in increased production of shrimp seed.

The core area of the Tiger Reserve is totally closed to entry while "pass through" is allowed in the sanctuary. The buffer area is worked on a 15 year coppice rotation and the 24 Parganas (more degraded) on a 20 year rotation. Each year 1000 ha of buffer and 1300 ha of Parganas are felled for coppice apart from standards of some species and seed bearers. Only trees over 5 cm are cut. Any licensee disobeying the rules of the Forest management risks losing his cutting licence for the following year. Honey collection is about 50 tonnes/year.

The traditional method for regenerating degraded mangroves is closure. In 1990 the Forest Department began afforestation of blank forest areas and new mud flats with manual planting and aerial seeding. The annual programme is 1000 ha. Pilot efforts to form forest protection committees in villages adjacent to the forest has begun to obtain cooperation of the local people in management and income sharing opportunities.

The Sundarbans Development Board (SDB) has since 1973 assisted in developing agriculture in the reclaimed areas. Between 1973 and 1981 the Board developed an engineering wing, a fisheries wing and a social forestry wing. IFAD funded a 5 year project to support this integrated development from 1985 - 1989. The social forestry wing has been planting embankments which are generally of 50 - 100m bank width. Some 1500 ha have been planted out of a proposed programme of 3500 km (35,000 ha). The mangroves planted on the embankments help stabilise the embankments which otherwise have to be repaired every 15 days. Embankments are controlled by the Irrigation Department. The produce from afforestation would be shared with local people.

Tiger project has been operating for 11 years and includes various components directed towards the forest fringe population, including construction of wells, apiculture and shrimp culture. Response from villagers has been good and they are better disposed towards tigers when they see some benefits accruing to themselves. The scheme will be extended to the 24 Parganas.

Sundarbans Forest staff are 400 of which 170 are officers and the rest boatmen and supporting staff.

An Action Plan for the Biosphere Reserve including mangrove afforestation research, socio-economic development, and a marine national park has been formulated and will be funded by a $10.9 million grant from GOI.

Navigation

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SOUTHWEST AREA WATER RESOURCES MANAGEMENT PROJECT (FAP-4)

NAVIGATION

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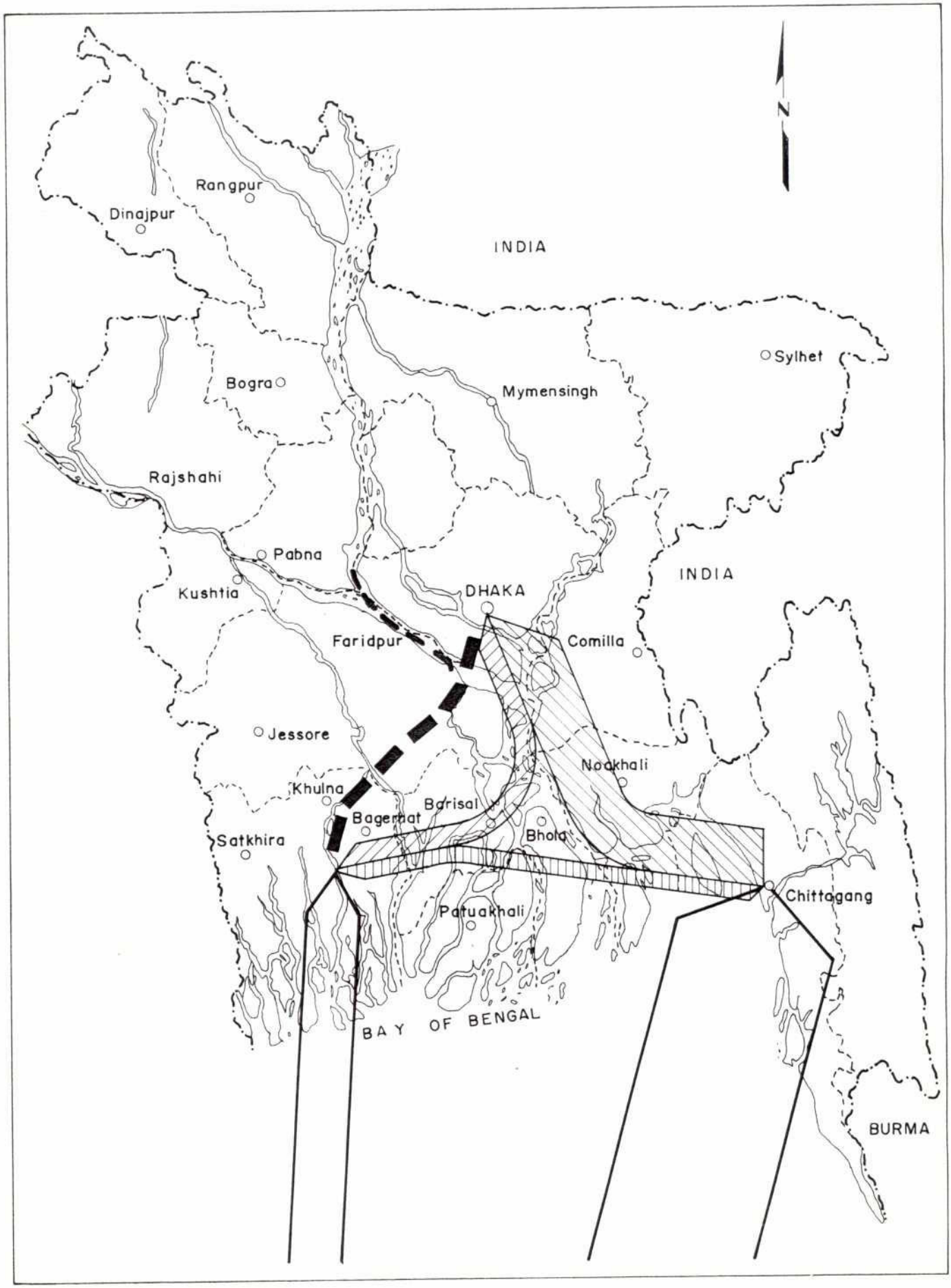
ACRONYMS AND ABBREVIATIONS

BIWTC	Bangladesh Inland Water Transport Corporation
BIWTA	Bangladesh Inland Water Transport Authority
BIWTMAS	Bangladesh Inland Water Transport Master Plan Study
BTS	Bangladesh Transport Survey
BWDB	Bangladesh Water Development Board
CD	Chart Datum
CEP	Coastal Embankment Project
DHI	Danish Hydraulic Institute
ESCAP	Economic and Social Council for Asia and Pacific
GK Project	Ganges-Kobadak Project
LADW	Least Water Depth on Water
MPO	Master Plan Organisation
NORAD	Norwegian Agency for Development Corporation
NPV	Net Present Value
NW	North West
POL	Petroleum Oil and Lubricants
R&H	Roads and Highways
RK	Mr. R. Kvam
SLW	Standard Low Water
SWA	Southwest Area
UNDP	United Nations Development Programme
USD	United States Dollar
WB	World Bank

Figure 1.1



Project Area

1 INTRODUCTION

The Terms of Reference require to examine and assess the medium and long-term resources potential and constraint of the multi-sectoral harvesting activities including navigation within the context of the changing and variable resources setting of the region. The navigation study was conducted largely during August and September 1992 as part of the sectoral studies.

In this study inland water transport is considered as an economic activity together with other activities like fisheries and forestry in formulating the development and management plan where land and water resources are the critical elements and agricultural growth the main indicator. At the same time possible impacts on the delicate environment of the area shall also be considered.

It is therefore the aim of this study to qualify and also try to quantify the impacts on navigation caused by developments already completed or proposed by other sectors within the Area.

To be able to do so with the required balance and emphasis it is necessary first to determine and describe the present situation for inland water transport in Bangladesh and to assess the sector's socio-economic value.

This task is facilitated by the Bangladesh Inland Water Transport Master Plan Study (BIWTMAS) which was carried out for the Bangladesh Inland Water Transport Authority (BIWTA) in 1989. Much information in this thorough and extensive study focussing on inland water transport is still valid and therefore reference is made to this study.

The project area is shown in Figure 1.1.

2 INLAND WATERWAYS

2.1 Introduction

Bangladesh is a riverine deltaic country. It is criss-crossed by three major rivers (Ganges, Brahmaputra and lower Meghna) and numerous other regional and small rivers. This physical condition has enabled inland transport to become a natural and relatively cheap from of transport. In certain parts of the Southwest Area (SWA) it is the only mode of transport.

2.2 Navigation

Navigation may be defined as the act of moving a vessel safely on a body of water. The purpose of navigation could be for the sake of transport (the movement of passengers and/or goods), fishery, sand mining or pleasure. River transport is by far the most important cause for employing navigation in Bangladesh whereas pleasure boating is less than insignificant.

There are three important elements in navigation:

- The waterways, which are normally provided by nature; in this case they are an integral part of a river delta.
- The vessels, which are built by man must suit the particular navigation conditions (e.g. water depths and/or wave disturbance) as well as the subject of transportation (e.g. passengers or liquid bulk).
- The harbours (berthing facilities), which are also created by man, shall provide conditions suitable for the transfer of passengers and/or cargo from landward transportation to waterway transportation and vice versa.

In the SW Area of Bangladesh river traffic has developed along four lines of operations:

- Ocean going traffic to and from Mongla
- River traffic including passenger and cargo vessels as well as tugs and barges
- Country boats
- Ferry traffic

In the subsections below the waterways will be dealt with first and separately. After this, each of the three above mentioned lines of operation have been addressed.

2.3 Rivers as Waterways

In the Southwest Area as in the rest of Bangladesh almost all waterways are natural rivers. They may be divided into four categories:

(a) The main rivers are the Ganges and the Jamuna which merge into Padma and flow into the Lower Meghna and the Bay of Bengal. These are immense rivers, 5 to 15 km wide,and their peak flows are the main cause for the annual floods in Bangladesh. Together they form the north and east boundaries of the study area.

(b) Tributaries are rivers with local catchment areas and their flow depend on local rainfall and evaporation. Most of them are meandering and discharge into the main rivers. This category is not characteristic for the Southwest Area.

(c) Tidal rivers are rivers dominated by the semi diurnal tides in Bay of Bengal having a range of 3 - 4 m. These rivers are relatively stable as the tidal flow maintains their profiles (to the extent the tidal flow does not change due to human interference). The tidal rivers are numerous in the southwest area.

(d) Connectors take off from one (main) river and discharge into another river at a confluence. Connectors have no catchment areas of their own. In the Southwest Area Gorai and Arial Khan Rivers are good examples. Because connectors make the river system into a network they are very important for navigation.

The navigability of natural rivers depends heavily on the morphological changes and changes in the hydraulic characteristics of the rivers. The discharge of all rivers in Bangladesh except the tidal ones vary over the year. The low water period lasts from December to May with lowest water levels recorded in March and April. During the low water period navigation is hampered in many rivers and in many cases it is discontinued.

In addition to seasonal variation of the water depth the average dry season water depth decreases in the main rivers, tributaries and connectors because of the increasing volume of water used for irrigation and other purposes.

Connectors may deteriorate not only due to water abstraction but also due to siltation of the off-take. Once a connector starts silting up, it deteriorates fairly rapidly because the water flow is not forced to pass and to erode the shoals. Instead the flow shifts to an alternative route with less resistance.

The tidal rivers during the years have been affected by the construction of polders whereby the flooded spill area has been decreased, the tidal flow and flow velocities reduced causing siltation and rising of the river bed. Further, the reduced upland fresh water discharge has allowed the seawater to penetrate further inland. The clay fraction of the silt will settle in the brackish zone whereas it would have remained suspended in fresh water. Consequently, the reduced fresh water discharge will cause siltation to move further up-country.

2.4 Waterway Classification

Four to five years ago the classification of the inland waterways was linked to the traffic and thereby to the commercial value rather than to the navigability. E.g. class I routes should be of major concern to BIWTA as regard to conservancy and maintenance and the users should have a guarantee of the specified navigability within reasonable limits throughout the year. So it was not required that a certain route should have a definite water depth throughout. The route might be composed of section with different depths, and this actually was the case.

Navigation Routes are presently classified according to the draught of the vessel but the BIWTMAS recommended new classification criteria as follows:

Class I : Least available depth (LAD) of 3.6m to 3.9m to be maintained all year round

Class II : LAD of 2.1m to 2.4m to be maintained and necessary aids for navigation shall be provided. But no guarantee can be given for the specified depth throughout the year.

Class III : Routes where it is usually not feasible to maintain LAD exceeding 1.5m to 1.8m. These routes are traffic link of regional importance. BIWT shall carry

out (simple) channel markings as required. Specified navigability may be expected during the greater part of the year.

Class IV : Seasonal routes, for which it is not feasible to maintain a LAD of 1.5m in the dry season.

It appears from interviews with BIWTA officers that the recommended classification is accepted.

The purpose of a classification is to provide masters, pilots, maintenance personnel, engineers etc with the possibility of conveying information in a convenient manner. Speaking about a waterway of a certain class should immediately describe a number of key parameter of the waterway in question.

However, in Annual Ports & Traffic Report, 1990-91 by BIWTA it reads: on page 11:

> "..... the navigable routes are classed according to the draught allowed for vessels navigating the routes, usually 3.6 meters, 1.8 meters and 0.9 meters. This classification is with respect to the standard low water (SLW) which statistically is valid 95% of the time."

While the recommended classification refers to the water depth, BIWTA refers to the draught of the vessel.

With respect to water depths and/or draughts BIWTA, when requested, issues a map which by means of a colour code shows the drafts (1.0, 1.25, 1.50, 1.75, 2.0, 2.5, 2.75, 3.0 and 3.5m) of routes BIWTA consider to be the navigable waterways.

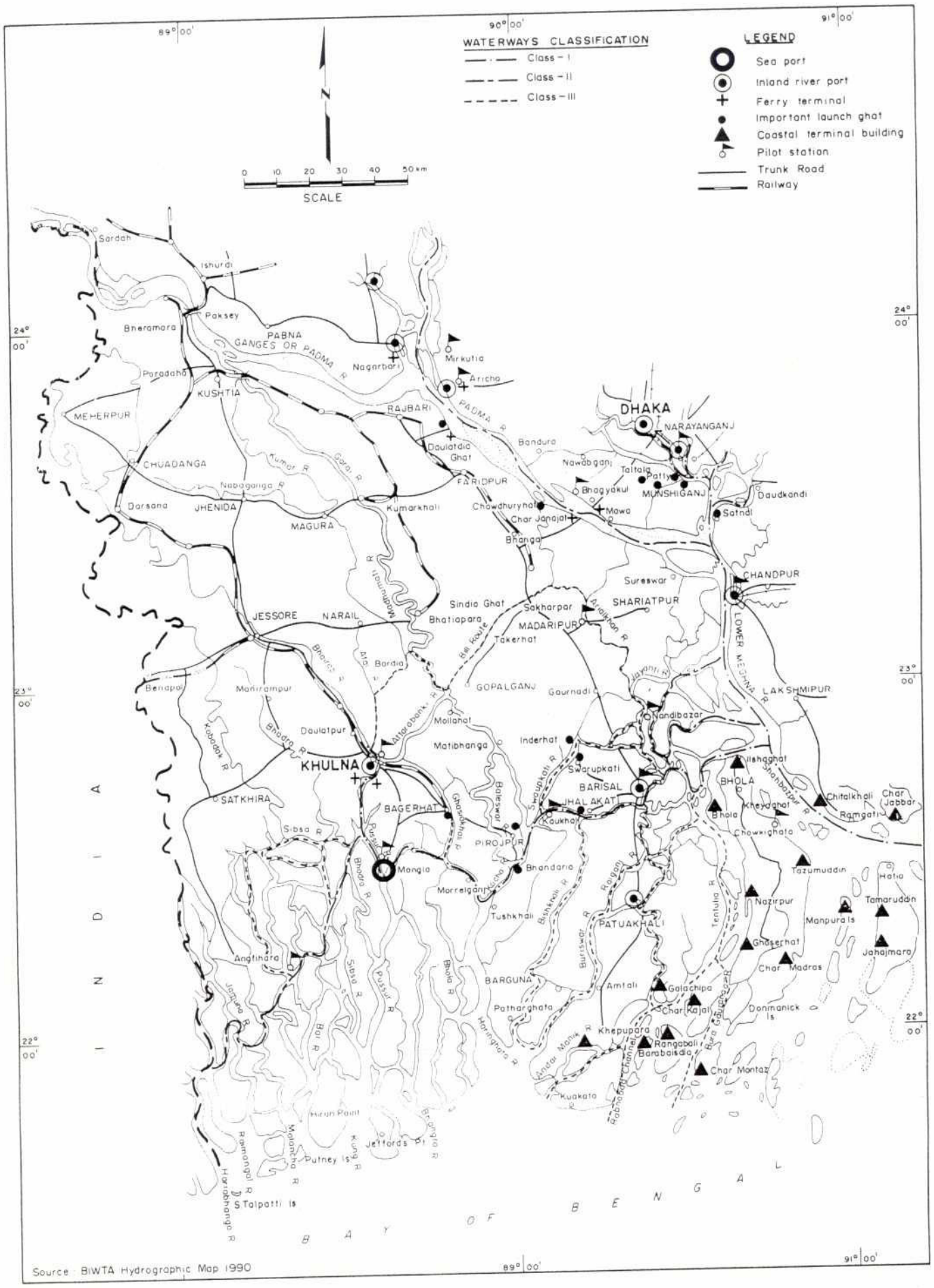
Table 2.1 shows the classified routes in the SWA. Figure 2.1 shows the principal navigation routes in the SWA with the appropriate colour coding as issued by BIWTA in May 1992.

TABLE 2.1

Classified Routes in Southwest Area

Class	Routes	Description	Distance Km
I	Chowkighata - Maheswarpasha	Lower Meghna, Swarupkathi River, Ghasiakhali canal, Passur, Bhairab River	270
II	Deara - Barisal	Meghna, Arial Khan	85
II	Chandpur- Aricha Nagarbari	Padma, Jamuna	96
II	Passur-Raimangal	Chunkuri, Suturkhaliu, Arpangasia River	143
II	Hizla-Shaistabad	Meghna, Arial Khan	30
III	Khulna-Kalikapur	Bhairab, Madhumati beel route, upper Kumar, Arial Khan	138
III	Atai/Bhairab junction-Abalganti	Atai River	15
III	Kalikapur-Nandibazar	Arial Khan, Jayanti	56
III	Kaukhali-Babuganj	Swarupkati river	52
III	Ghasiakhali-Bagerhat	Ghasiakhali river	18
III	Kobadak-Tepakhali	Kapatakshi river	85
III	Barisal, Jhalakati, Patherghata	Kirtankhola, Biskhali	116
III	Jhalakati-Patherghata	Gazalia, Bishkhali	89
III	Barisal - Aamtali	Kirtankhola, Khairabad Channel Pandab Nulla, Rajaganj river, Patuakhali river & Bighai river	96
III	Barisal-Char Biswas	Arial Khan via Shaistabad, Tentulia river	125
III	Khepupara-Mohipur-Kuakata	Nilganj Andar Manik river	36
III	Bhola-Chan Montaz	Tentulia river	95

Figure 2.1



Source : BIWTA Hydrographic Map 1990

Principal Navigation Routes

2.5 Maintenance of Waterways

It is well known that several of the rivers in Bangladesh for various reasons are deteriorating because of sedimentation. This reduces the water depth which in some cases become critical to navigation. Therefore in order to take advantage of the rivers as a means of transport it is necessary to remove the sediment.

This is normally done by dredging the shallow areas. Also the development of "chars" in the main rivers may hamper navigation and will therefore have to be dredged. In some cases the dredging/removal of silt may be carried out by bandelling which is the installation of mats on vertical frames of bamboo poles on both sides of the navigation channel at suitable place in the braided rivers like Jamuna. If correctly oriented the mats will develop spiral currents which will prevent sedimentation in the channels and/or even causing scour. Bandelling is always placed at certain angles with flow direction and therefore does not work in tidal rivers and for this reason alone is seldom used in the Southwest Area.

To maintain the navigation depth in the classified waterways BIWTA operates 8 cutter suction dredges. In fact the dredging works carried out by BIWTA may be subdivided in three categories:

1) Maintenance dredging is the main task

2) Development dredging is performed in connection with new projects related to the inland water transport

3) Third party dredging related to ship's access to private/public berthing facilities or related to development of areas required by private parties or other agencies is also carried out by BIWTA if capacity is available.

The maintenance dredging is characterised by:

- Several small jobs (50000 m^3 to 200,000 m^3) spread over the country
- Face heights normally 0.5m to 2.0m
- Cuts normally 2 x 30m wide and varying in length from 50m to 5km, and accessible from two sides
- Dead end cuts providing access to jetties

Table 2.2 shows BIWTA's dredging performance from 1977/78 to 1991/92. During the 1977/78 to 1986/87 period the maintenance dredging averaged 650,000 m^3 per year whereas development dredging amounted to nearly 1.6 M m^3. The annual output varied from 1.8 to 3.5 M m^3, averaging 2.5 M m^3.

The Third Inland Water Transport Project, appraised by WB in 1990 includes the procurement of support equipment for the dredging operation and a commitment by BIWTA to test and if successful to introduce 3 shift operation on their dredgers.

Table 2.2, however, also shows that the performance in the period from 1988/89 to 1991/92 has not improved. It is understood that this is partially due to lack of funds. Savings in connection with such temporary close downs are in the order of 15% to 25% corresponding to the cost of fuel, lubrication and some repairs. The annual production is still 2.5 M m^3 but dredging volumes related to maintenance dredging and development dredging have reversed compared to the first period.

TABLE 2.2

Dredging by BIWTA and BWDB in M m^3

Year	Maintenance BIWTA	Third Party	Development BIWTA	Total BIWTA	Total BWDB
77-78	422	295	1060	1777	4050
78-79	712	-	1619	2331	4160
79-80	629	-	2058	2687	4300
80-81	413	190	2120	2723	2430
81-82	702	25	2793	3520	1800
82-83	833	672	1351	2856	
83-84	320	316	2278	2914	2842
84-85	995	500	1371	2866	3704
85-86	379	265	1134	1778	1640
86-87	1029	785	24	1837	1722
Sub Total	6434	3048	15808	25289	
Average	643	305	1581	2529	
87-88				(2147)	2600
88-89	1674	770	163	2608	
89-90	1816	-	1148	2964	
90-91	1485	347	638	2470	1240
91-92	983	800	1165	1948	
Sub Total	5958	1917	2114	9990	
Average	1490	479	529	2498	

Source: BIWTMAS and Ref. 8

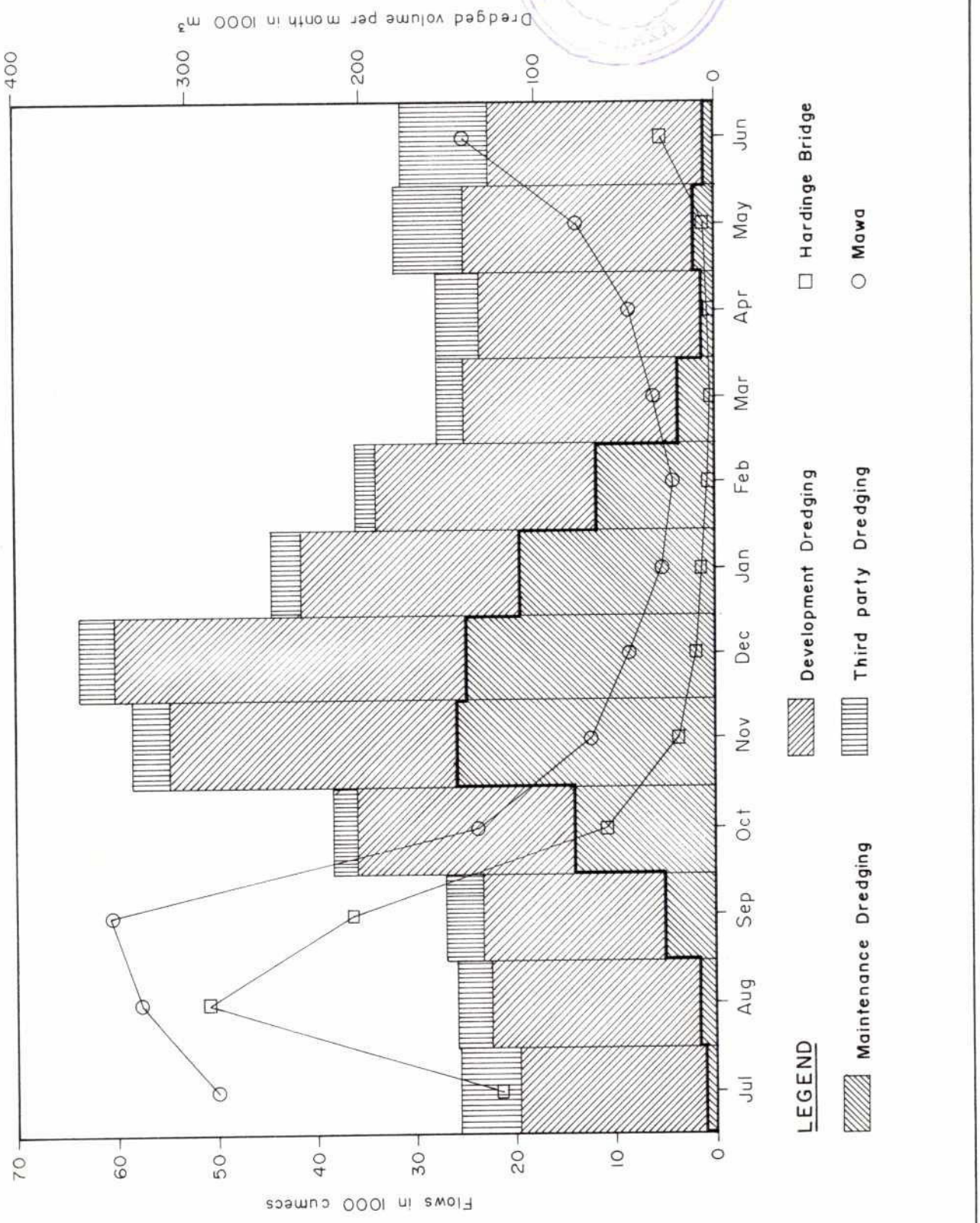
Figure 2.2 shows the timewise relationship between the execution of maintenance dredging and water level in the non-tidal rivers represented by the flow of the Ganges at Hardinge bridge and at Mawa. The figure also indicates that substantial spare capacity is available. This spare capacity may be estimated as follows:

(1) Three of the eight dredgers have less capacity than the other five. For the sake of convenience it is assumed below that BIWTA operate 7 dredgers, each with a capacity as the above mentioned five.

(2) BIWTA during an interview informed that with 2 shifts the actual dredging time is 0.75 x 2 x 8 h = 12 hours and that the dredging capacity is approximately 215 m^3/h.

(3) Annual production of 7 dredgers may be calculated : 7 x 12 h/d x 215 m^3/h x 24 days/month x 10 months equals 4.3 M m^3. The actual performance during a 14 years period is only 58 percent of this amount.

Figure 2.2



Timing of Maintenance Dredging Relative to the Water Level Represented by Typical Flow

(4) BIWTA also informed that they charge 35 Tk/m^3 internally and 55 Tk/m^3 externally.

(5) If 60% of the costs of dredging under prevailing condition are fixed costs the marginal cost per m^3 for dredging beyond 2.5 M m^3 is 0.4 x 35 = 14 Tk/m^3, only, whereas the overall unit price in case production was raised to 4.3 M m^3 would be reduced to 0.6 x 35 x 0.58 + 35 x 0.4 = 12.2 + 14 = 26.2 Tk/m^3 which is only 75% of the present unit cost.

The Consultants have been informed that about 7 years ago some maintenance dredging was carried out west of Jhalakati. Apart from this and from regular maintenance dredging of the jetty access at Barisal no maintenance dredging has been carried out in the Southwest Area. The Barisal maintenance dredging has been estimated at 200,000 m^3 per year.

2.6 BWDB Dredging

The Consultants visited the Dredger Organisation of BWDB, which operates 11 nos. 18" dredgers and 16 nos 12" dredgers.

The small dredgers which are mechanically operated were all procured in the mid 1950s. Due to careful maintenance they are generally in fair working condition. One of the small dredgers is a suction dredger. The rest are cutter suction dredgers like the larger dredgers.

The 18" dredgers are hydraulically operated and were procured 10 - 12 years ago.

It is the obligation of the Dredger Organisation to procure jobs from Government/Private agencies and private individuals to maintain as a self financing organisation. But priority is to be given to the work of BWDB. If the Department have spare capacity, dredging jobs may be carried out for third party.

The Organisation has a standing arrangement to carry out dredging at the intake canal for G.K.Project. This work lasts three months only, each year and is carried out by 2 small and 2 large dredgers. These four dredgers remain at the site and are idle during 9 months of the year.

Recently the Organisation has been instructed to dredge the river mouths of Gorai River and Arial khan River. These jobs are in the planning stage.

At the time of the visit to the BWDB four dredgers were in operation (or operational), 4 large and 9 small dredgers were idle and the rest were being repaired. Three of these were for major repairs.

The total annual output of the BWDB dredgers is listed in Table 2.2.

When dredging for third party the Department charge per m^3 according to tariffs established by BWDB. The current prices are

0'	-	3000' discharge pipe	62.00 Tk/m^3
4001	-	5000' discharge pipe	72.90 Tk/m^3
6001	-	7000' discharge pipe	86.00 Tk/m^3

To these prices shall be added the cost of a tug to be used for shifting and the cost of mobilization and demobilization which may come to 30% extra. The present tariffs have been in use for 3 or 4 years.

The 18" dredgers were claimed to have an output of 230 m^3/h. Assuming the dredgers to be operated by 2 shifts and being productive 75% of the time the total annual capacity may be calculated as follows:

$(11 + 0.4 \times 16) \times 0.75 \times 16h/d \times 230\ m^3/h \times 24$ days/month x 10 months $= 11.5 \times 10^6$ m^3/year. This figure may be reduced to 10.0×10^6 m^3/year taking into account the age of the 12" dredgers.

Comparing this amount with the actual output it is evident that there is a very substantial unused capacity.

2.7 Opening of Silted Waterways

Elsewhere in this study waterways which are subject to siltation have been identified. They are located in an east west zone extending from Jessore in north to Mongla in south and coincide with the upper reach of the tidal rivers. From discussion with BIWTA it is evident that maintenance dredging has not been carried out in this area. In order to get an idea of the economy related to the reopening of a previously navigable river the following illustrative example has been worked out:

1. We assume that the "River - X" has a water depth of 0.3m to 0.6m in the dry season. This depth is insufficient even for country boats.

2. Along this river are located recipients and dispatchers of cargo. These people preferred to use road transport for their cargo. It is assumed that the transport by road is the same distance as by waterway. Figure 2.3 shows "River - X" and the road. Both river and road are dead end so the vessel or the truck will travel up-river the distance L and down-river the same distance (L in km).

3. Figure 2.3 also shows the cargo intensity which has a centre of gravity the distance ßL from the entrance to "River-X." The total volume of cargo is C in tons/year.

4. Transport and dredging costs

Road transport	p	(Tk/t x km)
River transport	q	(Tk/t x km), country boat, draught 0.9m
Dredging	g	(Tk/m^3)

5. The following costs are calculated:

Investment cost: $I = \alpha L \times W \times d \times g \times 10^3$
Annual maintenance cost $M = rI$
Annual saving in transport: $s = ßL \times C \times (p-q)$

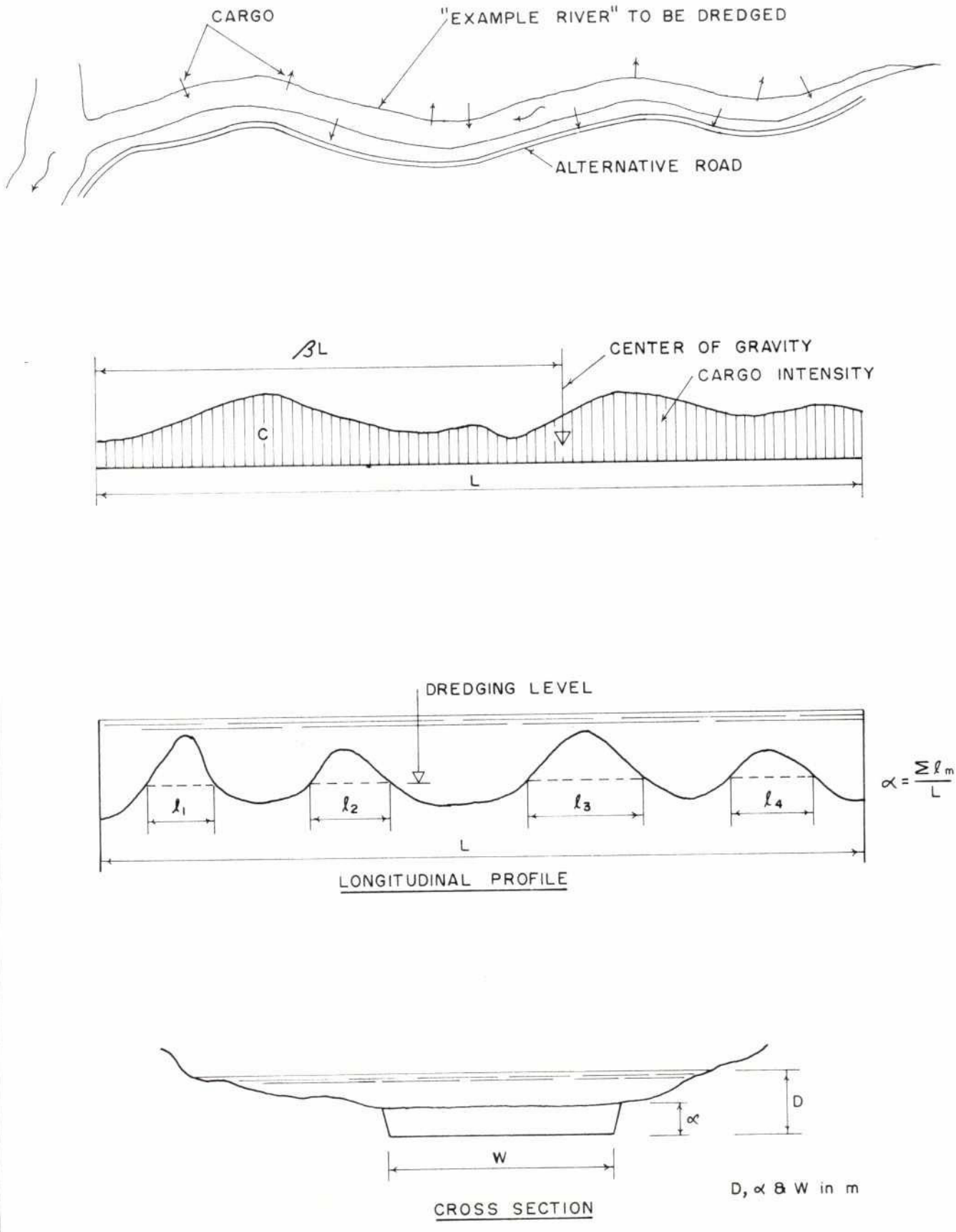
Next, the annual net saving S-M is discounted at an rate of interest of 12% over 20 years. Factor F = 7.469

6. Investment cost: $I = \alpha L \times 24 \times 0.75 \times 35 \times 10^3 = 630000\ \alpha L$ (Tk)

Maintenance cost: $M = I = 0.05\ I = 31500 \times \alpha L$ (Tk/y)

Saving $S = ßL \times C\ (p-q) = ß\ LC \times (1.8 - 0.9) = ß\ LC \times 0.9$ (Tk/y)

Figure 2.3



Opening of Silted Waterway, Assumptions

7. The net present value (NPV) of the annual net saving shall equal the investment:

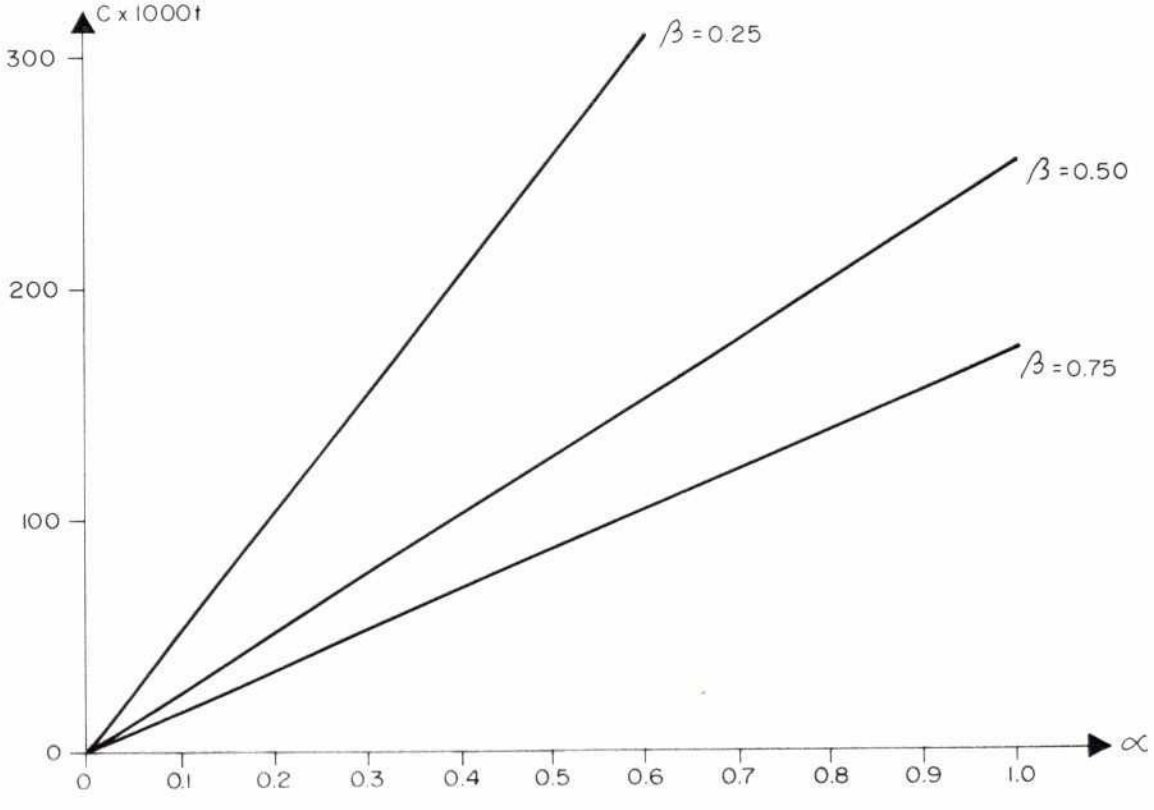
$(S - M) F = I;$
$(ß\ LC \times 0.9 - 31500 \times \alpha L)F = 630000 \times \alpha L$
$0.9F\ ßC = 31500\ \alpha\ F + 630000\ \alpha$

$C = (35000 + 700000/F)\ \alpha/ß$

$C = 128720\ \alpha/ß$. This result has been shown in a graph on Figure 2.4.

If it is assumed that α would be between 0.2 and 0.4 the minimum amount of cargo which must switch from road to river in order to pay for the investment and the maintenance is 35000 t/y. In reality it would probably be more. Such quantity may be possible in connection with industry and perhaps also with urban areas.

Figure 2.4



Opening of Silted Waterway, Results

3 COUNTRY BOATS

3.1 Vessels

In Bangladesh "country boat" means any wooden, non-mechanised craft used on inland water, along the coast or in the Bay of Bengal. For the Southwest Area Water Resources Management Study the following definition which is based on one presented in chapter 5 of Ref 7 is adopted.

> Commercially operated, cargo-carrying boats plying inland, on shore and off-shore routes, constructed in wood in traditional design and which are, mechanically or non-mechanically propelled.

This definition excludes most

- small rowing boats)
- canoes) Used mainly in rural areas for
- dugouts) transport of passengers, private
- dinghies) belonging and crops
- fishing craft
- any motorised vessel whose design is not derived from traditional boats.

It seems that the above narrowing down of the expression "country boat" does not result in a comparatively reduction of types. We are left with a wide range of boats in terms of capacity, design, type of construction, type of commodity carried, route pattern and socio-economic relationship.

(During the Consultants preparation of this Report they consulted with Norwegian Agency for Development Cooperation (NORAD) Mr. Reidar Kvam, Assistant Resident Representative, previously a prominent member of a team of experts recruited for the execution of the now almost completed Country Boat Pilot Project. Mr. R. Kvam who will be referred to as RK verbally provided factual data).

Some country boat dimension are provided in Table 3.1.

TABLE 3.1

Country Boat Dimensions

Boat Type	Length		Breadth	Depth	Draft	Capacity	
	Loa (m)	Lvl (m)	B (m)	D (m)	d (m)	(Maunds)	(t)
Soronga	12.5	10.0	2.5	0.8	0.6	275	10.3
Kusha	14.3	13.2	2.7	0.9	0.6	250	9.3
Malar	17.4	15.3	4.7	1.6	1.3	1600*	59.7
Patam	1	8.9	3.1	0.9	0.6	350	13.1
Podi	13.1	12.1	4.1	1.7	1.2	1200	44.8
Chandi	8.0	6.2	2.6	1.0	0.8	150	5.6
PML,Kosha	14.3	11.6	2.7	0.8	0.6	350*	13.1
Ghashi,PTB	11.0	8.2		1.0	0.6	350	13.1
Raptani	15.9	15.1	5.2	1.5	1.0	1400*	52.2
Suronga	11.9					175	85
Patman	12.5					275	pass

*Estimated by the Consultants
Source: RK

3.2 Number and Capacity of Country Boats

It appears that the number of country boats is not known. It is remarkable that although the importance of country boats in the river transport is recognised this subsector has failed to establish a place in the official transport statistics and has either been inadequately covered or completely neglected in national transport surveys.

In Table 3.2 is reproduced from Ref 4 a list giving number and capacity of boats by district from 1979. No source is attached to this data but it is believed to originate from the 1977 Agriculture Census. The total number of boats is added up to 720600 and the average capacity is calculated at 38 Maunds = 1.4 t which indicates that the count include a great number very small boats. The table also shows that 33% of all country boats but nearly 50% of the total carrying capacity are in the SW Area.

The following is quoted from Chapter 5 of Ref 7.

> "The two most serious attempts to estimate the number of country boats were made by the Transport Survey of East Pakistan of 1961 and the Bangladesh Transport Survey (BTS) of 1974. The estimates arrived at in both surveys are frequently cited in the available literature on country boats.
>
> The first survey placed the number of boats, of all sizes and categories, at 300,000. Of these 68,000 were commercially-operated cargo-carrying boats, the category used as a basis for defining the scope of this study. The 1974 BTS make use of a series of assumptions to arrive at a figure of 63,300 cargo-carrying country boats with a capacity in excess of 30 maunds. While both figures are broadly comparable, they clearly underestimate the number of country boats in commercial operation. The methodologies used in both studies, for example, give inadequate attention to the role played in freight operations by small boats especially in respect of rural-rural routes. Actual numbers were thus certainly higher than those recorded in both studies."

In Chapter II of the same reference it reads:

> "Estimates of the total number of commercially operated country boats in Bangladesh vary from 63,000 to 270,000. The estimates vary so greatly due to differences in definition of 'commercial operation' (are boats used throughout the year or for a few months during the peak monsoon floods), and to assumptions concerning minimum size. Since we have not carried out a national survey of country boats, we cannot verify previous estimates. Our analyses do, however, show that the important studies conducted by Rahman in 1963 and the Economist Intelligence Unit in the early 1970s were biased towards rural-urban transport routes, arterial routes, and transport between the main centres of economic activity. The surveys underestimated country boat movements within rural areas and over stressed the importance of bigger boats and certain types of commodities within the country boat sector. This leads us to conclude the boats that are operated commercially throughout or for part of the year would be in excess of 200,000."

Volume III, page 6-14 of Ref 6 reads:

> "BBS statistics tell that some 87,000 country boats were commercially operated around 1983-84, transporting slightly more than 11 million T/yr; and that the number of (commercially operated) passenger country boats was about 162,000."

Section 7.6 of Ref 8 refer to the estimate of 722,000 country boats from 1977 but guesstimates the number of country boats having a load capacity of 150 mound (= 5.5 t) or more and taking part in longer distances transport at 20,000.

Also in Ref 8 it has been guesstimated that the above 20,000 country boats annually will carry 4.4 M t, whereas 80,000 to 180,000 "small" country boats will carry 7.6 M t intra district. Based on some information on the distribution of boats with respect to size and capacity it may be calculated that the average capacity of country boats larger than 150 maund may be approximately 450 maunds or 16.8 t. This leads to a total capacity of the 20,000 boats of approximately 335,000 t. Because the country boats are slower than the modern river vessels the proportion between total capacity and total annual cargo volume should be larger for this subsector than for the modern river traffic.

TABLE 3.2

Number and Capacity of Boats by District (1977)

District	No of Boats	Carrying capacity/boat		Total carrying capacity x 1000 t
		(Maund)	(t)	
SW Area	85300	79	2.9	247
Faridpur	72700	36	1.3	95
Barisal	17700	70	2.6	46
Jessore	40900	47	1.8	74
Khulna	2100	60	2.3	5
Kushtia	20900	46	1.7	36
Patuakhali				
Subtotal,SW Area	239600	56	2.10	503
In % of Total	33%			49%
Noakhali	4300	75	2.8	12
Sylhet	87400	22	0.8	69
Dhaka	86100	31	1.2	103
Chittagong	13900	99	3.7	51
Chittagong H.T.	6600	10	0.4	3
Comilla	118800	25	0.9	111
Jamalpur	14400	24	0.9	13
Mymensingh	50100	29	1.1	55
Tangail	33200	24	0.9	30
Bogra	2600	33	1.2	3
Pabna	24000	42	1.6	38
Rajshahi	26800	23	0.9	24
Rangpur	12800	30	1.1	14
	720600	38	1.4	1029
	100%			100%

Between 1979 and 1988 the total capacity of the modern river vessels slowly increased from 12% to 17% of the total cargo volume carried. This changed to about 27% for 1989 and 1990, probably due to a sudden and substantial drop in the total traffic. Therefore it is estimated that the number of commercially operated country boats on the basis of capacity/cargo ratio 0.17.

Total capacity : 0.17×4.4 M t = 0.75 M t
Number of boats $7.5 \times 10^5 / 16.8 \approx 45000$

This result indicates that in Ref 8 there may be an inconsistency between the estimated total volume of cargo carried and the number of boats. If we also apply the ratio 0.17 to the "small" boats, say average 70 maund ≈ 2.5 t we find a total number :

Cargo carried : 7.6 M t
Capacity required : 0.17×7.6 M t = 1.3 M t
Number of small boats : 1.3 M t/2.5 t/boat = 520,000

The above calculation are in no way claimed to provide a more accurate estimate than the ones quoted above. They merely seem to indicate that Ref 8 has under estimated the number of "active" country boats.

3.3 Other Information

With respect to distribution of boat sizes RK explained that Country Boat Pilot Project had included the execution of a survey which had yielded the following data.

- Approximately 18% of the surveyed boats are less than 70 maunds
- Approximately 50% of the surveyed boats are 200 maunds or less
- Approximately 18% of the surveyed boats are 500 maunds or more.

- Country boats with capacities of 500 maunds and above provide 50% of the carrying capacity

- Country boats with capacities of approximately 250 maunds and less provide 24% of the carrying capacity.

- Country boats with capacities approximately 70 maunds or less provide 3% of the carrying capacity

Length of trips averaged 7 miles (11 km) for passenger transport and 75 miles (120 km) for cargo transport according to the above mentioned survey.

Based on the average size of crew on different types of boats, table 5.1 in Ref 7 and the boat size distribution above, it has been calculated that the overall number of crew is 4.4.

3.4 Operation

The country boat operation is limited to the rural areas of Bangladesh and consequently linked to agriculture. Many boat owners as well as most of the operators and crews are from the rural areas, the boats are built in the rural areas and also in particular serve these areas.

Approximately 60% of all boats are owner operated. Typically the owner operator has some land but insufficient to engage in full time agriculture. He rarely has more than one boat and this boat is the main income for the owner and his family.

Owner-supervisors do not work the boat themselves. They may have several boats and it is often so that they also have considerable land holdings. Many owner supervisors are involved in trade and use their boats as an integral part of their business. Rarely the boats are their main source of income.

Finally, a very small group of boat owners rent their boats to others for a full year at time.

The crew, or the boatmen - usually are recruited from the group of people who have no property and are poor.

Country boat operations take place in the free market and there are virtually no rules and regulations except which stems from cultural and social tradition and practices.

Country boats need not register and only very few do. Registration does not secure any formal rights or legal protection. The possible introduction of registration of country boats would certainly expose the sector to bureaucracy and might open the door to undesired malpractices. Both should be avoided.

Many boats have at least a temporary and informal arrangement with a trader that guarantees freight. Boats are also often contracted by middlemen, e.g. food grain and jute. Much transport is obtained in connection with periodical local markets.

All loading of country boats is done manually by groups of porters. Loading may be delayed if ports and "ghats" are congested.

Unloading is also done manually and may be delayed for a number of reasons. The trader may simply refuse to unload, because he uses the boat as free storage until a buyer of the cargo is found. The buyer may wait to unload until godowns space has been secured. Delays are also experienced where the country boat has to compete with modern river vessels which always are afforded priority. Country boats receive no compensation or demurrage.

Country boat operators often have difficulty in obtaining back haul cargoes, in particular in urban areas.

3.5 Mechanisation

Mechanisation of country boats in Bangladesh started on a large scale in the northern parts of the country, around 1985. In the beginning the boats were fitted with irrigation pump engines (Shallow Tube Well). These pumps were used in agriculture during four months in the dry season, so the engines could be used elsewhere for the remaining part of the year. According to a survey carried out by the "Country Boat Pilot Project" (this project which was executed by NOAMI for BIWTA and financed by Norway and the Netherlands started in January 1990 and was a continuation of a previous project financed by the same donors) more than one hundred of the 205 boats surveyed got engines during the period 1985-89. Based on this survey and a traffic count also carried out under the above mentioned project it has been estimated that by 1990 60% to 75% of all large boats (above 50 maunds) have been mechanised, varying from 40% in south to 90% in NW.

4 MODERN RIVER TRAFFIC

4.1 General

The river traffic dealt with in this section is referred to as "modern" in order to distinguish it from the country boats which also take part in the traffic on the rivers.

The modern river traffic includes the public sector represented by BIWTC and the private sector. Indirectly also BIWTA take part in the modern river traffic by being responsible for maintaining the navigability of the water ways and by being the owner of some of the port facilities.

Data on the activities of the public and the private sectors may be obtained from the Annual Ports and Traffic Reports issued by BIWTA. It is, however, important to be aware that e.g. data on cargo and passenger traffic are incomplete because they do not include the full private sector. It is simply not a requirement that shipping companies or private jetty owners report their activities. In many other countries it is normal practice that the ports record all movements of vessels in and out of the port as well as data on loading and unloading of cargo. In this country the ports are not a number of wharves contained within sheltering breakwaters but a number of floating and fixed, private and public jetties, located apparently at random and between each other over long sections of the river. E.g. the "port" in Khulna extends about 15 km along the banks of Pussur, Atarabanki and Bhairab Rivers. This non-concentrated layout may not have encouraged the idea of keeping records.

With respect to passengers the records are divided on the two categories: public and private. The records on the cargo traffic does not make it possible to distinguish between the above mentioned two categories.

4.2 Vessels

Table 4.1 contains data on capacity, main dimensions and speeds for different vessels used in the modern river transport.

TABLE 4.1

Typical Data on Vessels

Type of Vessel	Capacity	Typical Main Dimensions				Speed	
		Lo, a (m)	B (m)	Draught d (m)	Displacement (m^3)	Laden (km/h)	Unladen (km/h)
BAY X-ING							
Coaster	1000t	63	12.3	3.7		12	16
Tanker	1000t					12	16
Minibus	1500t					14	18
Pusher	1350hp					(4)	18
Tug	900hp						
Barge	640t	60	9.0	2.5			
Barge	350t			1.4			
Barge	300t	45	8.5	2.1			
Flat	500t	61	9.1	2.1			
INLAND VESSELS							
Passenger vessel	50pass	13	2.9	1.0	18.3	12	16
Passenger vessel	250pass	29.5	6.7	1.2	120	12	16
Passenger vessel	450pass	41	8.5	1.5	310	12	16
S-P Cargo vessel	650t	45	9.2	2.9	820		
S-P Cargo vessel	350t	39	7.4	2.5	500	8	14
S-P Cargo vessel	250t	35	7.5	2.3	385	9	15
S-P Cargo vessel	50t	21.5	6.2	1.7	125		
Cargo launch	80t					7	12
Tug	265hp				1	(4)	18
Barge	350t					4	8
Barge	250t	40	9.0	1.8			
Flat	900t	67					

4.2.1 Cargo Vessels

Table 4.2 contains number, total capacity and average capacity by type of vessel for selected years between 1978 and 1991. The vessels have been divided in bay-crossing vessels and inland vessels.

The table shows that the sizes of the following type of vessels have increased during the period covered:

- Bay-crossing : Coasters, tankers and dump barges
- Inland : Self propelled (s-p) cargo vessels and dump barges.

The sizes of bay-crossing dump flats, inland tankers and dump flats have remained the same or even reduced.

The total capacity of all categories of vessels except for bay-crossing and inland dump flats have increased. This is in particular true for self propelled cargo vessels which have increased their total capacity by a factor 6 between 1978/79 and 1990/91.

In the right hand column it is indicated for each category of vessels the split between the public and the private sectors. It may be noted that the public sector is operating only 1% of the self-propelled cargo vessels, none whatsoever dumb flats and a mere 15% the dump barges. This, in connection with a reduction from 23% in 1986-87 to 13% in 1990/91 of the public sectors' participation in the ownership and operation of the entire inland and bay crossing dry cargo flat, is in accordance with a strategic objective adopted by BIWTC in connection with Third Inland Water Traffic Project. This long term objective is for BIWTC to:

> "Become a financially viable organisation, and to concentrate its activities in these sectors of inland water transport where the Government needs to remain involved, i.e. the ferry sector and the coastal passenger sector. The cargo sector ..... will be gradually phased out."

4.2.2 Passenger Vessels

Table 4.3 contains number, total capacity (in terms of passengers) and average capacity by type of vessel for 1987 through 1991. It appears to be characteristic that there are no significant changes in the sizes of the Passenger vessels.

TABLE 4.3

Number and Capacity (Passengers) of Registered Passenger Vessels

	1983	1984	1985	1986	1987	1988	1989	1990	1991
PRIVATE SECTOR									
No of Vessels					151	165	171	192	206
Total Capacity					50530	56939	54914	64723	70805
(Ave. Capacity)					(335)	(345)	(321)	(337)	(344)
No of Launches					1355	1384	1419	1437	1462
Total Capacity					101739	102882	104573	105786	107607
(Ave. Capacity)					(75)	(74)	(74)	(74)	(74)
Total Nos	1325	1359	1433	1489	1506	1549	1590	1629	1668
Total Capacity	128032	132370	149125	155122	152269	159821	159487	170509	178412
PUBLIC SECTOR									
-									
No of Vessels					17	16	16	13	13
Total Capacity					8837	7987	7987	7059	7099
(Ave. Capacity)					(520)	(499)	(499)	(543)	(546)
No of Launches					0	7	7	19	11
Total Capacity						280	280	280	280
(Ave. Capacity)						(40)	(40)	(15)	(25)
Sub total (Nos)					17	23	23	32	24
Sub total (Capacity)					8837	8267	8267	7339	7379
In % of Private sector					6%	5%	5%	4%	4%
No of coastal vessels					10	8	10	8	3
Total Capacity					2308	1808	2308	1808	816
(Ave. Capacity)					(231)	(226)	(231)	(226)	(272)
No of Sea trucks					2	3	16	7	6
Total Capacity					260	285	285	955	759
(Ave. Capacity)					(130)	(95)	(18)	(136)	(127)
Total Nos	35	32	35	36	29	34	49	47	33
Total Capacity	7678	6875	7584	8331	11405	10360	10860	10102	8954
PRIVATE + PUBLIC									
Total Nos	1360	1391	1468	1525	1535	1583	1639	1676	1701
Total Capacity	135710	139245	149125	163453	163674	170181	170347	180611	187366

It is note worthy that the public sector owns only 4% to 6% of the inland passenger vessels and launches but 100% of the coastal vessels. This seems to be in line with the BIWTC's objective quoted in 3.2 above.

4.3 River Traffic

4.3.1 Cargo

The development in cargo traffic as reported in Annual Ports and Traffic Report is presented in Table 4.4. The cargo quantities have been broken down into a number of major commodities and "others." Some of the commodities exhibit considerable variation over the years. This applies to two of the major commodities: Food grains and fertiliser.

The total amount of cargo transported shows a dramatic drop in 1989/90 and again in 1990/91. The quantity of cargo transport in the year 1990/91 is only about 70% of the quantities in 1987/88 and 1988/89. People with long experience in inland shipping agree that the cargo volume has declined during the years in question but a drop as the one indicated does not reflect reality. In this connection reference is made to a statement made on page 43 of the Annual Ports & Traffic Reports for 1989/90 and 1990/91 which reads:

> "About 30% of operators did not co-operate by submitting comparative performance statistics of important commodities movement."

Similar statements were not included in the three previous Annual Port and Traffic Reports.

Figure 4.1 shows a plot of the BIWTA records on cargo traffic. Because of the above mentioned "30%" lack of data the results for 1989/90 and 1990/91 have been plotted with adjusted values to reflect realistic figures.

1989/90 : 4473/0.7 = 6390 x 10^3 t
1990/91 : 3824/0.7 = 5463 x 10^3 t

BIWTMAS' projection of the cargo volume up to year 2005 has also been shown on Figure 4.1. For the base year 1985/86 the split between the modern fleet and the country boats has been as follows:

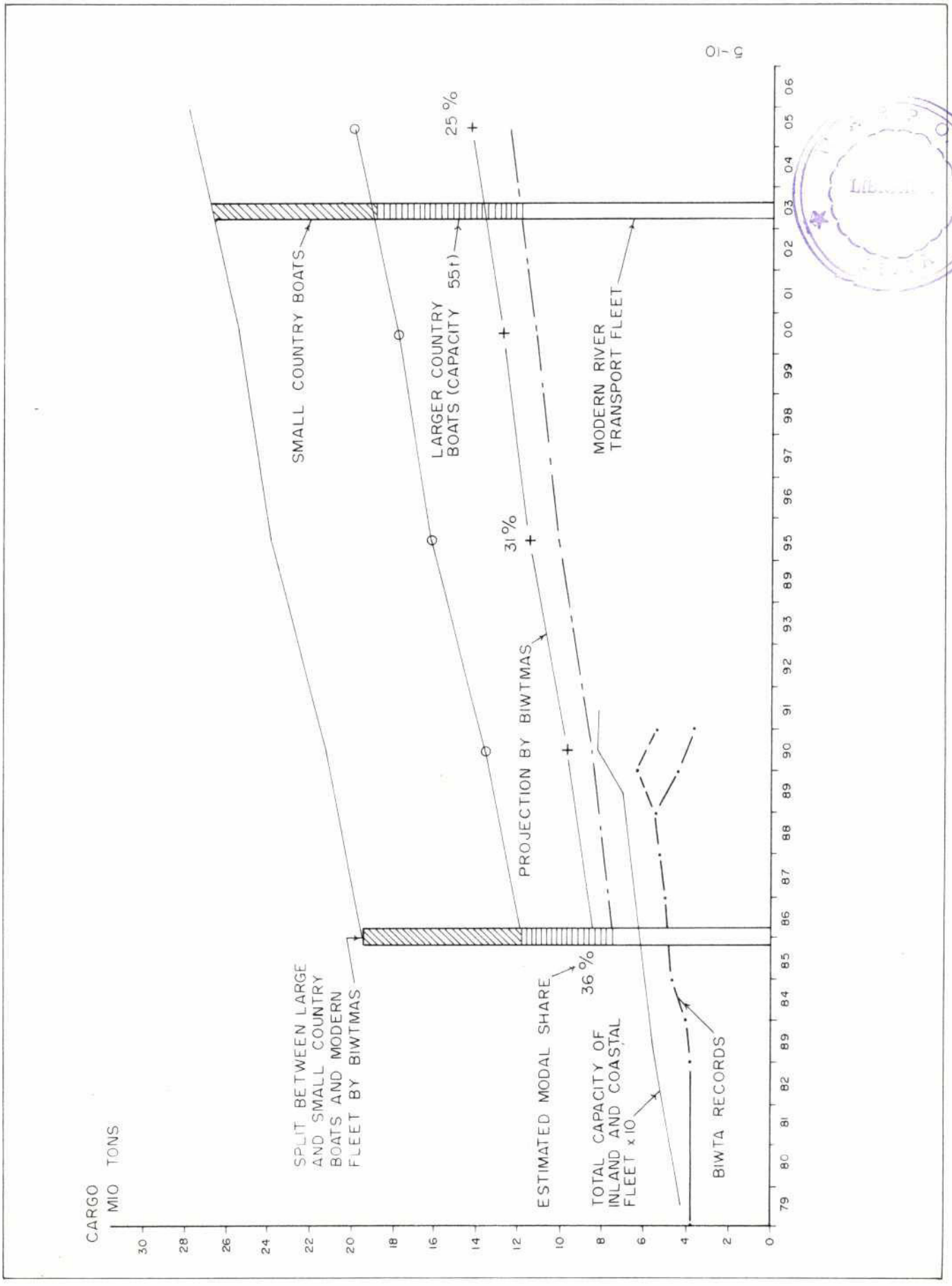
Modern river fleet, total cargo traffic:	7.4 M t	38%
Large country boats:	4.4 M t	23%
"Small" country boats	7.6 M t	39%
Total	19.4 M t	100%

It is interesting to note that a small fraction of the large country boats have been included in the modern river traffic.

Nobody is more interested in the cargo transport market than the private shipowner. They watch market and plan their activities ahead of events. An important element in this business is to plan so that sufficient carrying capacity is available when required. Therefore the development of the fleet is seen as a competent and revolving forecast of the future short and medium term cargo traffic. For this reason also the total carrying capacity of the modern fleet has been plotted on Figure 4.1.

This plot indicates a gradual and steady development of the fleet and therefore also the traffic. The rate of development (growth) may be calculated at 5.8% annually. As comparison the projected growth of the cargo traffic may be calculated at 3.7% annually.

Figure 4.1



Cargo Traffic by Modes

The overall conclusion on the projection of the cargo traffic is that the records collected by BIWTA are of a very limited value.

The Consultants therefore adjusted the BIWTMAS forecast to reflect the mild recession in transport in the last two years.

4.3.2 Passengers

The transport of passengers during selected years is presented in Table 4.5 together with various other key data.

For 1985/86 the number of operators is listed as 599 in BIWTMAS but according to Annual Port & Traffic there should only be 458 operators. From BIWTMAS it appears that 100 out of 494 local operators are from the SW Area. Similarly 152 out of 629 launches and 85 out of 218 routes are in the SW Area.

The number of passengers suddenly drops from 53 M to 38 M in 1987. There seems to be no explanations to this. From 1987/88 and onwards the number surprisingly show a gradual decline inspite of predicted increases.

The data on passenger - km are not comprehensive and therefore not conclusive.

TABLE 4.4

Transport or Cargo on Inland Waterways in '000 Tons

	78/79	82/83	83/84	84/85	86/87	87/88	88/89	89/90	90/91
Petroleum products	896	1047	1086	1226	1692	1670	1953	1820	1554
Food grains	736	874	905	1329	909	1343	1130	689	655
Cement	376	483	613	702	705	785	824	609	473
Fertilizer	401	334	282	382	405	669	759	458	262
Jute	327	231	143	223	305	165	190	194	148
Jute products	220	223	157	185	169	127	110	111	90
Stone, shingles, sand	173	172	239	160	217	174	161	133	180
Salt	25	68	112	76	74	53	49	22	37
Iron, steel, mechinery	10	7	20	9	61	70	34	26	49
Coal	59	29	12	21	56	44	35	101	43
Sugar	4	2	6	44	63	57	25	17	2
Wood/Fire wood/Bamboo	67	61	54	76	79	72	71	74	62
Fish	25	15	18	23	21	24	23	57	73
Other	495	268	285	383	348	103	105	162	196
Total	3814	3814	4032	4839	5104	5356	5439	4473	3824
Cargo traffic for 1989/90 and 1990/91 adjusted corresponding to lack of data								6390	5463

TABLE 4.5

Passenger Traffic and Other Key Data

	Source	78/79	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91
LAUNCHES, PRIVATE											
Nos of operators	1	370	400	450		599					
Nos of operators	2				455	458	464	474	486	710	613
Nos of launch routes	1,2	214	222	260	261	264	269	270	271	256	229
Nos of ghats	2				1410	1415	1420	1422	1425	1135	1200
Nos of time tables (TT)	1				639	645	786	796	808	305	310
Nos of launches main TT	1,2	522	721	770	775	776	800	810	822	850	728
Water way water TT (km)	1,2	5240	5350	5350	5350	5465	5356	5356	8620	8620	8620
PUBLIC & PRIVATE											
Length of water) Private	2						8800	8620	8620	8620	8620
Routes in km) Public	2						1399	1896	1988	1505	743
) To											
Number of) Private (min)	1,2	41.47	45.87	46.87			48.23	33.01	28.69	27.46	24.44
Passengers) Public (min)	2						0.99	0.72	0.70	0.69	0.65
) Total (min)	2						49.22	33.73	29.39	28.15	25.03
) Ferry (min)	2						4.70	4.31	5.11	5.69	5.81
) Total	2						53.92	38.04	34.50	33.84	30.90
		1.66	1.19	1.27							
Pass.km, private ($x10^9$)	1,2						1.42	28.5	247.3	236.7	210.7
Pass.km, public ($x10^9$)							0.37	9.5	11.6	9.6	4.8
						1.60	1.79	38.0	258.9	246.3	215.5
Passenger km by BIWTAMS	1										

Source 1: BIWTMAS; Source 2: Annual Port & Traffic Report

5 OCEAN GOING TRAFFIC

5.1 Port of Mongla

Although located approximately 80 km inland, Mongla is the second largest sea port in Bangladesh. It is situated on the east bank of Pussur River, about 1½ nautical miles upstream of the Mongla-Nullah confluence.

The fairway buoy is located in the bay southeast of the bar with a minimum water depth of approximately 5.5 m below CD. Tidal variations raise the water level so that vessels with a draught of about 7.2m to 8.2 m may pass.

The navigation channel in the Pussur River and its approaches is marked by 41 lighted buoys and 2 lighted beacons for day and night navigation.

Mongla Port is equipped with a marginal wharf consisting of 5 berths, (each 183 m long) and 6 swinging mooring buoys. In addition to the vessels moored at the buoys, 15 to 20 vessels may be anchored within a stretch of about 10 km working range.

Cargo handling equipment includes 7 rail mounted quay cranes, 3 straddle carriers, 31 fork lift trucks 11 mobile cranes, tractors and trailers, which seems perhaps more than adequate.

The transit sheds and the ware-houses cover 39000 m^2 and are under-utilized.

The Mongla Port originally was known as Chalna, started functioning in 1950 as an Anchorage on the Pussur river at Chalna. Due to vortex formation and wave action, the Anchorage was shifted to Mongla, the present location in 1954.

The construction of deep water berths and other ancillary facilities at Mongla were started in 1962 as per recommendation of Consultants Frederick R. Harris and Partners. By now 5 permanent berths, transit sheds, warehouses, open storage and other facilities have been constructed at Mongla. Modern cargo handling equipment including wharf cranes are therefore port operation. During feasibility stage (1954 - 1960) the Pussur Channel was found to be an excellent and stable waterway in the SW Area for establishment of Second Sea Port in the then East Pakistan.

The stability of the Pussur channel in front of the permanent berths at Mongla may be seen in Table 5.1.

TABLE 5.1

Stability of Pussur Channel

Survey Date	Mean csa $(ft)^2$
January 1954	60612
December 1956	60181
February 1959	61237
March 1961	60093
December 1965	61740
December 1966	60874
November 1970	62625

Source: Farleigh, Ref 1

However due to construction of coastal embankments and depletion of upland flow from the Gorai - Madhumati system, the condition of the Pussur channel deteriorated.

The changes in channel dimensions in section 1 to 9 infront of berths at Mongla at 400' apart are shown in Table 5.2 below.

TABLE 5.2

Changes in Channel Dimensions

Section	Dec 1966	Nov 1970	Dec 1973	Mar 1976	Feb 1980
1	61532	60705	56333	47647	48924
2	60693	62636	56031	49822	47400
3	62425	62188	54028	48940	48303
4	60302	62805	52441	49766	46750
5	61875	63425	52850	44397	45400
6	59369	61478	55469	47672	48160
7	60840	60146	53467	47306	43773
8	59464	65130	54340	48864	48422
9	61070	65117	52662	49073	47684
Mean	60874	62625	54180	48165	47202

Source: Farleigh Ref 1.

The stability of Pussur channel in the Port reach rapidly deteriorated.

A representative section of the Pussur channel in front of the berths is shown in Figure 5.1.

Prior to 1967 the Pussur downstream of Chalna was very stable. Deterioration at Chalna confluence started in 1968 and moved downstream. During the end of the liberation war in 1971 ships were sunk in the Pussur channel. Many barges and small vessels were also sunk. As a result there was great channel deterioration and reduction of depth.

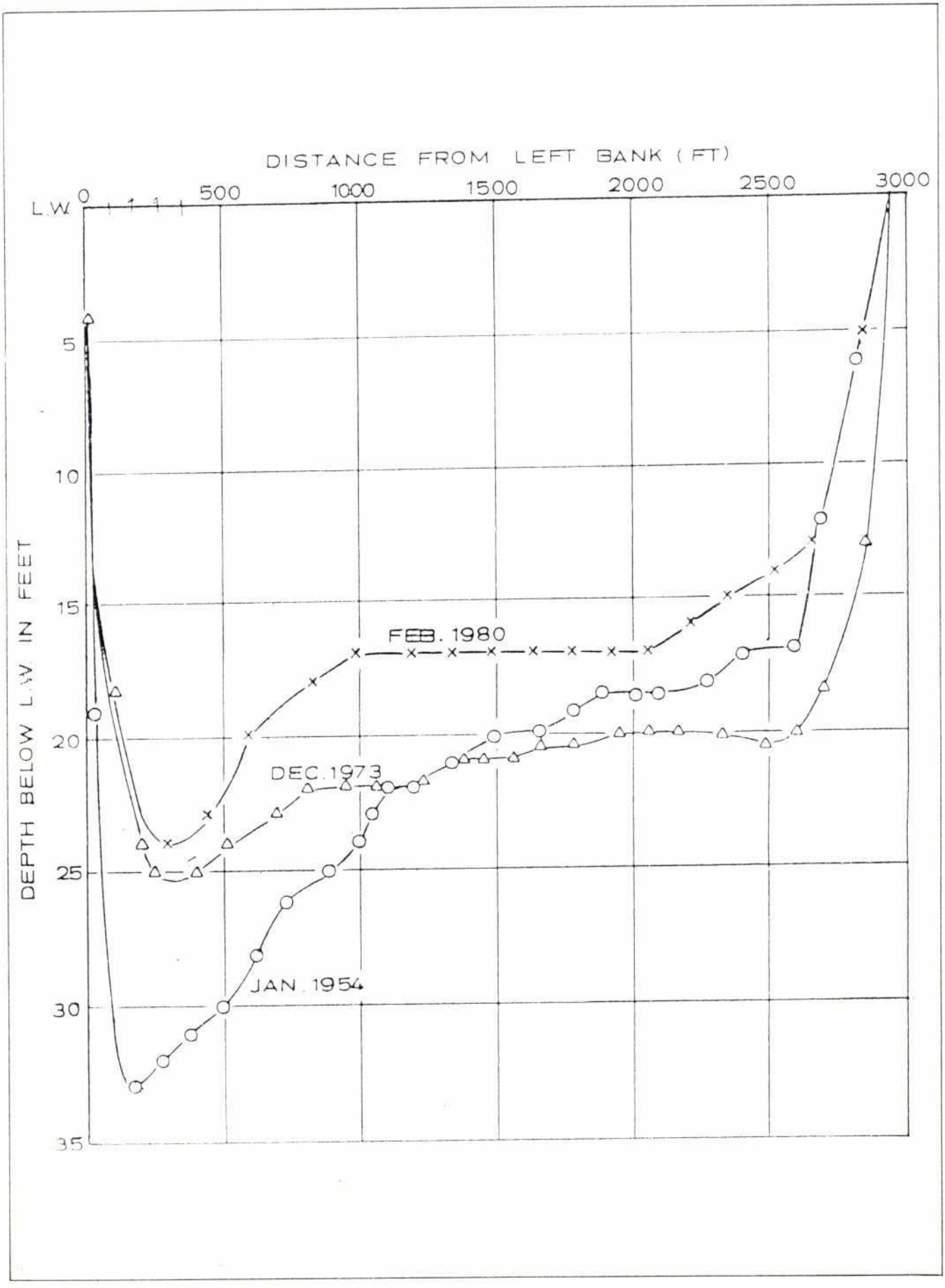
5.2 Traffic, Operation and Connecting Transport System

The cargo traffic on Mongla Port in 1991/92 and average values of 1987/88 through 1990/91 are presented in Table 5.3.

The major part of the cargo is discharged by or loaded on to the vessels at anchor. Also vessels at berth are seen discharging on to the quay as well as into lighters at the same time. The details of the cargo being handled over the wharves and at anchor are illustrated below where numbers and quantities refer to the average of 1987/88 through 1990/91.

Ships at wharves:			
Conventional vessels, Nos		55	
Vessels carrying containers, nos		135	190
Ships at anchorage, nos			279
Ships, total, nos			469
Handling of cargo ('000 t):	Import	Export	Total
At wharves	37	94	131
At anchorage	1942	535	2477
	1979	629	2608

Figure 5.1



Pussur River Cross-Section
at Port of Chalna Shipping Berths

TABLE 5.3

Cargo Traffic through Mongla Port

Year		Unit	Import	Export	Total
1991/92	Cargo	'000 t	2054	596	2650
	Containers	TEU	6821	6817	13638
Average 1987/88 through 1990/91	Cargo	000t	1979	629	2608
	Commodities:				
	Jute			43%	10%
	Jute products			53%	13%
	Food grain		35%		26%
	Cement		40%		30%
	Fertilizer		15%		12%
	Coal		5%		4%
	Salt		2%		2%
	Shrimp			1%	0%
	General cargo				3%
			100%	100%	100%
			= = =	= = =	= = =
	Containers: Loaded	TEU	756	6940	7696
	Empty	TEU	6867	727	7594
	Total	TEU	7623	7667	15290

Since the central region of the Southwest Area is a major producer of jute and jute products it is not surprising that these commodities make-up a very substantial share (96%) of the export through Mongla Port. Also jute and jute products from other parts of the country, e.g. the region around Dhaka make their way to Mongla for export. This export is containerized. Mostly the jute and the jute products arrive by barge at Mongla and are stuffed in containers at the port. This traffic, which is not matched by a similar import in containers, has resulted in a substantial imbalance with respect to containers. In fact it is necessary to import empty containers corresponding to nearly 7000 TEU in order to be able to provide sufficient containers for the jute related export. It is not surprising that Mongla Port is looking for a greater share of the containerized import.

Table 5.4 provides information on the import/export at both Mongla Port and Chittagong Port. It is seen that during the years 1984/85 through 1991/92 only 23% of the import passed through Mongla. e.g. the entire import of petroleum products, which make up 22% of the import, passed Chittagong because Mongla has no oil jetty or oil storage facilities. The export has been shared with 51% passing through Mongla. However, the export through Mongla has been stagnating around 630,000 t the last 8 years whereas the export through Chittagong during the same period has steadily increased at a rate of approximately 6% annually.

An important point is how Mongla is connected to the domestic transport system. Here Mongla is left somewhat in the open.

The northwest region of Bangladesh which should be the natural hinterland for Mongla Port cannot be reached directly by inland waterway because of siltation in the rivers. Road

connection is difficult because of ferry crossings at Khulna and Paksey and transport by rail will require that the cargo is carried by road and ferry or by barge to Khulna, the southern most point of the railway net work apart from Bagerhat.

The shortest road link between Dhaka and Khulna is fragmented by 8 ferry crossings over a distance of about 250 km.

A result of the incomplete connection between Mongla and the domestic transport network is that: 1) Most import/export cargo passing Mongla Port is carried by inland water way, 2) Some cargo to the northwest is travelling east then north and finally in western direction, and 3) Some import cargo to the northwest is taken in via Chittagong.

5.3 Future Projection

The projection presented in Table 5.5 of the future export/import through the two seaports are in no way the result of an in depth analysis, but merely rough estimates taking into account general information on some of the main commodities.

The import of foodgrain has decreased at a rate of 3.3% over the period 1985/86 to 1990/91, see Table 5.4. Possibly this is a result of the Government's drive for self sufficiency. Even though this policy may remain it is assumed that the import of foodgrain will reduce at a low rate, only. A might estimate would be: 1500 t in 95/96 and 1200 t in 2000/01.

The import of cement has been fairly stable over the past 8 years. It is assumed that local production gradually will pick up the increased demand and therefore import will remain at 1.4 M t over the next 10 years.

It is understood that increased use of fertiliser is an element of the agricultural policy. In spite of increased domestic production, it is estimated that the import will increase to 1.0 M t in 1995/96 and then remain unchanged over the next 5 years.

POL and "Other" are expected to increase in the future at their present rates of growth which are 1.6% and 4.5%, respectively.

The export of jute and jute products has experienced a minor decline during the past 8 years. There seem to be no reason for increasing or decreasing the present export level.

Garments have increased by more than 50% during the last 4 years. We assume that the trend will continue, but at a lower pace, say 20%.

The split of the cargo between the two seaports is also presented in Table 5.5.

TABLE 5.4

Import/Export through Chittagong and Mongla Ports in '000 Metric Tons

Commodity/Item	Port	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	Ave	Percent
IMPORT											
POL + Oil in drums	Ctg	1675	2010	1785	2135	2016	2193	1904	1818		
	Mgl	0	0	0	0	0	0	0	0		
	Total	**1675**	**2010**	**1785**	**2135**	**2016**	**2193**	**1904**	**1818**	1942	23
Food grain	Ctg	2060	794	1340	2273	1706	1117	1275	1236		
	Mgl	908	448	445	1064	689	459	530	460		
	Total	**2968**	**1242**	**1785**	**3337**	**2395**	**1576**	**1805**	**1696**	2100	25
Cement	Ctg	735	579	626	599	799	573	514	452		
	Mgl	589	642	797	798	634	867	875	968		
	Total	**1324**	**1221**	**1423**	**1397**	**1433**	**1440**	**1389**	**1420**	1381	16
Fertilizer	Ctg	430	490	51	106	232	142	182	231		
	Mgl	429	185	97	200	413	258	304	391		
	Total	**859**	**775**	**148**	**306**	**645**	**400**	**486**	**622**	530	6
Coal	Ctg	1	30	89	48	22	282	45	31		
	Mgl	0	5	80	49	30	196	93	72		
	Total	**1**	**35**	**169**	**97**	**52**	**478**	**138**	**103**	134	2
Salt	Ctg	130	288	110	144	291	106	278	253		
	Mgl	70	86	24	63	49	8	33	115		
	Total	**200**	**374**	**134**	**207**	**340**	**114**	**311**	**368**	252	3
Other	Ctg	1797	1623	1835	1804	2056	2386	2084	2246		
	Mgl	90	195	114	62	67	104	69	48		
	Total	**1887**	**1718**	**1949**	**1866**	**2123**	**2490**	**2153**	**2294**	2060	25
Total Imports	Ctg	6828	5814	5836	7109	7122	6799	6282	6267	6506	77
	Mgl	2086	1561	1557	2236	1882	1892	1904	2054	1897	23
	Total	**8914**	**7375**	**7393**	**9345**	**9004**	**8691**	**8186**	**8321**	**8403**	**100**
Average 3 years			**7894**						**8399**	**8403**	
				..... Annual Growth 1.2%							
EXPORT											
Jute	Ctg	6	7	4	0	0	2	3	2		
	Mgl	250	409	380	247	271	319	244	255		
	Total	**256**	**416**	**384**	**247**	**271**	**321**	**247**	**257**	300	23
Jute products	Ctg	144	130	114	121	104	78	138	169		
	Mgl	314	341	340	353	342	363	279	328		
	Total	**458**	**471**	**454**	**474**	**446**	**441**	**417**	**497**	457	36
Fertilizer	Ctg	0	0	0	171	336	109	253	107		
	Mgl	0	0	0	17	13	0	18	0		
	Total	**0**	**0**	**0**	**188**	**349**	**109**	**271**	**107**	128	10
Naptha, Molasses, Bunker etc	Ctg	18	33	69	118	140	170	227	181		
	Mgl	0	0	0	0	0	0	0	0		
	Total	**18**	**33**	**69**	**118**	**140**	**170**	**227**	**181**	120	10
Fish, dry & frozen shrimp, frozen goods	Ctg	9	8	5	12	5	11	17	17		
	Mgl	5	9	8	8	8	10	11	10		
	Total	**14**	**17**	**13**	**20**	**13**	**21**	**28**	**27**	19	2
Garments	Ctg	0	0	0	19	11	44	74	110		
	Mgl	0	0	0	0	0	0	0	0		
	Total	**0**	**0**	**0**	**19**	**11**	**44**	**74**	**110**	32	3
Other	Ctg	153	160	211	198	238	282	207	184		
	Mgl	8	3	3	3	3	3	5	3		
	Total	**161**	**163**	**214**	**201**	**241**	**285**	**212**	**187**	208	16
Total Export	Ctg	330	338	403	639	834	696	919	770	616	49
	Mgl	577	762	731	628	637	695	557	596	648	51
	Total	**907**	**1100**	**1134**	**1267**	**1471**	**1391**	**1476**	**1366**	**1264**	**100**
Average 3 years				1047					1411		
						– Annual Growth 6.1% –					
TOTAL TRAFFIC											
Total Import		8914	7393	7393	9345	9004	8691	8186	8321	8403	87
Total Export		907	1100	1134	1267	1471	1391	1476	1366	1264	13
Total Traffic		**9821**	**8493**	**8527**	**10612**	**10475**	**10082**	**9662**	**9687**	**9667**	**100**
Average 3 years				8947					9810		
						– Annual Growth 2.9% –					

TABLE 5.5

Cargo Volume Projections in 1000 Metric Tons

Commodity	Port	90/91	95/96	00/01
IMPORT				
POL + Oil in drums	Ctg	1975	2140	2320
	Mgl	0	0	0
	Total	1975	2140	2320
Food grain	Ctg	1200	1050	800
	Mgl	500	450	400
	Total	1700	1500	1200
Cement	Ctg	500	500	500
	Mgl	900	900	900
	Total	1400	1400	1400
Fertilizer	Ctg	200	400	400
	Mgl	300	600	600
	Total	500	1000	1000
Other	Ctg	2575	3220	4000
	Mgl	250	300	390
	Total	2825	3520	4390
Total Import	Ctg	6450	7310	8020
	Mgl	1950	2250	2290
	Total	8400	9560	10310
EXPORT				
Jute + Jute products	Ctg	130	130	130
	Mgl	620	620	620
	Total	750	750	750
Fertilizer, Naptha, Bunker etc	Ctg	350	400	455
	Mgl	50	10	15
	Total	355	410	470
Fish, Shrimp, frozen goods	Ctg	15	30	45
	Mgl	10	20	30
	Total	25	50	75
Garments	Ctg	80	180	450
	Mgl	0	20	50
	Total	80	200	500
Others	Ctg	195	263	350
	Mgl	50	7	10
	Total	200	270	360
Total Export	Ctg	770	1003	1430
	Mgl	640	677	725
	Total	1410	1680	2155
TOTAL TRAFFIC				
Total Import		8400	9560	10310
Total Export		1410	1680	2155
Total Transport		9810	11240	12465

The distribution between the two ports will be very much affected by 1) Government's policies with respect to the national transport network and 2) The possibilities of maintaining the required navigational water depths in Mongla Port and Pussur River. Point 2) is dealt with in sub-section 6.4 below.

In respect of the national transport network reference is made to the Bangladesh Transport Sector Review carried out by the World Bank. This study included the development of a network model of the road, rail and river transport system. In this model several scenarios and their effects on the total cost of transport were tested against a base network. Scenario 8 examines transport flows when cargo moving through the two sea ports is rationally split relative to the inland origin or destination. This scenario resulted in the largest system cost reduction for freight transport (115 M USD per year). The study finds that the potential for development of Mongla Port deserves special attention and that the Government should attach a high priority to dredging investments which are relatively minor costs in comparison with other major investments now planned for the transport sector.

Bangladesh Transport Sector Review also advocates the development of certain arterial corridors and arrives at the conclusion that the system of arterial corridors combined with a rational split of the traffic between the two sea ports would result in a reduction in total system operating costs of the order of 10%.

The Government of Bangladesh - in fact - is seriously considering the execution of a study which should result in a Master Plan for the Chittagong, Mongla and Dhaka ports which will identify such physical facilities and other measures in the three ports that will ensure a development towards economically optimal transport of all cargo.

To which extent the Government of Bangladesh has accepted the above mentioned ideas on arterial corridors is not known.

For several years it has been considered to open a route through Bangladesh and India for over land transit traffic to/from Nepal, but no such traffic exists at the moment. Events in this connection have been:

- 1978; Memorandum of understanding between Bangladesh and India signed.
- 1982, January 31: Report sponsored by UNDP and prepared by ESCAP on Prospects of Inland Waterway Transportation in Bangladesh for Nepal Transit Traffic completed and issued.
- 1986, September 1-4, The Sixth Session of Bangladesh Nepal Economic Commission appoints a joint study team to examine the possibilities of routing Nepal's Cargo to Mongla Port and make recommendations to the concerned authorities.

Rough guesstimates arrive at a possible Nepal Third Country Transit Traffic of magnitude as shown below:

1995 : 1.5 x M t
2000 : 2.0 x M t
2005 : 2.5 x M t

Mongla Port is an obvious point for the cargo to be transferred from/to sea transport. This study has not attempted to estimate the share of the Nepal Third Country Transit Traffic which could be diverted through Mongla.

The various data and information provided in this sub-section clearly illustrate how difficult it is, at this stage, to assess the future potential of Port of Mongla and subsequently to quantify the possible benefits or disbenefits to the port caused by water resources developments.

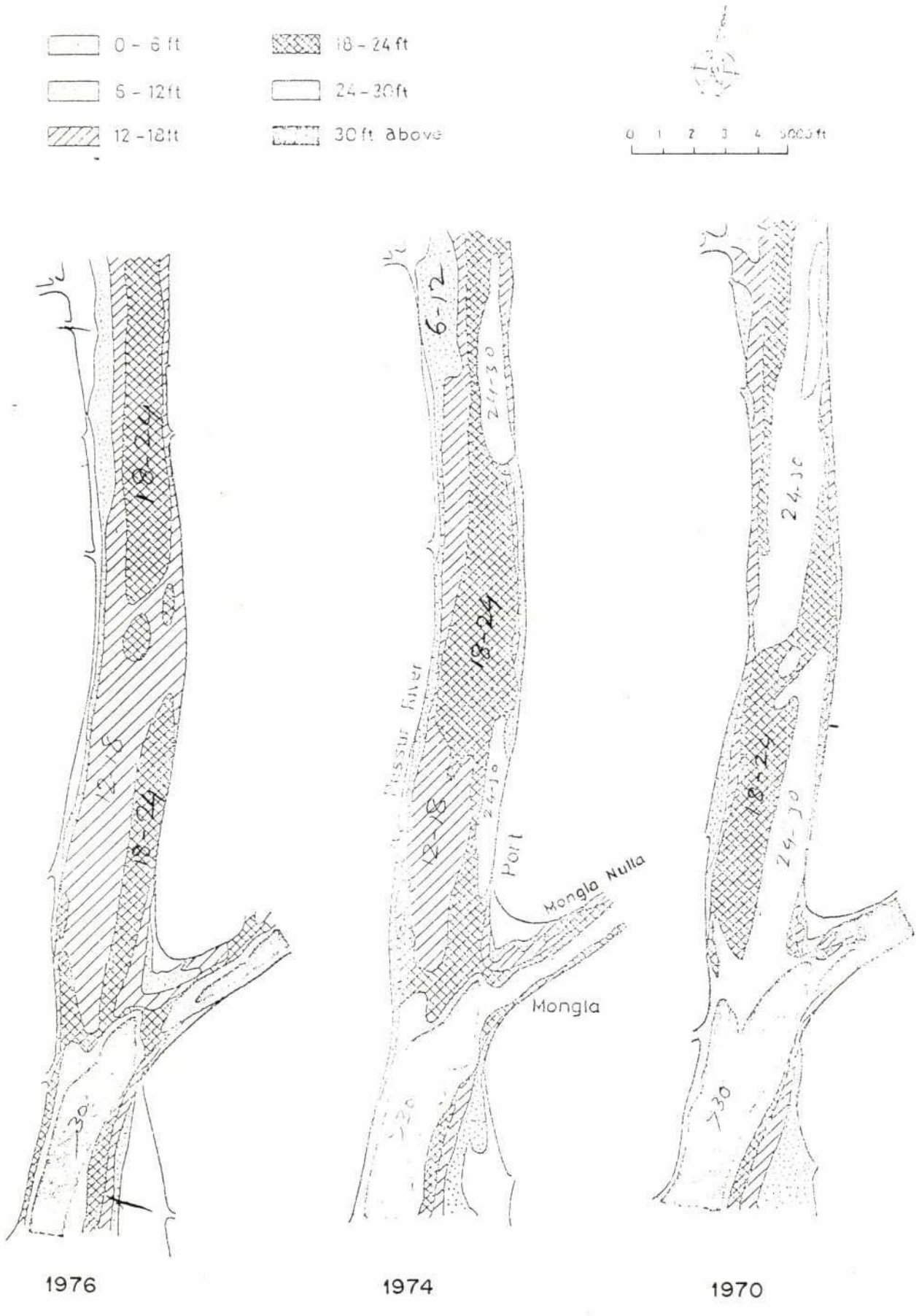
5.4 Siltation and Dredging

It is well known (Ref. 1, 5, 9) that Mongla Port since 1970 has been subject to substantial siltation and therefore frequent dredging has been necessary to maintain the desired water depth along the berths. Some data illustrating this are presented below.

Farleigh (Ref 5) illustrates the deterioration of the port reach during 1970 to 1976 by contoured charts reproduced in Figure 5.2. Further, measurements of the LW cross sectional area at 9 equally spaced cross-sections off the future or existing berths between 1954 and 1989 are illustrative. Mean values are reproduced in Table 5.6 together with data from another cross-section of the Pussur River, about 2 nautical miles upstream of the Port.

Finally, Farleigh reports the results from test dredging of a 100' to 300' wide and 3000' long channel in front of the berths in 1983. He reports that maintenance dredging amounts vary between 0.79×10^6 cu ft and 0.86×10^6 cu ft. Because of the narrow interval these results look very convincing, but in fact some refer to a 100' wide channel and other to a 300' wide channel. Further, Farleigh's calculation when switching from the 100' wide to the 300' wide channel are unclear and are therefore not used except for those from a 11 weeks (= 2.5 months) period Jan - Mar 1984 where dredging had stopped and sedimentation was measured at 2.44 ft corresponding to approximately 1 foot a month.

Figure 5.2



Port Reach Surveys, 1970-1976

TABLE 4.2
Numbers and Capacity of Registered Cargo Vessels in the IWT Fleet

Type of vessel	1978-79		1982-83		1986-87		1988-89		1989-90		1990-91		Pub/ Priv. (%)
	Nos	Load capacity (t)	Nos	Load Capacity (t)	Nos	Load Capacity (t)	Nos	Load Capacity (t)	Nos	Load Capacity (t)	Nos	Load Capacity (t)	
BAY CROSSING													
Coasters (dry)	50	31521	100	74114	97	72479	113	85629	115	87197	100	76053	22/78
[Aver. Capacity]		[630]		[741]		[747]		[757]		[758]		[761]	
Tanker (POL)	24	20540	30	25389	40	34435	58	68219	63	73463	64	73463	17/83
[Aver. Capacity]		[856]		[846]		[861]		[1176]		[1166]		[1148]	
Tug	7		6		6		6		5		5		
Dumb Craft-Flat	8	4512	8	4584	0	-	4	2256	4	2256	0	0	
[Ave. Capacity]		[564]		[573]				[564]		[564]			
Dumb Craft-Barge	54	31068	52	30852	35	24766	35	24380	76	52094	71	51274	46/54
[Ave.Capacity]		[575]		[593]		[708]		[697]		[685]		[722]	
Bay Crossing (dry)		67101		109550		97245		112265		141547		127327	
INLAND													
S-P Cargo Vessel [1]	372	48818	562	96278	889	167310	1156	244003	1163	271023	1247	298249	1/99
[Ave. Capacity]		[131]		[171]		[188]		[211]		[233]		[239]	
Inland tanker	1	388	8	2635	13	4693	21	6699	21	6699	23	6699	
[Ave. Capacity]		[388]		[329]		[361]		[319]		[319]		[291]	
Tug	142		175		182		192		200		192		
Dumb craft-Flat	101	63605	88	55241	73	43728	64	37405	43	22356	43	22356	0/100
[Ave. Capacity]		[630]		[628]		[599]		[584]		[520]		[520]	
Dumb craft-Barge	653	156249	675	176738	702	186982	655	178809	657	179922	618	169660	15/85
[Ave. Capacity]		[239]		[262]		[266]		[273]		[274]		[275]	
Barge or Flat (POL)	12	2804	23	6820	23	6674	26	6674	26	6674	26	6674	
Others	54	6057	45	5501	32	4003	31	3965	218	50897	200	49261	32/68
[Average Capacity]		[112]		[122]		[125]		[128]		[233]		[246]	
Inland, Total (dry)		274729		333758		402023		464182		524198		539526	
Inland, Total (POL)		3192		9455		11367		13373		13373		13373	
BAY CROSSING AND INLAND FLEETS													
Total Capacity (dry)		341830		443308		4992668		576447		665745		666853	
Public sector in percent of total dry						23		16		14		13	
Total Capacity (POL)		70293		119550		108612		125638		154920		140700	
Public sector in percent of total POL						9		10		8		9	

1) Self Propelled Cargo Vessels Source : Annual Ports and Traffic Reports, BIWTA

TABLE 5.6

River Cross-sectional Areas 1954 - 84

Date of Survey	River c.s.a. at LW in ft²					
	Port Reach of existing cr. present berths			Laudubi Khal Reach 2 km upstream Port		
Jan 54	60612					
Dec 56	60181					
Feb 59	61237					
Mar 61	60093					
Dec 65	61740	Stable		56690		
Dec 66	60874		Construction of	54562		
					Stable	
Dec 67			Polders	56250		
Dec 69	62070					
Nov 70	62625					
Aug 72	54016			49144	Siltation	
Dec 73	54180	Siltation		50174	Siltation	
Apr 74	51157			44865	Stable	
Feb 76	46346			41527		
Aug 76	48323	1) Dredging		44690		
Oct 78	47618			39638		
Feb 80	47202	Stable		43943	Stable	
Jun 80	47870					
Mar 82	48249					
May 82	48730					
Dec 82	48493					
Mar 83	50353					
Jul 83	56880	2) Dredging		43500		
Sep 83	52380					
Jan 84	54530					

Notes: 1) Dredging at jetty front removing 3m - 3.5m silt; Refilled within 15 months.

2) Dredging 11.69 x 10^6 ft³ = 310024 m³ recorded by Farleigh

TABLE 5.7

Data on Dredging 1983 to 1989

Place of Dredging	Dredging Year	Completion Year	Dredged Volume	Achieved Depth
Jetty front	Early 1983	Late 1983	12.17×10^6 cu ft = 345 067 m^3	- 28.0 m
Jetty front	1986	1986	3.82×10^6 cu ft = 108 360 m^3	- 28.0 m
Jetty front	Nov 1988	Feb 1989	7.41×10^6 cu ft = 210 201 m^3	- 28.0 m

In Table 5.7 gives the data on dredging between 1983 and 1989. The data originate from Mongla Port and have been used for the following computation of the rate of siltation.

Period of time : 5 years and 2 months = 62 months

Volume removed : $(3.82 + 7.41)\ 10^6 = 11.2 \times 10^6$ cu ft.

Corresponding to 0.18×10^6 cu ft/month

or 0.2 ft/months ($\approx$ 0.06 m/month) assuming the area in question is 300' x 3000'.

By the end of the 1980 ies dredging was again required. On the basis of international competitive bidding a contract was signed in November 1990 with M/S China Harbours Engineering and the work commenced in March 1991 and is nearly completed. The work consists of:

Approach (confluence)	- 8.5 m	0.8×10^6 m^3
In front of berths	- 8.5 m	0.3×10^6 m^3
At Sabour beacon	- 8.0 m	1.7×10^6 m^3
Southern anchorage		1.0×10^6 m^3
Reserve		0.1×10^6 m^3
		3.9×10^6 m3

Verbally the Consultants have received the following data from Mongla Port:

	Depth below CD in m	Rate of Siltation
Confluence February 10, 1992 July 4, 1992	 9.0 8.3	0.15 m/months
Sabour Beacon April 4, 1992 July 7, 1992	 9.1 8.1	0.32 m/months
Southern Anchorage March 15, 1992 June 17, 1992	 9.0 7.0	0.65 m/months
In front of Berths July 25, 1992 " " "	 Min 8.5 m Max 11.0 m	

The Mathematical Model study in Pussur - Sibsa River Study (Ref 13) reports from the same dredging work that in the Sabour Beacon Area the dredging was carried out to 2-3 meters below existing bed level and that setting to near initial levels took place in 3 to 4 months. This indicates a rate of siltation in the order of 0.5 m to 1.0 m per months.

Based on the above data the siltation rate is estimated at 0.25 m/month at Confluence, Sabour Beacon and the channel in front of the berths, and the total area to be dredged is estimated as follows:

-	Approach	800 x 250 =	200000 m²
-	In front of jetty	100 x 300 =	300000 m²
-	Sabour Beeca Area	100 x 350 =	350000 m²
-	Total Area		850000 m²

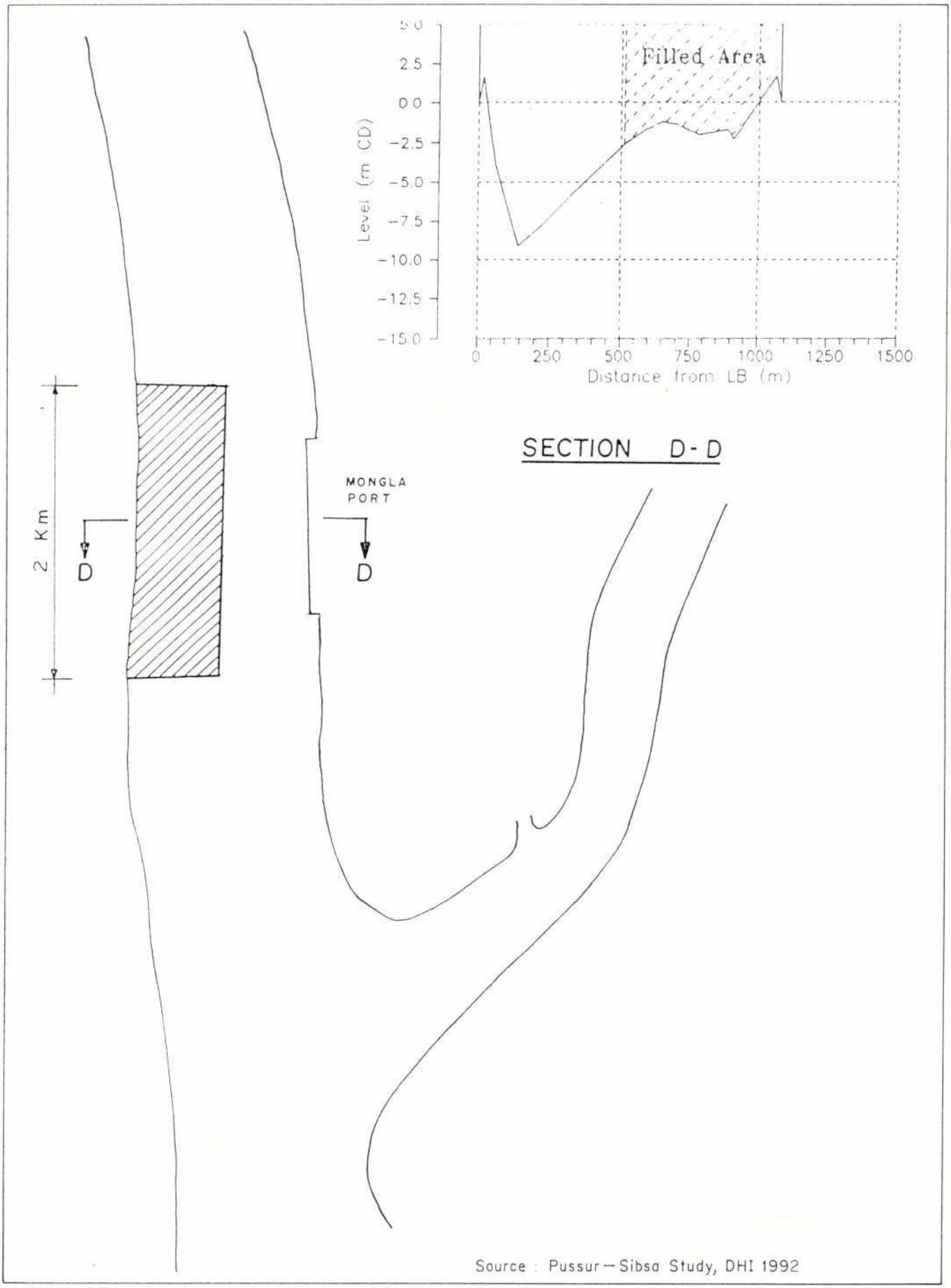
Annual maintenance dredging will then be 850,000 x 0.25 x 12 = 2.6 M m^3/year. This estimate does not include dredging in Pussur River south of Pussur Nullah Confluence.

5.5 Schemes to solve Mongla Port Siltation

The first scientific investigation and study of the problem was carried out by Farleigh. He had mathematical modelling of the river net-work carried out at HR Wallingford. Eight schemes were tested. Scheme No. 6 included a constriction of the Port Reach to two-thirds of its width over a length of approximately 3 km (tested in scheme 2) combined with compensation dredging (tested in scheme 6). This was the only scheme without adverse effects throughout the entire network.

Recently Danish Hydraulic Institute has carried out a mathematical model study of the Pussur - Sibsa River System (Ref 9, 13, 15). All together 12 schemes were tested however the study was inconclusive. Only two of these shall be briefly mentioned:

Figure 5.3



DHI Scheme 2
Constriction near Mongla Jetty

- Scheme 2; Constriction of Pussur River from a width of nearly 1100 m down to 500 m over a 2 km section of the river off the Port area. The testing shows that the scheme has no measurable effect on the hydraulic key parameter of the river system in general. At Mongla Port peak velocities will increase by about 50% (Figure 5.3).

- Scheme 3; Approximately 250 m wide and 4.8 km long channel to level - 12.3m C.D. near the left bank. This scheme will result in reduction of the peak velocity by 1% to 15% off the port. Impact on the Pussur - Sibsa River system in general will be insignificant. In this case also the sedimentation was analysed in a mathematical model. Based on this the annual sedimentation has been estimated at 0.9 x 10 m^3 to 2.4 x 10 m^3. The report recommend that further considerations of this scheme are based on an annual silting rate of 1.7 x 10^6 m^3. Capital dredging has been estimated at 6 M m^3 to 6.5 M m^3. Finally this scheme will slightly raise the net transport in Pussur River, which is a positive effect (Figure 5.4).

Based on the above results of mathematical modelling the Consultants find that three solutions may be possible:

(a) Dredging when and as required. Annual maintenance dredging 2.6 M m^3. Annual cost: 5.2 M USD

(b) Dredging of 250 m wide and 4.8 km long channel to level - 12.3 m. Capital dredging 6.5 M m^3. Annual maintenance dredging 1.7 M m^3. Capital cost 13 M USD; Annual Cost 3.4 M USD

(c) Combination of DHI scheme 2 and schemes recommended by Farleigh. Constriction of Pussur River off Mongla Port in combination with a dredged channel (250m x 2000m). The width of the river is reduced from 1100 m to 500 m by a 2000 m long embankment connected to the right bank by a 600 m long access bund. Building materials will be sand, sand in jute bags, geotextiles and stones (armour).

Construction cost incl. dredging of channel: 7.0 M USD

Annual costs: Maintenance of embankment 0.3 M USD

Discounting the investment and annual costs over a period of 20 years using a rate of interest of 12% results in

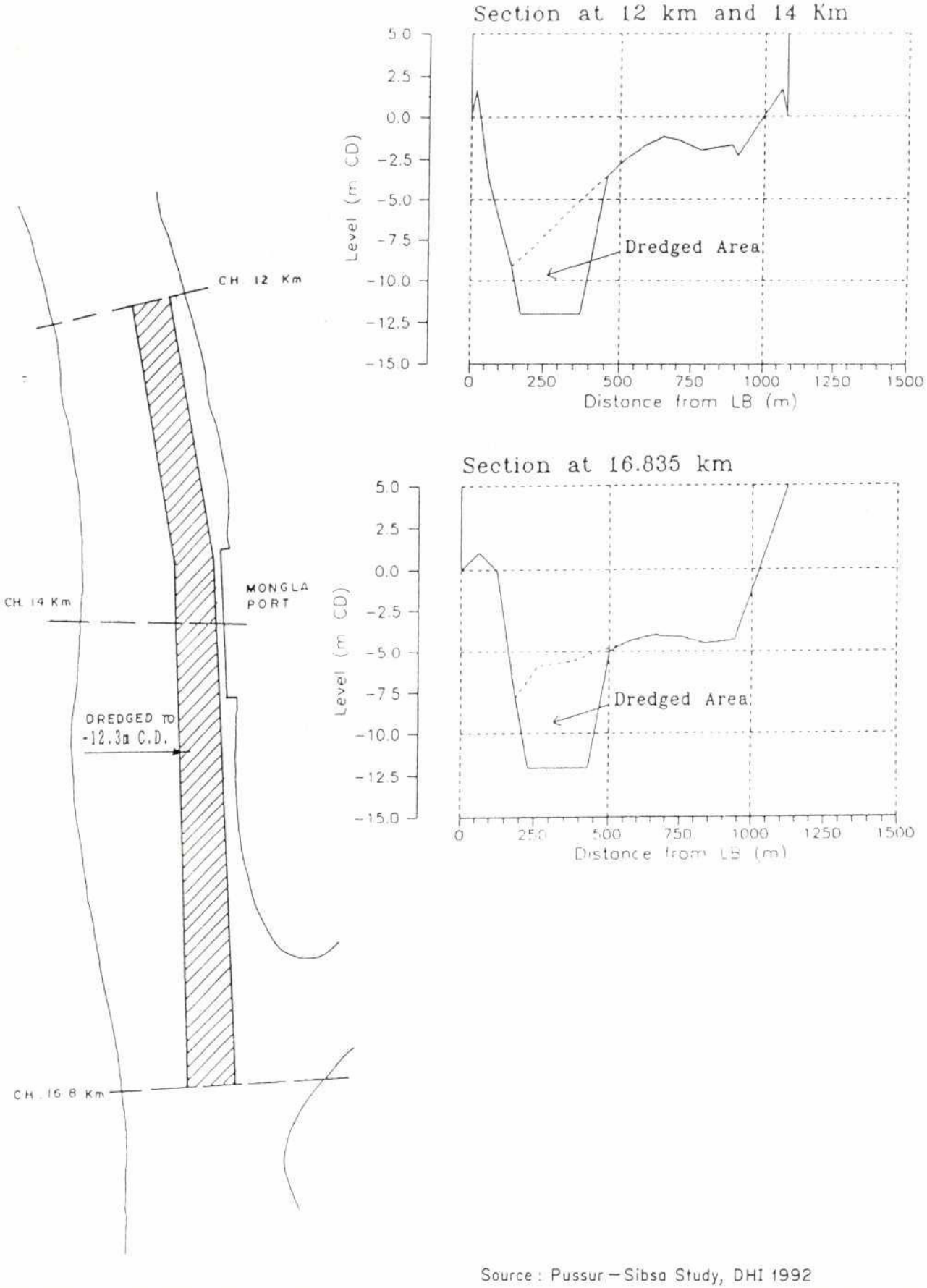
Solution:		a	b	c
NPV (M USD)	39.0	38.5	10.8	

This indicates that solution (c) may be the most economical of the three.

It should be noted, however, that the result of the above analysis is based on the data which have been available. This basis is insufficient for selecting the solution but it is adequate as background for specifying further investigations.

Note: The costs calculated above do not include possible maintenance dredging South of Mongla Confluence.

Figure 5.4



Source : Pussur – Sibsa Study, DHI 1992

DHI Scheme 3
Dredging near Mongla Port

The maintenance dredging done by the Mongla Port Authority during the period from 1979 to 1990 to increase depth in front of the jetties were not successful. Table 5.8 shows the statement of trial/maintenance dredging. Capital dredging contracted with China Harbour Co and recently completed was also not successful. The rate of siltation is shown in Table 5.9 Without change of tidal storage, then navigability of Pussur Channel is not likely to be improved.

Therefore local dredging may not be successful to maintain navigability of Pussur channel.

TABLE 5.8

Statement of trial/maintenance dredging from 1979 to 1990

Sl No	Name of Agency	Place of Dredging	Dredging year	Completion year	Executed Volume m^3	Cost in Taka	Achieved Draught ft. C.D.	Remarks
	Completed work							
1	BWDB	Jetty front	1979	1981	327285.00	8907521.00	--	Not successful
2	BIWTA	Jetty front	1983	1983	345067.00	14917258.00	28	--
3	BWDB	Confluence	1983	1985	122900.76	6093000.00	--	Not successful
4	BWDB	Sabur beacon	1984	1984	231177.00	10692968.00	28	
5	BIWTA	Confluence	1984	1985	204580.00	8859000.00	--	Not successful
6	BIWTA	Jetty front	1986	1986	108360.00	4933786.00	28	
7	BWDB	Jetty front	1988 (20.11.88)	1989	210201.18	10447605.29	28	
8	BWDB	Confluence	1989	1989	62533.82	3001623.36	--	Not successful
	On going							
9	BWDB	Jetty front	1990 (01.04.90)	Ongoing	100000.00 upto 25.8.90	5759501.50 Paid as advance 25% of total amount		Contract volume of Earth - 397,207 m^3 contract Tk 23038006.00 @ 58/= per m^3

TABLE 5.9

Rate of Siltation at Mongla Port

1. Siltation Rate after Dredging

(a) Confluence

Date	Av. Depth below chart Datum
10.2.92	9.00 m
04.7.92	8.30 m

(b) Sabur Beacon

28.4.92	9.1 m
26.7.92	8.1 m

(c) Southern Anchorage

15.3.92	9.00 m
17.6.92	7.00 m

2. Available Draft infront of Jetty

According to post Dredging Hydrographic Survey on 25.7.92.

Minimum - 8.5 m below C.D.
Maximum - 11.0 m below C.D.

3. Draft Restriction at the Outer Bar

Anticipated Draft Chart attached.

4. Seal at Confluence

1050 m x 200 m of the seal at Confluence has been dredged up to a depth of average 9.00 m below C.D.

5. Tidal Surge measurements on 29.11.88

	Time	Height
(a) Mongla	22:00 hrs	14:40 6+ above CD.1
(b) Hiron Point	19:30 hrs	13:60 6+ "

6. Channel depth Historical Changes

The draft and position of Navigational channel from Fairway to permanent port is found gradually decreasing every year. Although the draft of the navigational channel at one or two points has been found increasing but it is found that there is a tendency of decreasing the draft and width of the navigational channel at most of the points.

6 FERRY SERVICES

In Bangladesh 27 ferries are being operated by the BIWTC, and Bangladesh Railways. Another 20 ferries are being operated by the Roads and Highways Department.

(i) BIWTC Ferries:

BIWTC is operating ferries at the following places:

(a)	Aricha	-	Daulatdia
(b)	Aricha	-	Nagarbari
(c)	Bhuapur	-	Sirajganj

The above are class II Routes and the draft limit is 1.8 m. Since ferry is a link for the vehicular traffic, BIWTA is marking the route for day and night navigation. The draft is assured throughout the year by undertaking preventive bandelling and dredging so that these essential services are almost never suspended.

At the above ferry terminals, the ferry approach and shore pontoons are maintained by BIWTA with rising and falling water levels. Since the banks are being eroded and sometimes channels are shifting away the BIWTA is always arranging substitute approaches in advance at suitable location in order to avoid disruption to the ferry operation. Even so the ferry services are disrupted for a day or two every year.

The BIWTC operates modern Ro-Ro ferries and ordinary self propelled ferries with flap gates. Pusher barges are also being used as ferries on Aricha-Daulatdia and Aricha-Nagarbari routes.

The Roads and Highway Department is operating ferries at Pakshi near Hardinge Bridge, Rupsa ghat at Khulna and 5 to 6 ferries on medium and small rivers in the Southwest Areas. At Rupsa ghat the shore approaches are maintained by BIWTA. In rest of the places, the shore facilities are maintained by the R & H Department. These ferries are for passenger and vehicular traffic.

(ii) Bangladesh Railway Ferries

The Railway Department is maintaining its own ferry services across the Jamuna river for ferrying passengers and goods connecting Bahadurabad Fulchari, and Jagannathganj Sirajganj. These ferries are having draft of 1.8 m and can carry passengers up to 3000.

The Railway is also operating wagon ferry across the above two lines. However these services are outside the Project area.

Table 6.1 gives the details of the number of ferry and launch etc in the study Area.

TABLE 6.1

Number of Launch and Ferry Ghats of BIWTA in SWA (February, 1990)

Name of District	Terminals	Launch Ghat	Ferry Ghat	Coastal Island Terminal Jetty	Total
Faridpur	-	1	-	-	1
Madaripur	-	3	-	-	3
Goalanda	-	1	-	-	1
Gopalganj	-	4	-	-	4
Khulna	1	13	10	-	24
Barisal	1	14	2	7	24
Patuakhali	1	6	-	2	9
Bagerhat	-	4	-	-	4
Pirojpur	-	8	-	-	8
Jhalakati	-	2	-	-	2
Bhola	-	1	-	2	3
Barguna	-	4	-	2	6

Source: BIWTA

7 IMPACTS OF THE PROPOSED WATER MANAGEMENT MEASURES ON NAVIGATION

7.1 Introduction

The main objective of the Study is to prepare a water resources management plan for the SWA. Any measures proposed will have impacts on rivers and therefore on navigation in general. In the following sections, the major water resources options proposed are described together with an attempt to identify the impacts (positive or negative). Negative impacts will need to be counteracted and any mitigatory measures that need to be taken in the planning process are also discussed.

7.2 Augmentation of flows through the Arial Khan MB Route

During the execution of this study the possibility of dredging the existing Beel Route Canal for the purpose of using it for the supply of fresh water to the Khulna area has been looked at. The intention was that the fresh water should push the advancing saline front towards the sea. In this connection it was most relevant to review the pros and cons for using the connection also for river traffic. If this proved beneficial then the option will be more attractive, economically.

The canal was constructed in the early 1899-1905 and 30 years ago the Dhaka- Khulna passenger launch (The Rocket) used this route.

The scheme was studied in some detail as part of BIWTMAS, (see Ref 6, Annexes to Vol. III, Annex A-4.7).

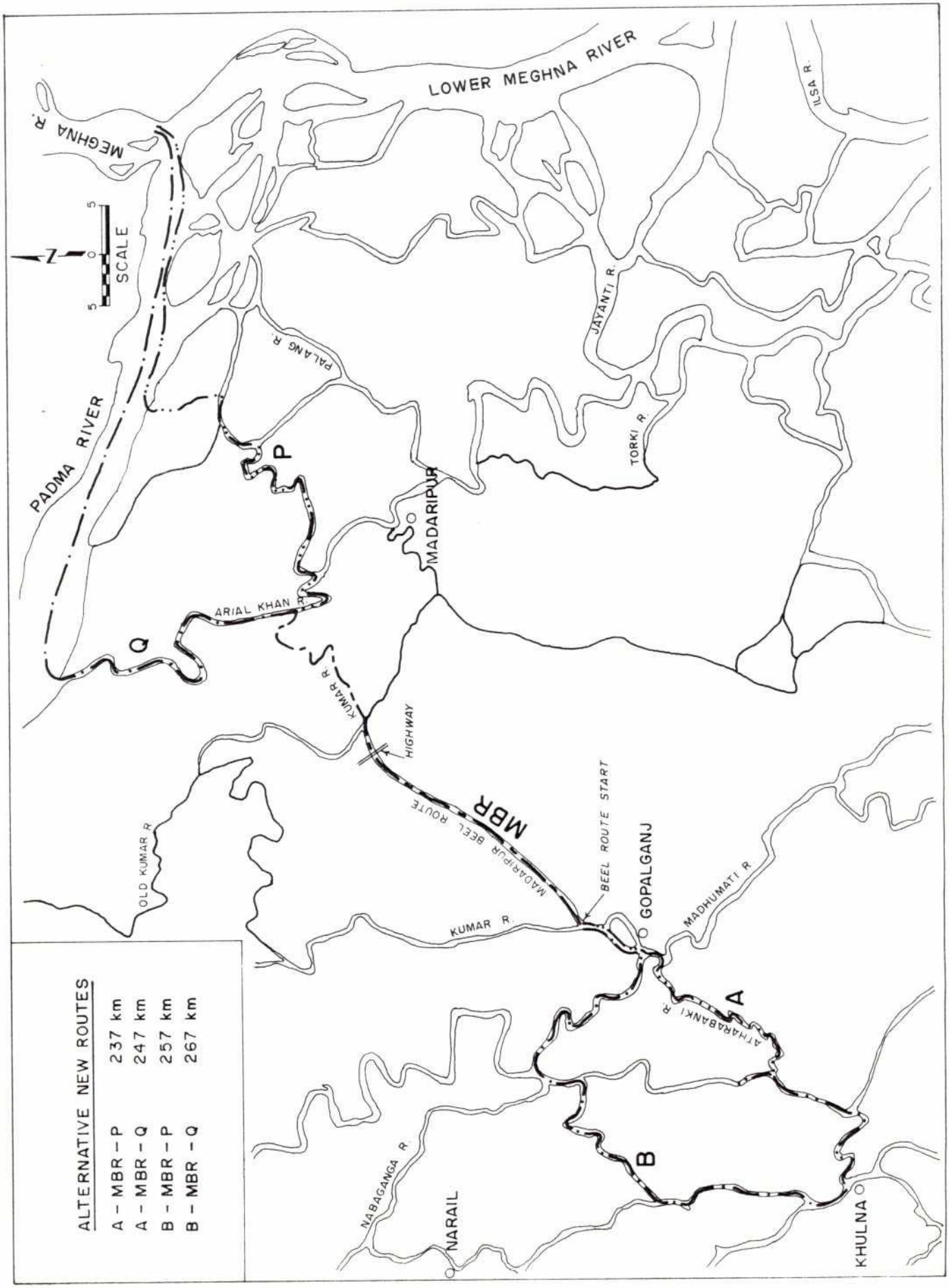
The revival of this route would considerably reduce the distance between Dhaka/Narayanganj and Khulna/Mongla and savings would include:

- saving in the transport of cargo
- saving in the transport of passengers
- diversion of traffic from road to river
- time saving for passengers

Consultants have reviewed the first point only.

In fact different routes between Khulna and Dhaka via Beel Route are possible, see Figure 7.1 Distances have been scaled on maps 1:50000, and listed in Table 7.1.

Figure 7.1



Alternative Routes between Khulna and Dhaka via the Beel Canal

TABLE 7.1

Distances in Km of Alternative Routes Khulna and Dhaka

		Route in Km			
		B-Q	B-P	A-Q	A-P
Khulna					
Via Atai/Madhumati	B	68.5	68.5		
Via Attarabanki	A			49.5	49.5
Start Beel Route		38.0	38.0	38.0	38.0
Highway Barisal - Faridpur		18.0	18.0	18.0	18.0
Junction Kumar - Arial Khan					
Arial Khan N	Q	33.0		33.0	
Arial Khan ENE	P		53		53
Padma River					
	Q	109.0		109.0	
	P		79.0		79.0
Dhaka					
	Km	267	257	247	237

For the purpose of this calculation we assume that Route A-Q will be selected.

Overall distances used in calculation are arrived at as shown below:

Dhaka			) 346 km
	Present route[1]	337 km	)
Mongla			)
		9	)
			) Centre of gravity for cargo from Khulna and Mongla.
		38	)
Khulna			)
	New route	247 km	) 285 km
Dhaka			

1) BIWTMAS.

Cargo Traffic

Cargo traffic between Khulna and Mongla on one side and Baghabari, Bhairab, Dhaka and Narayanganj on the other side has been extracted from Annual Port & Traffic Reports, BIWTA and presented in Table B According to the BIWTA average cargo traffic 1986/87 through 1990/91 has been found at;

DKA/NYG - KHL/MGL	570,000 t	11.8%
All river ports	4839,000 t	100%

Cargo traffic on all river ports is taken from the line on Figure 4.1 which separates modern river traffic from large country boats. (It should be noted that in Section 5 it has been proposed to shift the forecast two years to take into consideration the decline in cargo traffic observed in 1989/90 and 1990-91). The DKA/NYG - KHL/MGL traffic is estimated at 11.8% of the traffic on all the ports.

1992/93 (use 90/97) 8.7 M t x 0.118 = 1.03 M t

1997/98 (use 95/96) 10.2 M t x 0.118 = 1.20 M t

2002/03 (use 00/01) 11.4 M t x 0.118 = 1.35 M t

TABLE 7.2

Calculation of Cargo Quantities in 000 Tons

	Cargo Traffic between Khl and Bog, Bbha, Dha & Nar	Cargo Traffic between Mgl and Bag, Bha, Dha & Nar	1 + 2	Cargo Traffic between all ports in Bangladesh
	1	2	3	4
BIWTA DATA				
1986/87	133	548	681	5104
1987/88	163	539	702	5356
1988/89	132	532	664	5439
1989/90	102	362	464	4473
1990/91	41	296	337	3824
Average	114	455	570	4839
			11.8%	100%
PROJECTION				
Figure 5.3.A				
1988/89 (86/87)			920	7800
1992/93 (90/91)			1025	8700
1997/98 (95/96)			1201	10200
2002/03 (00/01)			1342	11400

Source: BIWTA

Transportation Costs and Vessel Split

Economic transport costs have been taken from BIWTMAS and multiplied by 1.15 to cater for price escalation. (Table 7.3).

TABLE 7.3

Transport Costs

Type of	Draft M	Cost Function	BIWTA Distance km		BIWTA + 15% Distance km	
			285	348	285	348
Self propelled	2.4	49 + 0.26D	0.43	0.49	0.50	0.56
	2.1	62 + 0.325D	0.54	0.50	0.62	0.58
	1.8	82 + 0.413D	0.70	0.65	0.81	0.75
Cargo launch		40 + 0.33D	0.47	0.45	0.54	0.51
Dumb barge		36 + 0.27D	0.40	0.37	0.46	0.42

The present split between different types of vessels is not known but has been estimated below as shown in Table 7.4 together with vessel split on the new route:

TABLE 7.4

Transport Classified by Different Type of Vessels

Type of vessels	Present	New Route	New Route	New Route
Depth (m)		2.7m	2.4m	2.1m
Draught (m)		2.4m	2.1m	1.8m
Self propelled vessel	45%	40%	35%	30%
Cargo launch	10%	10%	10%	10%
Dumb barge	45%	50%	55%	60%
Weighted cost, 348 km (Tk/txkm)	0.49			
Weighted cost, 285 km (Tk/txkm)		0.48	0.52	0.57

The calculated total transport costs appear below:

1992/93.
Present route 1.025×10^6 t x 348 x 0.49 = 193 M Tk

New route d = 2.4 m
$1.025 \times 10^6 \times 285 \times 0.48 = 140$ M Tk

New route d = 2.1 m
$1.025 \times 10^6 \times 285 \times 0.52 = 152$ M Tk

New route d = 1.8 m
$1.025 \times 10^6 \times 285 \times 0.57 = 167$ M Tk

The annual saving in M Taka is presented below:

Draught	2.4	2.1	1.8
1992/93	53	41	26
1997/98	62	48	30
2002/03	69	54	34

7.3 Augmentation of dry season flows through the Gorai

One of the proposals to augment dry season flows to the SW Region is through the Gorai. Various options with different discharges are described in detail in the Main Report. Due to the withdrawal of flows upstream at Farakka in India, the dry season flows in Ganges and therefore in Gorai has depleted and in recent years has been zero during the period from about December to April. The reduction in dry season flows has not only caused surface irrigation difficult during the dry season but also caused severe morphological changes in the rivers. As navigation is dependant on maintaining adequate water depth, this sector is seriously affected by upstream abstractions. The proposal to rejuvenate the Gorai during the dry season which will allow a maximum of about 250 m^3/s will have positive impacts. As part of the proposal dredging at the mouth and in some reaches downstream of the Gorai is proposed which is clearly beneficial to navigation.

The impact of proposed measures on Mongla cannot be quantified but the model studies indicate that this will not have any negative impacts on the Port. However, if some of the earlier recommendations for the Port of Mongla are implemented then the combination of this with additional dry season flows will have a positive impact.

7.4 Proposed Strategy in the CEP Area

For improving drainage congestion in the CEP Area several strategies were proposed in the coastal studies report (Volume 4). One of the strategies which affects navigation is closure of certain channels and sluices. These are described below with the possible effects on navigation.

In the Southwest Area in all 7 sluice gates and 5 closures have been proposed. These are:

Sluices

(i) At the South end of Haria river (junction with Sibsa)
(ii) At the South end of Gangrail (junction with Deluti)
(iii) At the South end of Gangrail (junction with Deluti)
(iv) At the junction of Solmari & Satla

(v) For Polder 27
(vi) For Polder 28
(vii) For Polder 24 and part of 25

Closures

(i) At upper end of Haria
(ii) At upper end of Gumkhali
(iii) At upper end of Taligatti
(iv) At upper end of Gangrail
(v) At upper end of Hamkura

Due to construction of closures at the upper ends of Haria and Gumkhali and sluice gates at the lower ends, these two rivers will be silted up and may survive as shrinked drainage outlet. It is likely that substantial part of the flow from Sibsa may be diverted through Delutia and Harbaria rivers and will reach the upper connectors of the Pussur river during flood tide. During ebb tide part of this flow may return through Pussur.

Due to construction of closures at the upper ends of Taligati and Gangrail rivers and sluice gate at the south end of Gangrail, the rivers Salta, Taligati and Gangrail will be silted up in due course. The rivers behind the sluice gates terminated by closures will be silted up and may be maintained as drainage canal by annual excavation. Consequently above closures and sluice gates the flood tide in Rupsa, Bhairab, and Atai will be increased and most likely that during ebb tide the water will return back through Kazibacha and Old Kumar up to Chalna point. Unless the mouth of Chunkuri is constricted, part of the flow will go to Chunkuri and to the Sibsa. Thus the gain of flow obtained due to above closures and sluices at upper reach of Pussur may not ultimately pass through Pussur.

Due to construction of proposed 7 sluices and 5 closures at the west of Khulna and Chalna, navigation in the affected rivers will be decreased by about 70%. Only small boats carrying agricultural goods will use the drainage canal inside the Polders.

It is expected that tide propagation through rivers by-passing the above poldered area will be increased. Kobadak river in the west may be benefitted.

If the incompleted polders on the east side of Pussur river are completed and closed in due course, that will curtail the spill area of flood tide and ultimately, the Pussur river, Mongla Nulla and Ghasiakhali river will be adversely affected.

Proposed Dredging of Kumar river from Takerhat to Arial Khan junction:

Though the proposed dredging of Kumar river is to remove drainage congestion, it will have positive effect on navigation. Therefore from navigation point of view, the excavation of Kumar river is favourable.

Similarly the dredging of Labangabati to connect Ichamati is favourable for navigation.

It can be concluded that the proposed water resources development is not likely to affect navigation beyond the extent discussed above.

7.5 Future Strategy for Preserving Navigation Routes

In a country like Bangladesh, navigation will continue to play very important role in the transport sector. But in the Southwest Region the strategy may be quite different from the past. In the South Central Region like Barisal and Patuakhali, the rivers and estuaries are still in active condition.

Mongla Port is centrally located and is expected to play an important role in the development of Southwest, Northwest and Central regions including Dhaka - Narayanganj area. Therefore the maintenance and upgrading of Pussur channel should get due importance.

- The existing trunk route from Dhaka - Chandpur - Barisal - Jhalakathi - Mongla - Khulna - Maheswarpasha may be maintained and upgraded.

- The transit route from Chalna to Raimongal may be maintained and upgraded.

- In the South Central region - Barisal - Patuakhali, the rivers are active. Water resources planning may not curtail existing tidal prism of the area. Better marking of channel and provision of embarkation and disembarkation facilities suitable to tidal fluctuation may be provided. All existing routes of this part are naturally maintained and may not be interfered.

For equitable development of the Southwest, Northwest and South Central Regions, Mongla Port may be connected by shorter waterways and shorter road ways with Dhaka.

- A shorter waterway from Mongla - Khulna through MBR has been preferred. In Section the details have been worked out. The economic worked out has shown an annual savings of Tk 34 to Tk 69 million through the year 1992 to 2002.

- The shorter road way Dhaka - Mawa - Khulna may be completed early for generation of more cargo at Mongla Port.

In the Satkhira area the upper connectors of Pussur - Sibsa rivers have been silted up badly.

If these are left in this condition the siltation will gradually move to the South and the navigability of Pussur will further be aggravated. As discussed elsewhere, the area may be enclosed by few bigger polders. The upper part of the dying rivers may be closed and at the lower end at the dike, appropriate lock gates may be provided to facilitate navigation by medium and small boats. Within the dike the rivers may be narrowed and excavated for navigation.

The tidal flow from the Pussur - Sibsa may be guided around the proposed big polders as discussed in Section 5.

The prospects of many of the smaller draft waterways in the Southwest Area are not bright. The continued effects of the developments discussed above and the increased abstraction of water for irrigation will adversely affect the navigational conditions. This underlines the need for a well-balanced development of waterways based on priority choices particularly where a conflict of interest arises between different 'users' of water under low flow condition.

To maintain critical depths at certain sections of the river, it is essential to provide the required minimum discharge. The reduction of flow below a required (minimum) discharge may have adverse effect on the navigational draft.

Required discharges for the selected tributaries and connectors are shown in Table 7.5. The discharge is indicative for maintenance of certain draft.

TABLE 7.5

Required discharges for the Selected Tributaries and Connectors

Present Conditions	Reference Station			
River Name	Name	SLW (m + PWD)	LAD (m)	LAQ (m^3/s)
Madhumati	Kamarkhali	1.08	1.20	25

Discharges for Least Available Depth						
Draft (m)	0.60 m^3/s	0.90 m^3/s	1.20 m^3/s	1.50 m^3/s	1.80 m^3/s	2.10 m^3/s
Name of River						
Gorai	7	20	45	70	140	180
Madhumati	5	10	25	45	70	100

LIST OF REFERENCES

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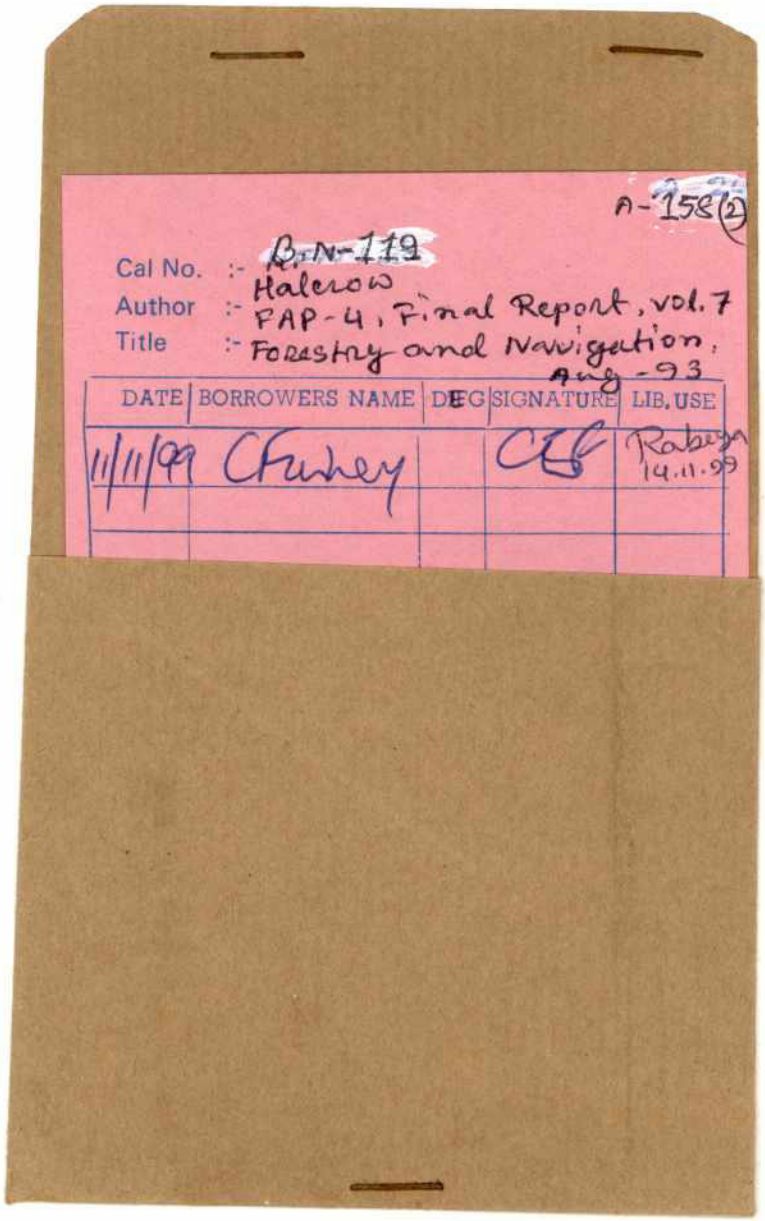

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