15

GOVERNMENT OF BANGLADESH
MINISTRY OF ENVIRONMENT AND FORESTS

SILVICULTURE

FORESTRY MASTER PLAN

ASIAN DEVELOPMENT BANK (TA NO. 1355-BAN)

UNDP/FAO BGD 88/025

1993

GOVERNMENT OF BANGLADESH
MINISTRY OF ENVIRONMENT AND FORESTS

SILVICULTURE

FORESTRY MASTER PLAN

ASIAN DEVELOPMENT BANK (TA NO. 1355-BAN)

UNDP/FAO BGD 88/025

1993

SILVICULTURE

TABLE OF CONTENTS

PROJECT 372001/20
FORESTRY MASTER PLAN,
BANGLADESH (TA NO.1355-BAN)

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: JANUARY 1993

SILVICULTURE

SUMMARY

Background

The Asian Development Bank, United Nations Development Programme and the Government of Bangladesh are financing the technical services to prepare a twenty year Forestry Master Plan. The Plan aims to help the GOB in preparation of long term development plans in forestry. This is of great importance due to the dwindling forest resources and the degradation of environment.

This report, the Forest Silviculture Report, presents the results of a study during 1992 by the Silviculturist, working under the Forest Management Specialist, how acted as the Subteam Leader. The Subteam worked under the guidance of the Team Leader.

Though the report is one of the specialist reports, it forms part of the overall Forestry Master Plan.

Assessment

Within the terms of reference the report assesses the natural and plantation resources of the country. It reviews the effects of past silvicultural treatments and the present silvicultural practices. The report discusses in detail the present silvicultural condition of three different forest zones viz: the hill forests, inland sal forests and littoral mangrove forests. The report reviews the effects of depletion of forest resources and shrinkage of forest in relation to demand and supply imbalance and the environmental deterioration.

Development Programmes

The report presents the development programme under two scenarios. It assesses the existing nursery distribution. It recommends proper nursery technique. The report also analyzes the seedling and nursery requirement for the development programme. The report discusses species and provenance selection with reference to site characteristics. As plantations will form a major part at the development programme and the report reviews the effect of teak plantations on soils in the hill forests and effects of large scale monoculture.

As the successful implementation of the development programme, particular under scenario 2 depends on higher yield from plantation, the report discusses tree improvement programme in some detail. Better tree selection, vegetative reproduction from clones and genetic improvement are discussed.

Silvicultural prescriptions for sal forests are reassessed and measures suggested to improve earlier prescriptions. This is in the light of experience gained with the Thana Banyan Project. The impact of agroforestry for sal forests and degraded land like USF is discussed.

The constraints and possibilities of large scale agroforestry are discussed. As the actual programme and investment requirements under agroforestry are in the Report on Participatory Forestry, this aspect has not been discussed in detail.

Regarding Sundarbans the report recommends continuation of the existing system till the results of the study by Specialist Team are available. The report, however, suggests extension and improvement of the coastal afforestation project.

Finally the impact on watershed management, environmental protection and enhancement of supply are discussed. A yearwise programme of silvicultural activities is presented in Appendix of the Report.

Major Issues

The major issues in silviculture are:

Silvicultural System for Hill Forests

The Hill forests are more than half of the forests of Bangladesh. Large parts of these forests are have been clear felled and planted up. Silvicultural treatment for the remaining natural forests is an important issue. Most of the natural forests are bare or are full of overmature trees producing little or no increment. Even if we retain these forests, renewable resources like trees have a growth cycle. We have to replace old and mature trees by new ones. If left untended, the crop would deteriorate.

The growth rate of the natural forests and existing plantation is very low due to poor silvicultural treatment. So there is a shortfall in supply of forest product compared to demand. Correct silvicultural practice will enhance the supply. We can increase the supply many fold by replacing the existing natural forests by high yielding plantation crop. Recent advances in genetic engineering and tissue culture have made this possible. We should develop high yielding varieties of timber trees.Then we should fell the existing low yielding plantations and replace them by high yielding varieties as soon as possible.

At the same time it is desirable to preserve as much of the remaining natural forest as possible. This is necessary for maintenance of biodiversity. This would mean that we fell only part of the natural forests during the next 20 years for planting up with high yielding plantation species.

Problem of Sal Forests

Silviculture of sal forests is complicated by large scale encroachment of forest land is most acute in the sal forest areas of the central and northern regions. Any solution of the problem has to consider the socioeconomic problem of landlessness. Agroforestry and participatory forestry has resulted in recovery of extensive areas. To prevent further degradation of forest land, the BFD has to convince the villagers that the agroforestry is in their interest in the long run. To get the confidence of the farmers, BFD should associate NGO's and community groups in the program. Then the FD should grant some sort of tenurial right to the villagers. There might be conditions that the farmers maintain tree cover and abide by the terms of agreement with the BFD. In addition to encroachment, the loss of coppicing power by sal rootstock is another problem.

Mangrove Forest Silviculture

The mangrove forests of the Sundarbans are under a selection system with yields of major species being fixed. In 1959 the FD fixed the yield of gewa and sundri in accordance with the inventory by Forestal. There has been some controversy after the recent inventory by ODA, The is due to fixing of a lower yield after the ODA inventory. The Newsprint Mill has challenged the ODA's findings. The BFD has set up sample plots for determination of the increment.

Till the FD can analyze the data from the sample plots, the yield of gewa should be as per ODA's findings and lower utilisable diameter. There is also the problem of sundri die back. There could be introduction of other mainland and mangrove species. To increase the supply of pulpwood there might be trial plantations of other pulpable species.

The Sundarbans forests not only supply pulpwood to the Newsprint Mill but serve the industrial and non-industrial needs of the surrounding population. Any silvicultural system has to consider this.

Utilisation of the Unclassed State Forests

In the Chittagong Hill Tracts there are more than 700,000 ha of USF land. Most of it is bare and has little top soil left. The tribal people cannot make living by practising jhum cultivation. Short rotation community plantation and agroforestry plantation may help. Medium rotation plantations of fast growing species would help conservation and increase the supply of wood. It would generate employment, as most of the investment on plantation would be in the form of wages. The BFD should convince the tribal people that they will gain in the plantation program. Any silvicultural system should provide for short term income for the people till the maturity of the tree crop. It should not unnecessarily disturb the tribal cultural basis.

People's Participation

Our silvicultural programme, particularly in the Hill Forests involves creation of extensive planation with very high MAI. This involves technical, institutional and financial problems. We do not think that this will succeed without active participation of the people. This can be secured by setting up of semi-independent organisation under the MOEF or by system of enterprises. Public cooperation is essential for protection of the investment on plantations. The private bodies could also be associated with wood using enterprises and marketing of the products.

Protection of Environment and Wildlife

Silvicultural systems for the whole country have to consider protection of environment and wildlife. Recurrent floods cover large part of the country. Floods, of course, are largely due to deforestation in the upper regions of the catchment areas of the Ganga and Brahmaputra. These are outside the territorial limits of Bangladesh. Along with seasonal floods, there exists aridity in dry months due to lowering of water table. There is also environmental degradation due to soil erosion both by wind and water.

To counter such environmental degradation there should be tree planting on vacant marginal lands. There are lands along sides of roads, railways, canals and embankments which should be planted up. Side by side village forest extension program should be taken up. In addition to protection of environment these steps will increase the available wood supply.

Forests are the last resort of a number of threatened birds and animals.Though there are a number of sanctuaries and parks, much remains to be done to enforce the game laws.

Coastal Afforestation

Cyclone in coastal areas cause extensive damage to life and property.The loss will be less if the Authorities restrict settlement on new chars. For protection of existing settlements there should be embankments and belts of trees along the embankment. Such coastal plantations are in existence for the last 25 years. There are more than 112,000 ha of such plantations now. These plantations should be extended.

Moratorium on Felling

There is now a moratorium on felling in most parts of the forest, though surreptitious fellings are going on. As the BFD cannot enforce the moratorium, we recommend that the Government lift the moratorium. Our recommendations for development are this basis.

PROJECT 372001/20
FORESTRY MASTER PLAN,
BANGLADESH (TA NO.1355-BAN)

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: JANUARY 1993

SILVICULTURE

INTRODUCTION

General

The Asian Development Bank, United Nations Development Program and the Government of Bangladesh are financing the technical services to prepare a twenty year Forestry Master Plan. The Plan aims to help the GOB in preparation of long term development plans in forestry. This is of great importance due to the dwindling forest resources and the degradation of environment.

This report, the Silviculture Report, presents the results of a study for over a year by the Silviculturist assisted by members of the Production and Management Subteam, working under the guidance of the Subteam Leader and the Team Leader.

Silviculture is the basis of all aspects of forestry operation. A sound silvicultural system should develop the forest resource base and maximise production without harming the environment. Above all it should be sustainable.

Within the terms of reference the report assesses the current silvicultural practices of the country. It reviews the effects of past management plans and current silvicultural practices. Wherever necessary the plan recommends new sets of prescriptions to supersede existing silvicultural practices.

Except for the mangrove forests, plantations will be the major source of supply of forest products in future development programmes. Besides state forests there will be plantations in village homestead groves and on marginal land. Successful plantation programme depends on sound nursery practice. Selection of suitable species and provenances in essential. The Report considers these aspects of silvicultural programme. To increase plantation yield the Report recommends tree improvement projects.

For hill forests the Report prescribes extensive plantation programme and conservation of major part of natural forests. For mangrove forests the Report supports the present silvicultural practice and the coastal afforestation project.

For the sal forests and for marginal land the Report extends the scope of agroforestry techniques.

The Report presents future silvicultural programmes under a modest target Scenario 1 and a more ambitions Scenario 2 programme. The present situation is the Status Quo situation.

The present report is one of various reports prepared by the Production and Management Subteam. The Production and Management Subteam Report incorporates parts of the finding of this report.

The above is only an outline of the different aspects of the report.

Background

Bangladesh's forestry sector gave Tk 12.6 billion, 2.6% of 1989/90's gross domestic product at constant prices. This amount is slightly higher than the Fisheries and Livestock sector. Under

the Fourth Five Year Plan the sector's allocation is Tk 8.4 billion. This is 2.1% of the Plan's overall investment.

Estimated present round wood demand is 13.2 million m^3. This includes logs, poles, pulpwood and fuelwood, and totals about 0.12 m^3 per capita. Fuelwood and logs are the major products needed (62% and 34% respectively). Government's development goal is a 5% annual growth rate in gross domestic product. To support this economic and development target, the Nation will consume 16.5 million m^3 of wood annually by the year 2023.

Of the current demand a significant portion comes from village forests. The present supply from villages is 0.7 million m^3 of sawlogs and 4 million m^3 of fuelwood or a total of 4.7 million m^3 out of the present demand of 13.2 million m^3. Incidentally the current potential supply from regular sources is 8.2 million m^3 for all kinds of wood products. The silvicultural development programme should hence aim to increase the supply on a sustained basis.

State Forests

The total State Forest in Bangladesh including USF land under the control of BFD is about 2.2 million ha. A large part of the area has no tree cover. Over 20 year period ending in 1980 the forest cover declined by 2.1% annually. Apart from the declining tree cover the increment of the forest is low compared to international standards. The growth rate of natural hill forests is 0.5 to 1.5 m^3/ha/A. Increments of mangrove forests and sal forests are lower. The increment in existing teak plantations in the hill forests are 2.5 m^3/ha/A. Future yields are likely to be about 7-10 m^3/ha/A. Both levels are unacceptably low by world standards.

Village Forests

Village forests provide a significant portion of the wood supply of the country. Besides wood production village forests have several other important uses. They provide fruits for human consumption, fodder, building material, raw material for cottage industries and wood for furniture, construction, carts, boats and agricultural tools. Village forests are essential to support villagers' life style. The combination of different cultivated plants allows permanent production throughout the year. The continuous flow of small quantities of various products helps the farmers in maintaining economic and nutritional stability.

Of late the production in the village forests is decreasing. This is due to shortage of land and greater demand for wood. The Plan will recommend steps to increase the output of village forests. This will be possible through incentives and better genetic material.

Public Land Groves

In addition to State forests and village forests, there are extensive plantations on non-forest public land, such as roadside, railway embankment and canal banks. The Master Plan aims at increasing the output from such marginal land.

FOREST LAND

Land Evaluation

Land evaluation for forestry involves land classification and capability or suitability assessment. Its purpose is mainly for landuse allocation in national and regional development planning and for district and local forest management planning. It also helps in determining research priorities and comparing research findings from different regions.

Labrousse (1984) and de Lannoy (1985) made the first landuse surveys in Bangladesh. Stevens (1986, 1987) has outlined a methodology for application of such surveys to small (less than 100 ha) areas at forest range and beat level. A comprehensive, computerized data base for landuse planning is available in the Bangladesh Agricultural Research Council (BARC) Computer Centre in the reports of the Land Resources Appraisal of Bangladesh for Agricultural Development (FAO, 1988).

The land resources appraisal (LRA) is primarily for use in planning agricultural development. But it contains a wealth of information of great value to other landuse planners and managers

FAO (1988) reports recognise thirty agroecological zones in Bangladesh. The FAO reports describe them as basis for determining land suitability for agriculture. The reports base the zoning on landform, soils, patterns of flooding, and climatic regimes. Zones effectively coincide with the major physiographic units or subunits. This provides more detail than is necessary to identify and define the ecological conditions for tree growth are relatively uniform.

Climate

The Land Report Appraisal recognised 92 agroclimatic zones based on climatic variations. These are the lengths of the kharif (wet season) growing period, the pre-kharif transition period, the cool winter period, and the summer period with extremely high temperatures.

The complexity of so many agroclimatic zones is not necessary for forestry purposes. Although mean annual rainfall varies from less than 1,500 mm in the west to more than 5,500 mm in the northeast, the rainfall during the monsoons is more than adequate for tree crops throughout the country. This does not imply that the growth of trees in Bangladesh is never limited by water deficiency. On the contrary, soil moisture availability is often limiting factor for tree growth during the dry months. Foresters should take this into account in land evaluation. They should consider environmental factors other than the rainfall regime, such as topography and soil physical properties.

The thermal regime is the other major climatic factor for consideration. The centre, eastern and southern half of the country rarely experience temperatures more than 40°C. Such extreme temperatures may occur only in the west for not more than five days in the year, usually in April and May. They create very high potential evapotranspiration demand. Strong winds and low humidity often accompany these high temperatures. These can have adverse effects on annual crops. They have less significance in determining land capability for forestry than for agriculture. Major thermal zones recognised in the LRA are based on the length of the cool winter period with minimum temperature <15° C. This lasts for 4-6 weeks along the coast, 6-8 weeks in the hinterland and for 13-16 weeks in the northwest and northeast. The southeastern half of the country rarely experiences temperatures outside the range of 15°C minimum to 40°C maximum, while the north-western half is hotter in summer and cooler in winter. The thermal regime does not have any influence on the growth of trees.

The report, therefore, does not regard climate as a limiting factor in land capability assessment for tree species in Bangladesh. This is not surprising as the latitudinal range is small and most of the country is only a few metres above sea level. This is not to say that climate does not affect tree growth. It states merely that the thermal and rainfall regimes throughout Bangladesh are suitable for most of the species, we are likely to use.

Physical Features

Physiography, embracing landform and soil parent material, was the primary factor for differentiation of agroecological regions in the LRA. The LRA recognized 20 primary

physiographic units together with 53 secondary units and 143 tertiary units. These were too many for defining dendroecological zones i.e. zones defining tree growth. We have aggregated them into 10 physiographic units. A map showing their geographical distribution of the units with brief description is in Appendix 2. LRA Report 2 FAO (1988) gives the descriptions of the individual units.

Soils

Brammer et al (Land Resources Appraisal, 1988) carried out detailed soil survey of Bangladesh. Accordingly Brammer formed general soil types for Bangladesh.

Although general soil types represent a very broad level of classification, the FMP simplifies them further for the purpose of land capability assessment for tree species, by aggregating them into eight categories. This report aggregates the soil types on the basis of regional occurrence of physiographic units. Although one aggregation or group may contain two or more type with quite distinctive properties (see Report 2, FAO, 1988 for descriptions), it does not invalidate such grouping for the purpose of this working paper.

Appendix 2 gives a list of the groups and the soil types they contain, together with a map showing distribution of soil types.

Area Statement

The forests of Bangladesh are in three zones as described below:

a. Hill Forests in the greater districts of Chittagong, Chittagong Hill Tracts and Sylhet.

b. Inland forests in the central and northern zones, and

c. Littoral forests in the delta and coastal regions.

Table 1 below gives the area statement by legal status.

Table 1 - Area Statement of Forests by Legal Status (ha)

Forest type	Reserve forest	Protected forest	Vested forest	Acquired forest	WAPDA and Khas	Unclassed State forest	Total
Hill	594,383	32,303	2,636	11,004	-	721,344	1361,670
Inland	68,140	2,689	19,985	31,198	-	-	122,012
Littoral	656,579	-	-	6	101,526	-	758,111
Total	1319,102	34,992	22,621	42,208	101,526	721,344	2241,793

The above table shows the area according to the legal status of the land. It does not in any way imply that the land is under the actual control of the Forest Department. Much of the land is under the occupation of encroachers. Appendix 2 gives the area statement by divisions. In the Appendix are tables showing the type of ground cover as far as we would ascertain.

The map on frontispiece shows the location of the forest areas.

Comparison of the forest location map with the maps in Appendix 2 gives frontispiece information regarding physiography and soil type of different forest regions.

FOREST TYPES

General

Except in the littoral mangrove forests, large areas of natural forest have been converted to plantations. This is particularly true for the hill forests. Here plantations of teak and associate species have replaced significant portion of natural forest. This has changed the character of vegetation over large areas.

Plantations were also tried in sal forest. Most of the earlier plantations failed to survive. Recent plantations are of fast growing exotics. This has again changed the character of vegetation in some areas.

In the littoral areas, coastal plantations are of mangrove species and outside the forest areas.

The description below is for surviving natural forests. Type and extent of plantations will be described later.

Hill Forests

Of the major three categories, the Hill Forests are the most important. They are more than half of the State forests of the country. They are also important from the economic and environmental point of view.

Most of the description below applies to the forests of greater districts of Chittagong Hill Tracts and Chittagong. The forests of Sylhet are extension of the forests of Chittagong Hill Tracts and Chittagong. Human interference has, however, altered them, as described in the particular area. The outline below describes in brief the forests of the Hill Forests zone. "Forest Types of Pakistan" by Champion, Seth and Khatak gives further details of the forest types.

1. Dipterocarp Forests

The forests consist of mixtures of many tropical evergreen and tropical deciduous trees, occurring in association with bamboo jungles. There are more than a hundred tree species. Though no single tree type is uniform or clearly defined over a large tract, garjan (Dipterocarpus spp) is the predominant species in the top storey; civit, narikeli and chundul occur in mixture. In the middle storey important species are tali, kamdeb, chapalish, nageswar, pitraj, jam, bandarhola, champa and toon. Commonest tree species in the lower storey are batna, jam, jarul and gamar.

Ecologically the forest is a transition type. It possesses many of the characteristics of the Burmese forests and also of the Eastern Himalayan forest, with the exception of the indigenous teak of the Burmese forests and sal of Eastern Himalayan forests.

The forest types often intermingle and merge with one another. The majority of the understorey trees are evergreen, while the bulk of the dominant and emergent trees are deciduous. Some of the deciduous trees shed leaves in winter, while some just before monsoon, resulting in apparent evergreen appearance of the forest. The stands are generally multistoried and pure stands of a single species are limited.

Average merchantable tree volume is rather low rarely exceeding 150 m^3 per ha. Several of the dominant trees are over 70 meters high with breast height diameter of more than 200 cm. Many of the trees have well developed buttress at the base.

Ecologically the following four types of forests are found: (i) Tropical Wet Evergreen, (ii) Tropical Mixed Evergreen, (iii), Tropical Moist Deciduous and (iv) Tropical Open Deciduous.

2. Savannahs

Savannahs cover large parts of the Unclassed State Forests of greater Chittagong Hill Tracts, stretching into reserved forests in many places. The vegetation consists of tall grasses (sun grass) with average height of 1.25 meters and scattered trees.

3. Bamboo Forests

Bamboo occurs in abundance, particularly in Greater Chittagong Hill Tracts and Sylhet. Bamboo occurs in pure patches or as undergrowth of other forest types. Of the many species four are commercially important. These are muli, mitenga, daloo and orah. Muli is the predominant species. It occurs as undergrowth in many timber stands or extensively as pure bamboo stands on well drained slopes. Individual culms are produced at intervals of 60 to 90 cm along rhizomes. On good sites these culms grow to heights of 18 meters and attain diameter of 7.5 cm.

4. Fresh Water Swamp Forests

These forests occur in low lying areas of North Sylhet. The main species are hijal, jarul and pitali.

The outline above describes in brief the forests of the Hill Forests zone. "Forest Types of Pakistan" by Champion, Seth and Khatak gives further details of the forest types.

Inland Sal Forests

The inland plains forests are parts of Tropical Moist Deciduous Forests, locally known as sal forests.

Sal (Shorea robusta) is the predominant species. The trees are 10-25 metre high and deciduous. Associated species are palas (Butea monosperma), haldu (Adina cordifolia), koroi (Albizzia spp.) bahera (Terminalia bellerica), kurchi (Holarrhena antidysentrica), haritaki (Terminalia chebula), kusum (Schleichera oleosa), sonalu (Cassia fistula), chaplash (Artocarpus chaplasha) and udal (Sterculia sp.).

The forests consist of sal coppice in patches, occasionally with other tree species. The forests lie in the districts of Dhaka, Tangail, Mymensingh, Rangpur, Dinajpur and Rajshahi. There is a small patch of Sal Forest in Comilla. More than 66 percent of the Sal Forest is blank or under the possession of encroachers.

The sal forests existing today are the vestiges of extensive forests of earlier days. Sal (Shorea robusta) is the predominant species in these forests.

Champion, Seth and Khatak, in their book "Forest Types of Pakistan" classified these forests as Tropical Moist Deciduous Forests and subdivided the same into two subtypes; (a) Moist sal forests and (b) Sal Scrub Forests. The moist sal forests are severely depleted leaving some sporadic intact sal forests mostly of coppice origin. The sal scrub forests are the result of extreme human interference in the densely populated parts. Here the people cut back the sal coppice repeatedly. So that the stumps have lost coppicing power, creating small and big blanks.

Littoral Mangroves Forests

The Sundarbans are the mangrove forests of Bangladesh, lying at the southern extremity of the Ganges River Delta bordering on the Bay of Bengal. The forests extend to 80 km north of the sea. The forests stretch from the Baleswar River on the east to the Hoogly River on the west. Off the forests approximately 5,800 km^2 is in Bangladesh out of which 4,100 km^2 (70%) are land and 1,700 km^2 (30%) are water.

The Chokoria Sundarbans forests cover an area of about 8,540 hectares and form the delta of the Matamuhuri River in the district of Greater Chittagong. This is one of the oldest notified reserve in the subcontinent. Due to heavy human interference only a small patch of the Chokoria Sundarbans now exists. The Chokoria Sundarbans forests of Chittagong differ from the Khulna Sundarbans in the abundance of Dalbergia spinosa and profusion of Aegialities retandifolia in the forest. There are 20 species of trees at Chokoria Sundarbans but they do not attain heights of more than 10 to 15 m.

The following description applies mainly to the Khulna Sundarbans.

The forest area is flat. Elevation is within 3 meters of sea level. Complex networks of streams and rivers intersect the forests. Till recently most of these streams connected with the Ganges system and received considerable overflow during part of the year. This has stopped due to construction of the barrage on the Ganges upstream and resultant silting of river downstream.

Curtis (1933) divided the Sundarbans into three zones, namely the fresh water (slightly saline), moderately salt water (moderately saline) and the salt water (strongly saline) zones.

Slightly saline zone: It includes northeast part of the forest which receives fresh water supply. It supports the best stand growing to 20 m high. The dominant species is Heritiera fomes. This is mixed with varying proportion of Excoecaria agallocha. The proportion of Excoecaria increases and Heritiera decreases, as one proceeds to the west and south The species next in importance is passur (Xylocarpus mekongensis), which frequently grows with kankra (Bruguiera gymnorrhiza). These two species occur in damper places. Common species as understorey beneath sundri are singra (Cynometra ramiflora) on comparatively dry soils, and amur(Amoora cucullata) on moist soils. Towards the more saline areas these species, though still found, become less plentiful. Here goran (Ceriops decandra) becomes the principal under storey. Golpatta (Nypa fruticans) is plentiful on the banks of channels and creeks.

Moderately saline zone: This is in the middle portion of the forest. The predominant crop consists Heritiera fomes and Excoecaria agallocha. Sundri decreases towards west and south. Passur, kankra and baen (Avicennia officinalis) are unevenly distributed. Nypa fruticans is plentiful.

Strongly saline zone: This is in the south and western part of the forest. With increase in salinity the quality of the forest deteriorates and height hardly exceeds 7 m. The forest consists mainly of sparsely spaced gewa (Excoecaria agallocha) and over dense goran (Ceriops decandra) interspersed with dense patches of hantal (Phoenix paludosa) on the drier soils. Dhundal (Xylocarpus granatum), passur (X. mekongensis) and kankra (Bruguiera gymnorrhiza) occur sporadically throughout the area. Nypa fruticans is scarce.

The location and effect of the different salinity zones of the Sundarbans appears in the map in Appendix 2.

NATURAL FOREST CROP CONDITION

Over the years the condition of the crop and growing stock has deteriorated severely, particularly in the Hill Forests and the Inland sal forests. The following sections describe in brief the condition in different forest zones. In a later section we shall discuss the silvicultural practices leading to the deterioration.

Hill Forests

1. Kassalong and Rankhiang Reserves

Forestal Forestry and Engineering International Ltd carried out in 1962 an inventory survey of the Kassalong (including Maitani Headwater) and Rankhiang Reserves of the Chittagong Hill Tracts in 1961. Previously there was an inventory of the Sangu and Matamuhuri Reserves. Forestal divided the forests in 8 cover types viz: (1) Timber, (2) Mixed Timber Bamboo, (3) Mixed Bamboo Timber, (4) Bamboo, (5) Plantation, (6) Non forested, (7) Non-productive Area and (8) Water. Forestal determined the growing stock of the forests for 23 important species and other miscellaneous species.

Twenty years later in 1983, there was a reinventory under Project BGD/79/017, "Assistance to the Forestry Sector of Bangladesh". The project took aerial photographs of the same areas but carried out the survey without any ground truthing due to abnormal law and order situation. All volume figures were compiled on the basis of earlier volume figures collected by Forestal. The survey revealed important changes in the forest covers. During the twenty year period the non forested area had increased alarmingly. The position has worsened during the 10 years since the last inventory. Forestal's area figures for timber types in Kassalong and Rankhiang were 52,689 ha and 20,325 ha respectively. The areas now are 41,393 ha and 1,167 ha respectively for the two reserves. The total area of the two reserves are 159,379 ha for Kassalong and 76,300 for Rankhiang. Appendix 2 gives the details of the inventories and the changes. According to Forestal the volumes for timber type forests are 136.6 m^3/ha for Kassalong and 171.5 m^3/ha for Rankhiang. Accordingly the total volume of the two reserves were 5.65 million m^3 and 0.20 million m^3. These figures may not hold now.

2. Sitapahar Reserve

Though Forestal in 1963, did an inventory of the forests of Rankhiang and Kassalong, this excluded the Sitapahar Reserve. Which was inventoried under FAO/UNDP Project BGD/79/017. The position has changed since the inventory. It now appears that plantations have replaced most of the natural forests. Out of the total area of 5,447 ha only 957 ha are natural forest and 3,740 ha are plantations. Some of the plantations date as far back as 1871. Besides plantations some areas have gone under water of the Kaptai lake. Details are in Appendix 2.

3. Sangu and Matamuhuri Reserves

There was inventory survey of the Sangu and Matamuhuri reserves before 1961 and again in 1984. The results of the two inventories are in Appendix 2. A study of the two inventory reveals the present position of these reserves. Since 1961 the productive forest land has decreased by approximately 17,180 ha and area under jhum has increased by 17,070 ha in these two reserves. Plantation areas have increased to about 5,037 ha in Matamuhuri reserve by 1990. The combined figures for Sangu and Matamuhuri reserves is 74,500 ha. The area of Matamuhuri reserve is 40,791 ha of which more than 16,000 ha are timber-type forest with yield of 73 m^3/ha. About half of the yield will be civit and one-eighth garjan.

4. Chittagong and Cox's Bazar Divisions

Project/FAO/BGD/85/085 carried out inventory survey of the forests. Appendix 2 gives the result of the inventory. The inventory divided the natural forest into four types viz: Type 1 - Large crown high forest, Type 2 - Small crown high forest, Type 3 - Disturbed garjan forest and Type 4 - Brush and scattered trees.

Since the inventory in 1985, the position has changed. Report calculations are the latest area figures of forest types as in the working plans (1991). Accordingly the figures for timber-type forests are 15,800 ha for Chittagong and 11,800 ha for Cox's Bazar divisions. Appendix 2 gives the area of different forest types.

5. Sylhet Forest Division

Project FAO/BGD/85/085 completed the inventory survey of the Sylhet forests in 1988. The table in Appendix 2 summarises the area of different forest types and volume yield. The survey revealed that unlike Chittagong and Cox's Bazar Divisions, the area of Type 3 - Disturbed garjan forest was negligible. These area figures have changed since the inventory. This report uses an area figure of 2,749 ha of timber type forest. Details of forest type areas are in Appendix 2.

6. Bamboo Forests

The Hill Forests supply most of the bamboos. The Chittagong Hill Tracts are the major supply area of bamboos. Forestal could not make complete inventory of the bamboos as muli, the main bamboo species, was in flower at the time and clumps were dying. In 1985 De Milde made a survey of Chittagong and Cox's Bazar forests. Besides the Government forests there are supplies from tea gardens. The potential supply from all these sources is 194 million culms. The village forests supply much larger quantities of bamboo about 528 million culms. So the total supply potential is 722 million culms.

Inland Sal Forests

1. Condition of the Crop

The sal forests of Bangladesh are the remnants of extensive forests, which formerly covered large tracts. Now the sal occurs only in two zones: the Central and the Northern zones.

The sal forests in central zone occur in large patches and are the left overs after heavy encroachment and indiscriminate illicit fellings. The forest structure is highly irregular and abnormal, age classes are uneven and intermixed. In the 1950's and 60's the Department raised sal plantations over large areas, most no longer exist. Only a few patches survived as well-stocked sal plantations in Tangail and Mymensingh Forest Divisions. Beginning in the 1970's, the Forest Department raised plantations of moderately fast growing indigenous species on recovered encroached lands. Most of the replantations failed due to hostile actions of the displaced people. During the period BFD raised some mulberry plantations on recovered areas. Later in the 1980's the Department again planted fast growing exotics on some recovered land, again all the plantations failed due to hostile action of the people.

Forests in northern zone occur in scattered patches. The notified area is more than 16,000 ha. The forests lie in eight Zillas and 27 Thanas of Greater Rangpur, Dinajpur and Rajshahi Districts. The proportion of treed area is low. It is highly deficient in fuelwood and construction timber. So wood demand is much higher than the capacity of the existing forests of the region.

The forested areas bear sal coppice of all ages. The ground is full of seedlings. But these do not get a chance to grow due to ground fires. Such fires sweep the forest floor every year during the dry season. These ground fire also eliminate other species not fire hardy. Associates of sal in Madhupur forests are ajuli, haldu, chapalish and kumbhi. The fire is both accidental and incendiary. People set fire to create wood ash. Rain washes the ash to the surrounding agricultural land, where it acts as fertiliser to the paddy crop.

The forests occupy the higher land locally called chalas interspersed with lowlying paddy field locally called baids, elevation difference is one to two meters. While the lowlying areas suit paddy cultivation, the benches when bare of forest cover quickly degenerate due to erosion and laterisation.

Conditions, in Madhupur forests are slightly different. There, the high land are much wider. Habitation of the Garo tribal people is mixed up with the forest. Encroachers grow pineapple on clear forest area.

Appendix 2 tables give the area figures for different kinds of sal forests area. Dhaka, Tangail and Mymensingh divisions in the Central zone, and Dinajpur, Rangpur and Rajshahi in the Northern zone are the major sal areas. In addition small patches occur in Comilla.

2. Growing Stock Evaluation

There is no accurate evaluation of the sal crop as a whole. Separate evaluations exist for parts of the forests of the Central zone. On wooded land the crop consists sal coppice of 10 to 50 years age. A few stands are older, but they exist in small patches near or around offices. FAO (1990) determined the stock volume/hectare by thanas according to age group. The figures vary widely from 20 m^3/ha to more than 100 m^3/ha, depending on the age, density and site quality. The data are from incomplete surveys during 1989 and may be out of date. They are only indicative of the yield potential.

On degraded land the crop is mostly 1-2 years old sal coppice cut over repeatedly for firewood. On degraded land young coppice of 2-5 years age is also present on protected areas. The data are from Kaliakoir Thana. In comparison to other areas the locality contains crop of better growth and stocking. Average volume of better stands comes to 5 m^3/ha and that for inferior stands to 3 m^3/ha.

Litoral Mangrove Forests

1. Crop Condition

The future of the mangrove forests of the Sundarbans is dependent on the state of natural regeneration. No accurate estimate exists of the extent of natural regeneration. From ocular observations, the apparent regeneration status over the greater part of the forest is poor. It is not enough to ensure normal stocking in future years. The forest floor in many areas is completely barren. Some high lands on the river banks, no longer support important mangrove tree species.

There is a decrease in fresh water flow in dry season due to diversion of Ganges water at Farakka Barrage in India. This led to adverse changes in the character of the soil. The result is deterioration of the forest, most noticeably dying of sundri. Regeneration of gewa is low. Further studies are necessary to find out if these are due to the decreasing flow of fresh water.

The Sundarbans ecosystem as a whole is less static than many other true mangrove forests (Davidson 1985). There are series of long term and short term ecological changes going on. There is a continuous process of new erosion and sedimentation due to the straightening of the

drainage system. The change in soil ecology is very rapid. Davidson (op. cit.) postulates that the site stays suitable only long enough to produce one generation crop with a full set of age classes. Sundri (Heritiera fomes), the climax species is now stable. But ecological changes are inevitable. This will cause changes beyond human control. Sundri in many places may become senescent and die out, a strictly natural process of succession.

2. Evaluation of the Crop

Curtis in 1933 carried out the first inventory survey of the Sundarbans forests. Forestal in 1960 did the second inventory with the help of aerial photography coupled with ground checks. In 1985 ODA conducted another inventory survey.

A comparison of the two latest inventory figures shows that there has been decrease in the standing volume during the interval. Forestal predicted certain increment figures on basis of ring counting and other measurements. It now appears that Forestal's increment figures were high and there was over cutting. The new stocking figures show a decrease over the period. The decrease is about 40% for sundri and about 45% for gewa. In the case of gewa, removals (excluding the volume of matchwood) amount to 66% of the estimated 1959 volume. This exceeds the present estimated volume by 16%. Removals of sundri are in absolute terms greater than gewa. But as proportions of standing volume, figures for sundri are lower than the figures for gewa. Estimated removals of sundri amount to 42% of the estimated 1959 volume and 70% of the present volume.

Chaffey (1985) gives the total volume of Sundarbans to be 10.6 million m^3 of which 64% sundri plus other species mixed with sundri and 17 % is gewa plus other species mixed with it. The remaining 19 % is keora, passur, baen, and dhundal. The figures are for volumes of sound merchantable timber - sundri (DBH >17 cm), gewa (DBH >12 cm and keora (DBH >30 cm). Appendix 2 gives further details.

PLANTATION CROP CONDITION

General

It will appear from the forest type areas Appendix 2 that there are 331,766 ha of plantation forests in the country. Some of these are failed plantations, but extensive areas carry valuable timber stock. There are 112,966 ha of plantations in coastal beat and 21,086 ha in the sal forests. Most of the plantations recorded against the sal forests do not exist or are in poor condition. The bulk of plantations are in Hill Forest zone. The records show 197,714 ha of plantations in the Hill Forests. At least 17% of the plantations recorded do not exist.

Many of the plantations have suffered severely from cyclones during the last two or three decades. This is particularly true for coastal plantations. In addition large, areas of plantations went under water from Kaptai Reservoir flooding. Pilferage and jhum cultivation in plantations is increasing in the Hill Tracts, where the bulk of the plantations lie. This is mainly due to abnormal law and order situation. Pilferage from plantations has increased also in other areas.

Hill Forests

Before 1980, most Hill Forest plantations were teak and associated species, mainly jarul and gamar. Occasionally there were garjan, dakijam and mahogany. Originally the rotation for these was 60 years. In recent working plans it is 45 years. Then there are medium rotation plantations for poles, peeler logs and pulpwood. Lastly there are short rotation plantations for firewood. Medium rotation plantations are of gamar, eucalyptus and mangium. The rotation is from 12 to 20 years. For short rotation crop, the species are malakana, acacia and eucalyptus. The rotation varies from 7 to 15 years.

1. Long Rotation Plantations

Of the plantations, the long rotation ones are the most extensive and commercially important. Table 2 gives a list of long rotation plantation by five year age classes, upto age 45 and above. Some plantations are now over 120 years old.

Table 2 - Area of Long Rotation Hill Forest Plantation

Age Class	Area by division or forest reserves in 5 year age class, ha											
	Kassa-long	Raingk-hiong	Sita-pahar	Matam-uhuri	Ctg	Cox's Bazar	Sylhet	Bandar-ban	Jhum Cont	Lama	Ranga-mati	Khagra-chari
45+	-	369	1385	-	386	163	647	-	-	-	-	-
40-44	149	130	312	-	226	504	306	-	-	-	-	-
35-39	932	206	352	-	1123	838	384	-	-	-	-	-
30-34	1296	596	350	717	554	1511	1109	-	-	-	-	-
25-29	1598	1057	321	720	1262	1546	1916	-	3360	-	-	-
20-24	4850	2755	500	720	2107	1625	1223	-	2444	-	-	-
15-19	1678	1300	283	720	652	1826	1120	-	1318	-	-	-
10-14	3572	3661	45	720	3006	2778	746	-	3389	-	-	-
5-9	4423	5395	49	720	6285	2080	1211	3704	3471	405	2655	688
0-4	688	3249	11	720	3208	3873	1820	3174	1382	1935	719	740
Total	19186	18718	3608	5037	18809	16744	10482	6878	15364	2340	3374	1428

Most of the older plantations are teak with some admixture of jarul and gamar. In plantations since 1980, garjan, dakijam and mahogany are also present. Generally, the plantations are in poor condition. There has been no thinning for years. The density is below 80%. Estimated average annual growth (MAI) is 2.5 m^3/ha/A.

2. Medium and Short Rotation Plantations

In recent years the Forest Department started raising medium rotation (12 to 18 years) and short rotation (7 to 10 years) plantations. The medium rotation crop is for pulpwood, peeler logs, transmission poles and smallwood. The short rotation crop is mainly for firewood supply. The tables 3 and 4 below list of the existing medium and short rotation plantations in the hill forests. zone.

Table 3 - Statement of Medium Rotation Plantations

Age Class in years	Name of Division and area, ha					
	Bandarban Pulpwood	Kaptai Pulpwood	Rangamati USF	Chittagong Med. Rot.	Cox's Bazar Med. Rot.	Sylhet Med. Rotation
10 to 144	-	5031	-	140	301	60
5 to 9	4902	6923	1083	375	2182	246
0 to 4	3818	6215	773	2520	792	3015

It will appear that many of the medium rotation pulpwood and short rotation firewood plantations passed the fixed rotation. But there has been no harvest due to lack of agreement regarding royalty rates and other terms and conditions.

Table 4 - Statement of Short Rotation Plantations (ha)

Age Class	Name of Division and Area	
	Chittagong	Cox's Bazar
5 to 9	261	1,637
0 to 4	985	554

Plantations in Sal Forests

In the early 1950's and 1960's BFD raised sal plantations over large areas. In course of years most of these plantations in Dhaka, Mymensingh and Tangail divisions have disappeared leaving only a few patches. Later in the 1970's BFD raised plantations of moderately fast growing indigenous species on recovered encroached lands. Most of these did not survive either due to hostile action of the people. Even later in the 1980's the Department again tried raising plantations of fast growing exotic species like eucalyptus and acacia. Most of these met with the same fate as before, except some plantations in Rangpur, Dinajpur and Rajshahi divisions.

During the last five years enrichment plantations and agroforestry plantations have started in the Sal Forest area under the Thana Banayan Programme. The targets are 16,000 ha of enrichment plantation on depleted Sal Forest and 3,000 ha of agroforestry plantations on encroached areas. Under enrichment plantations BFD aims to grow sal, mahogany, Xylia sp, Casuarina sp, koroi and toon. Agroforestry plantations are short rotation species like fast growing eucalyptus and mangium. Table 5 gives the areas of plantations surviving. Areas in parenthesis are areas with only scattered tree cover.

Table 5 - Statement of Plantation Areas in the Sal Forests (ha)

Age group	Divisions with Plantation Areas					
	Dhaka	Mymensingh	Tangail	Dinajpur	Rangpur	Rajshahi
10-15	(1674)	(3598)		122	-	-
5-10	(808)	(1397)		626	688	628
0-5	528	2650	3631	554	526	586

Coastal Plantations

In the 1060's, Coastal Bangladesh experienced severe cyclone and tidal bores. From 1966 the Forest Department started planting trees on the outside of the protective coastal embankments. Till now there are about 112,966 ha of coastal plantations. The species are mainly Keora and Baen with sone admixture of other mangrove species. The table below lists the area of coastal plantations by 5 year age classes in the 4 coastal divisions.

Table 6 - Area of Coastal Plantations by Age Classes, ha

Age Class	Divisions with areas of plantations				Total
	Chittagong Coastal	Noakhali Coastal	Bhola Coastal	Patuakhali Coastal	
20-24	1,043	629	1,562	-	3,234
15-19	1,252	795	634	418	3,099
10-14	9,439	7,372	2,799	2,378	21,988
5-9	11,300	10,136	7,599	4,963	33,998
0-4	9,712	19,240	11,638	10,057	50,647
Total	32,746	381,172	24,232	17,316	112,966

PAST AND CURRENT SILVICULTURAL PRACTICE

General

The forests of Bangladesh have been under professional management for over hundred years. The first forest reserves were in Sitapahar and in Sundarbans. Government declared these areas as reserves in 1875 under the Forests Act, Act VII of 1855. About that time the Government appointed professional forest officers to manage the forests.

Though the first working plan came into force in the Sundarbans during 1893, the forest was under systematic management from 1874. During that year, Schlich and Temple visited the Sundarbans and fixed the minimum exploitable girth for sundri.

The Forest Department started teak plantations at Sitapahar under the advice of Schlich in 1871. Thereafter, teak plantations continued on a regular basis. There was not much headway, however, in forest management, except in the Sundarbans. In the rest of the forest areas there was little demand for forest products and no infrastructure for harvesting the logs. Management of the greater part of the Hill Forests was on a care and maintenance basis.

The sal forests of the central zone were under private ownership upto 1950's. Government, however, managed them under an agreement with the owners. The State Acquisition and Tenancy Act of 1950 brought under Government large tracts of waste land and forests. The Department was managing these lands under the Private Forest Act of 1949. The act of 1950 extended the area of Government control. Large scale encroachment in Sal Forest area of central and northern zones, subsequently, offset this advantage.

Review of Past Silvicultural Practice

The silvicultural practice in the three forest zones of the country differed as described in the following paragraphs.

Hill Forests

Here the predominant silvicultural system was clear felling followed by artificial regeneration to the extent possible. Though natural regeneration is profuse if conditions are right, it is difficult to get the right type of regeneration at the right time. This is due to the large number of species

in the natural forest, with varying requirements of light and shade and soil conditions. BFD adopted the system of clear felling and artificial regeneration.

The aim was to convert large parts of the high forest to plantations within the rotation period. Even with a long conversion period, this was not practicable. The annual cutting and planting areas were too much to handle. The market was too limited. Infra structure for timber extraction was lacking. Inadequate staff and funds were also among the factors responsible. After the Partition in 1947, the Department started an inventory survey of the forests in parts of Chittagong and Cox's Bazar divisions. The inventory showed that enough forest resources were available for meeting the anticipated demand even on an enhanced scale. Subsequently the Department prepared the management plans without full scale inventory data. This was not a drawback, as the yield regulation was by area. Only a small part of the theoretical allowable cut could be worked.

1. Chittagong Hill Tracts Divisions

Sitapahar reserve was among the earliest notified reserve. It was the also the first area to have teak plantations. This was as early as 1871. After that plantation programme continued in Sitapahar, Kassalong and Rankhiang reserves.

The early history of Chittagong Hill Tracts forests is similar to that of Chittagong division as the forests were in Chittagong division till 1909. Cowan prepared a plan for the forests in 1923. After some years the plan was suspended. In the mid-fifties Zahiruddin's plan came into effect. Zahiruddin's plan like the earlier plan was without inventory survey of the forests.

In 1963 Forestal completed a detailed forest type mapping and inventory of the growing stock for the forest reserves for the Chittagong Hill Tracts. USAID undertook inventory of the Sangu and Matamuhuri Reserves. Earlier in 1960, the Government had set up the Forest Industries Development Corporation to expand logging operation in the Kassalong Reserve of the Chittagong Hill Tracts. The logging project harvested upto 1,000 ha of high forest annually during the mid-sixties. The Forest Department teak plantations on the cleared land. The project, however, could not make headway because of politically unsettled condition during the late sixties and because of tribal insurgency later on. In 1983, FAO carried out another inventory of the forest by aerial photography without any ground truthing. For the time being work in the forest is more or less at a stand still due to disturbed law and order situation. Till 1990, the records show a plantation area of 22,376 ha in Kassalong and another 18,759 ha in Raingkhiong. The actual plantations in existence are much less about 19,186 ha in Kassalong and Raingkhoing reserves. The reserve forests of the Hill Tracts, excluding the Sangu and Matamuhuri reserves, now lie in 2 forest divisions. These are the North and South divisions.

Sangu Reserve now is in the Bandarban Division and Matamuhuri reserve is in Cox's Bazar Division. Sangu Reserve is still inaccessible. The Department and later BFIDC carried out limited scale operation in Matamuhuri Reserve, where 5,037 ha of plantations exist. Appendix 2 shows the present position for the two reserves.

Besides reserved forests, the Chittagong Hill Tracts contain over 700 thousand hectares of Unclassed State Forests (USF), which is subject to Jhum cultivation. Most of this land is now denuded of tree cover, full of scrub jungle and subject to erosion. From mid-sixties a jhum control plantation project is in existence. There are now plantation schemes under Bandarban, Lama, Rangamati, USF, Khagrachari, Kaptai Pulpwood and Bandarban Pulpwood Divisions.

2. Chittagong, Cox's Bazar and Sylhet Divisions

One of the earliest forest divisions of Bengal was the Chittagong Forest Division. Till 1909 Chittagong Hill Tracts Forest Division was part of Chittagong Division. Cox's Bazar Division formed part of Chittagong Division till 1920. Thereafter it became separate and again a part of Chittagong Division before its final separation after partition.

Cowan in 1923 prepared the first working plan for Chittagong Division. The aim was to convert large part of natural forest to plantation. In 1939 Government decided to keep in abeyance the working plan prescriptions.

During the World War II campaign in Burma, heavy extraction took place to meet the war time demand. Dent prepared a scheme for felling and plantation to meet the demand.

After partition Ghani prepared working plans of Chittagong and Cox's Bazar Divisions for the period 1949-1969. From 1960 to 1969 there were extensive felling and planting operations under the plans, to meet development needs.

FAO in 1987, did inventory survey of the Chittagong and Cox's Bazar Forests with aerial photography and ground truthing. In 1989 FAO surveyed the Sylhet forests. On the basis of the surveys, BFD prepared revised working plans. The plans provided for conversion working circles of long and medium or short rotation. The targets in management plans are again too high and unworkable. Divisional conditions are more fully described is the following three subsections.

Chittagong - Since 1923 the silvicultural system has been a system of clear felling followed by artificial regeneration. During that time BFD raised 38,852 ha of plantations, though many areas are failed plantations.

Of the 52,471 ha of natural forest area as per the inventory survey of 1985, about 38% consists of small crowned secondary disturbed high forest. Only 13% are of good quality large crowned on disturbed low forest and 1% garjan forest from which practically all other species have gone. The remaining, 48%, consists of areas of brush with scattered trees.

Divisional records show that 38,852 ha of area were under plantations since 1923. But approximately 21,000 ha of planted area is lost. The reasons may be encroachment, illicit felling and the ravages of the 1941-45 and 1971 liberation war periods. Included in this figure is an unknown quantity of replanted area. Extensive damage to the plantations happens due to hurricanes. The recent hurricane swept over south eastern part of Bangladesh. After the hurricane in many places, affected people collected posts/poles and other building materials indiscriminately and damaged the plantations.

Even in the plantations which exist the stocking densities are poor. It may be bad economy to keep them for long.

Cox's Bazar - The silvicultural system has since 1923 been on a standard system of clear felling for harvest, with artificial regeneration. Since 1923 the Department raised more than 38,000 ha of plantations. Excluding Chakaria Sundarbans there are 24,438 ha of natural forest area. 57% of this consists of small crowned secondary disturbed forest and 42% is relatively good quality large crowned disturbed forest. The remainder is disturbed forest with only some garjan trees left. The high proportion of secondary forest is a result of large scale selective harvesting during the war period (1940 to 1945) and illicit felling and encroachment.

The existing plantation area is 24,210 ha (1991). This indicates that out of approximately 38,000 ha of plantations, 13,800 ha do not exist.

Approximately 30% of this remaining planted area is of poor stocking and condition. Lack of funds for post-establishment maintenance has, to a very large extent, hindered the growth of the majority of the plantations.

The figures above exclude Matamuhuri reserve, considered earlier.

Sylhet - The system of clear fell harvesting and conversion to plantations started with the working scheme of 1959. Since that time plantations covered approximately 17,600 ha. The office records show that there are 12,634 ha of plantations existing in Southern Sylhet and 1,169 ha in Northern Sylhet. Actual inventory shows that there are presently 13,803 ha of plantations of which 10,282 ha (74%) are long rotation species and 3,521 ha (26%) are short rotation species. Of the long rotation plantations approximately 80% are teak and 11% jarul, garjan, sal and chapalish.

Inland Sal Forest

The inland sal forests were under private ownership till 1950. The forests of the central zone of Bhowal in greater Dhaka district and Atia in greater Mymensingh district have, however, been under partial Departmental management for quite some time. As sal possesses excellent coppicing power, the system of management was simple coppice system, supplemented by artificial regeneration, where required.

The BFD prepared the first management plan for the Bhowal forests in 1917 and for Atia forests in 1934. The prescription was simple coppice system with retention of 10-19 seed bearer trees per hectare. There was provision for planting of blank areas and climber cutting. The plan prescribed yield regulation but this did not work.

After the Partition in 1947, the Forest Department divided the forest into two working circles. The first was the timber and conversion working circle. Here the aim was clear felling followed by plantation. The rotation for plantations was 75 to 80 years. The second was the coppice working circle. For the coppice working circle the rotation was 25 years. There were provisions for climber cutting, thinning and fire protection.

The position in the northern zone was worse. Before 1959, the forest areas remained under the control of the proprietors and there were indiscriminate fellings. In 1959 the Department prepared a management plan for the forests. The plan prescribed three working circles - conversion working circle (with artificial regeneration), coppice working circle and afforestation working circle. In 1976, BFD revised the plan to form a short rotation community forest working circle and a long rotation commercial forest working circle.

The silvicultural systems failed. There were no settlement operation and survey to determine the forest boundary. This led to unauthorized settlement and encroachment. Due to frequent coppicing at short intervals, sal root stock lost coppicing power.

- People removed the mother trees illegally. Due to absence of mother seed trees the system of coppice with standards did not work. The removal of seed bearer trees resulted in inadequate seedling regeneration.

The failure of the silvicultural system resulted in blanks and encouraged encroachments. Annual sustained production fell. 1972 the Department stopped all felling in sal forests, hoping to protect the sal areas. Instead this led to illegal fellings on an even a larger scale. Government's campaign for growing more food encouraged temporary cultivation of blanks in the forest. Encroachment in forest increased with very little permanent benefit to agriculture. The absence of maps showing legal boundary of forest land encouraged corrupt bailiffs of former landlords to issue false back-

dated settlement papers. The Department personnel watched with frustration as these fake settlers grabbed forest land. The deteriorating law and order situation worsened the situation. In the present position conventional forest management will not succeed. Agroforestry and participatory forestry involving the villagers is the only recourse. This will mean replacement of sal by fast growing exotics over large areas.

Littoral Mangrove Forests

There are two tracts of littoral forests. The smaller one is the Chakaria Sundarbans. It lies in the delta of Matamuhuri River in Cox's Bazar Division. Government notified it as a reserve in the latter part of the last century. As early as in 1911 there was a working plan for the area. But over the years the Department failed to do anything concrete to improve the condition of the growing stock. The area suffered from overfelling and illicit removal of forest products. Recently the Government transferred about 3,233 ha to shrimp cultivators. Uncontrolled shrimping cleared the remaining forest without authorization.

The Sundarbans in the delta of the Ganges and Brahmaputra has served people since time immemorial. In the eighteenth century forests were double their present size. Large scale deforestation drew the attention of the Government. They declared the Sundarbans as reserve forest under the Forest Act of 1874. The early management confined itself to realization of revenue on the export of forest produce.

The first working scheme came into force in 1893-98. Trafford prepared the first regular working plan for the period from 1912-13 to 1931-32. Trafford prescribed a selection system with exploitable girth limit of 1.35 m for sundri and a felling cycle of 40 years.

Curtis' plan came into existence in 1933 after detailed inventory of the forests. He took great pains in collecting accurate data for his working plan. Exploitable diameters for sundri on site quality I, II and III were 36 cm, 25 cm and 13 cm respectively and for gewa 36 cm, 28 cm and 20 cm. Felling cycle for the fresh water working circle was 20 years and 30 years for the moderately salt water working circle. Curtis's plan was too elaborate to follow and the Department prepared short term schemes from time to time.

In 1960, there was a second forest inventory of the Sundarbans with the help of aerial photography. From the inventory data the Forest Department prepared a working plan for 1960 to 1980. The Working Plan divided the forest into gewa (Excoecaria agallocha), sundri (Heritiera fomes) and keora (Sonneratia apetala) Working Circles. The yield regulations were by fixation of exploitable diameters for different species, under a cutting cycle of 20 years.

In 1981 the Overseas Development Administration (ODA) of the Government of the United Kingdom took a new set of aerial photographs for inventory survey. They completed the survey in 1984 and prepared a draft report, (Chaffey et.al. 1984). From the Report it appears that the increment for gewa was much less than Forestal's prediction. The position of sundri, the other major species, was better. For gewa, the new increment figure is 0.13 m^3/ha/A against Forestal's prediction of 0.42 m^3/ha/A. This is important as gewa is the raw material for the Khulna Newsprint Mill. The new corresponding figures for sundri are 0.41 m^3/ha/A compared to 0.35 m^3/ha/A from Forestal. Though the increment figure for sundri was better, removals of both gewa and sundri during the quarter century were more than the growth. This led to decrease in volume for the both sundri and gewa. This is apparent from the Table 7.

Table 7 - Volume Figure of Sundri and Gewa in 1959 and 1983

Item	Sundri		Gewa	
	m^3/ha	Million m^3	m^3/ha	Million m^3
1959 volume	34.5	13.04	8.7	3.30
Removals				
round timber	14.0	5.54	-	-
pulp/matchwood	-	-	5.5	2.17
1983 volume	19.9	7.78	4.6	1.82

The data regarding volume and increment in the Sundarbans are from a paper by Sydneysmith and Balmforth (1985), studying the paper it would appear that:

a. The ecosystem of the Sundarbans is not static but is changing.

b. Edaphic factors are affecting the ecosystem. There are changes in fresh water flushing and silt deposition. Soil salinity is increasing due to construction of barrage upstream. Poldering is restricting the flow of water. Then there are tectonic changes due to accumulation of vast quantities of silt.

c. Silvicultural felling of sundri to improve stand condition and growth has not been effective. Because of poor growth conditions or excessive felling, growing stock is less and forest canopy more open.

d. The quantity of gewa available for harvest is less and replacement is not enough to maintain industrial supply at the present level.

e. The quantity of sundri sawlog material is sufficient to allow for continued harvest at approximately the current rate. The problem of sundri top dying may, however, complicate the situation.

The Sundarbans is not only a valuable national asset, but a source of supply of raw material to a number of big and small industries. BFD cannot simply cut off the supply suddenly without causing major dislocation in the economy. The average yield from Sundarbans has been rather low, of the order of 1.0 m^3/ha/year, compared to 6.0 m^3/ha/year for mangrove forests of Thailand and over 8.0 m^3/ha/year for Malaysia. In both these areas there is the practice of clear felling in strips. Our immediate problem is not increasing the yield but sustaining it. Increase of yield should be the concern of future research. The prevalent idea is that decrease in gewa increment and lack of regeneration are due to increase of salinity. But increase in salinity cannot be the only reason. Gewa can tolerate salinity better than sundri. It is a fact that the Ganges barrage and the silting up of a large number of water channels have reduced the fresh water flow from upstream.

It is most interesting to speculate why the mortality rate of gewa and other salt tolerant species is higher than that of the sundri which prefers fresh water. This contradicts the prevalent idea that the salinity increase is the main cause of the deterioration of the forests. More likely other factors are involved such as edaphic changes due to a rise in the soil surface in relation to water level during high tide.

Conclusion

It is a fact that from early days most of the forests under BFD's control were under some sort of working plan with definite silvicultural prescription. But the history of working plans in this region is rather chequered. Most of the silvicultural prescription in the working plans were too sophisticated or unworkable. Even if the plan was workable, it failed to achieve the desired results.

For the Sundarbans, Curtis took great pains for the inventory and preparation of his working plan. But during initial implementation, field personnel found the prescriptions too elaborate and unworkable. A more practical scheme replaced the plan. In 1962 a working plan based on Forestal inventory came into force. Few years later apprehensions grows that there is not enough gewa regeneration. Silvicultural prescriptions in the working plan had failed to take notice of this or make any provision for inducing regeneration. The problem of sundri die-back appeared later. There were no specific silvicultural treatment for crop improvement or inducing regeneration of the major species. These are vital for any forest under selection system. There has been no new working plan after the 1985 ODA inventory. The forests are now under a provisional scheme.

In the sal forests, only the central zone forests have been under the control of the Department for some length of time. Some areas here have been under working plans for more than 75 years. But the Plans failed to achieve any result. The failure of the working plans was not without reason. The extent of the forest area was indeterminate. This led to large scale encroachment. Then there was a silvicultural reason for the failure. The success of the plan rested on sal's coppicing ability. Now that most of the sal stock has lost it's coppicing power, it appears that some sort of participatory or agroforestry technic is the only recourse left. This will mean replacement of sal by fast growing exotics over large areas.

For the Hill Forests again, most of the management plans were unworkable. Natural regeneration in most cases was uncertain. The plans relied on artificial regeneration. The aim was to convert the natural forest to a plantation forest during the conversion period. In most cases this was too ambitious a programme. In the early days the market was limited. Infrastructure for harvesting the natural forest was lacking. Funds and personnel for execution of the programme were not available. Even when BFD could raise the plantations these were neglected. Again, short term working schemes superseded most of the working plans.

One of the reason for the failure of the management plans was inadequate monitoring facility. Though the management plans prescribed maintenance and submission of Control forms, even enforcement was lack.

In conclusion one can say that the overall results of past silvicultural practice do not support healthy forestry development. The position has worsened in recent years. Over the 20-year period ending in the early 1980's, natural forest declined by 2.1% on the average annually. From 1984-90, the annual rate of decline was 2.7%. It is likely to be 3% by the year 2000 (UNEP GEMS). Part of the reason is the increased population creating pressure on forest land. BFD's role has degenerated to that of a police force protecting the forests. The productive role of BFD has diminished. While Bangladesh does not lack skilled professionals, the forests are deteriorating.

In the Sundarbans, the growth rate of gewa has decreased. Sundri, the other major species is suffering from die-back phenomenon. The reasons may be ecological or pathological.

In the sal forests there is the problem of large scale encroachment. Existing stocks are gradually losing coppicing power, rendering extensive areas blank. Large scale agroforestry might result in replacement of indigenous sal by fast growing exotics.

The Hill Forests are commercially the most important. Here the growth rate for natural forest has fallen to about 1.5 m^3/ha/A. Net plantation yield has fallen to a level of 2.5 m^3/ha/A from the earlier levels of 7-10 m^3/ha/A. The low rate of yield is due to pilferage and poor tending operation. There has been no thinning in most teak plantations for years. The crop is congested and there is little under growth due to dense canopy.

It will thus appear, that inclusion of sound silvicultural principles in the working plans is often meaningless. Nobody bothers to carry out the prescriptions for thinning and tending. Lack of funds is one of the reasons. Insufficient staff to look after hundreds of thousands of hectares of plantations is another reason. Then the meagre staff is kept busy on policing job.

Lack of upto date data regarding forest area and stocking prevents a more exact treatment of the position. The report presents the results of past silvicultural practice as far as available from data and field observations. In the Chittagong Hill Tracts, no observation was possible due to abnormal law and order situation.

SILVICULTURE ISSUES PROGRAMMES

General

Any forest management plan is dependent on the silvicultural system. Choice of any silvicultural system again depends on a number of factors. These are site conditions, characteristics of the major tree species and end use of the product.

Before outlining the future silvicultural development, it is necessary to discuss the silviculture issues and the required programme to meet the situation. These are covered in the remainder of this section.

Mangrove Forests

The Sundarbans is one of the largest single tract of mangrove forests. This forest is situated in a very ecologically sensitive zone. With change of site conditions, the species composition and yield of forest produce changes. This is succession and depends on the changes of site conditions like salinity, soil composition, sedimentation rate and size of sediments. Supply of fresh water in the Sundarbans is reduced due to dam at Farakka and also due to construction of flood control embankments upstream. Siltation of many of the small rivers and streams has also affected the vegetation. Many of the rivers along the boundary have completely silted up. Some border areas have merged with the agricultural land. These areas can no longer sustain mangrove forests. The opportunity costs of these areas call for comparison with alternative landuses, like agriculture or shrimp cultivation. As it is, the direct economic yield from the Sundarbans is rather low. If it falls further, alternative landuse possibilities will crop up. The Plan will not recommend this as an immediate step. But the possibility of alternative landuse exists in the long run.

Mangrove Forests Silviculture

A major silvicultural issue in the Sundarbans is the phenomenon of sundri die-back. This may be pathological or more probably due to ecological changes. Sundri is dying in areas which do not get tidal flushing for at least 8 to 10 days during spring high tide. Troupe in 1921 and Curtis in 1933 had predicted this. Salinity and siltation has increased all over the Sundarbans. This has changed the whole ecosystem. Sundri being most sensitive to these changes is affected more. With further increase in salinity and sedimentation rate, sundri may disappear from the forest. The solution is to find out more salt tolerant species like Heritiera littoralis from Honduras or Malaysia. On higher land not subject to tidal inundation, the possibility of growing non mangrove species exists.

Gewa is a hardy species and regenerates easily in blanks on river banks. Besides gewa is more salt tolerant than sundri. With proper tending there should be no problem to get gewa regeneration even in very saline areas, though the growth rate in such cases might be less. Other species like Kakra, Passur, Baen and Keora have not shown any sign of ecological degeneration. Goran has great demand as fuel and is often overcut. With protection it reappears.

Sundarbans forests are now under the Selection-cum-Improvement system with a 20-year cycle. Yield control is by fixation of exploitable diameter. Although sundri top-dying is happening, the silvicultural system need not change. However, BFD might consider reduction of felling cycle in areas affected by sundri top dying. Even without reduction of felling cycle, early salvage felling of dead or dying sundri should get priority for sanitary and economic reasons.

Hill Forests

Formerly BFD treated most of these forests on a care and maintenance basis. Even when work started in a limited way in some centres, large areas were left untouched. In silvicultural terms, these areas formed the unallotted periodic blocks. The idea was to carry out selection-cum-improvement system in these and other and unworkable areas. In more accessible areas BFD tried to induce natural regeneration by canopy manoeuvre. But this failed. Only clear felling and artificial regeneration worked. Lastly in the Hill Tracts, the Department tried artificial regeneration with natural regeneration in strips. This too failed and the only recourse was clear felling followed by artificial regeneration.

The deteriorating law and order situation has its impact on the forests. Most of the natural forests are now in depleted condition. There are few seed trees left. Left to itself there is little chance of natural regeneration. For raising plantations, the Plan will propose creation of seed orchards and import quality seeds when necessary. There will also be a genetic seed improvement programme for raising high MAI plantations particularly under Scenario 2.

There are on record 197,714 ha of plantations in the Hill Forests. Large areas of plantations are non existent. Even those which exist are in poor condition. It is uneconomic to keep these for long. The Plan recommends harvesting these plantations at accelerated rate without waiting for the full rotation age. The future rotation will be lower. The harvested plantation along with the felled natural forest will be planted up.

Hill Forest Silviculture

The recommendation is to preserve the greater part of the natural forests. Details of areas for felling and areas for preservation are in the section on Future Management Patterns. After 20 years there will be no felling in any natural forest in the Hill zone. In preservation areas, BFD may carry out only cultural operations like removal of dead or dying trees to make room for new regeneration. BFD may also do gully plugging and other anti erosion work in areas subject to erosion.

In clear felled forest areas and in harvested plantations the system will be clear felling and artificial regeneration. BFD should fell the older plantations first and then the younger ones. There should also be thinning and climber cutting for younger plantations.

In addition to cut over natural forests and harvested plantations, there are extensive areas of denuded and encroached areas. In rehabilitating planting encroached areas, BFD must give top priority to involving local people in a productive, positive way. Without their good will and cooperation afforestation programme cannot succeed. This also applies to the USF land in the Hill Tracts. In these areas the aim is to grow shorter rotation crop than in timber plantations. In this case, the people do not have to wait long for sharing the benefit. Non wood products can

provide for financial returns during the early years. Thereafter the people should get income from thinnings and part income from final fellings. The details of sharing will be mutually agreed between BFD and the people.

For any system of clear felling and artificial regeneration, rotation is an important issue. This is connected with the growth rate as indicated by MAI and the end use of the product. In encroached areas, the people's attitude will also determine the rotation. For long rotation timber plantations a rotation of 30 to 40 years is suitable. For denuded areas and scrub forests a shorter rotation is indicated, 20 years. Lastly short rotation plantations of pulpwood mostly in the Hill Tracts uses a 10-years rotation.

Inland Sal Forests

The sal forests are in the last stage of depletion. Extensive areas are under the possession of encroachers. Even in areas under the control of BFD the crop condition is not promising. There is little regeneration due to frequent ground fires. Existing stumps have lost ability to coppice. Plantations in the past have failed due to hostility of the people.

Sal Forest Silviculture

Traditional methods of managing these forests have failed. To save these forests BFD will have to consider a different approach. Absolutely nothing can be done without active cooperation of the people. While in the Hill Forests it is desirable to secure such cooperation, in case of sal forests it is essential. As such, some form of agroforestry is the only recourse left.

A start has been made in this direction under the Thana Banayan Project. BFD have been able to put large tracts of bare and encroached land under tree cover. This will of course mean replacement of sal by fast growing exotics on a short rotations of 7 to 10 years.

There will, however, be some enrichment plantation of sal and associated species in National Parks and in blank areas inside the forests. There will be some coppice. There will also be some aided natural regeneration. So the silvicultural system will be a complex, balanced combination of long and short rotation plantations, coppice regeneration and aided natural regeneration. Most of the encroached areas will be under short rotation agroforestry plantations.

FUTURE DEVELOPMENT PLANS

General

In the previous section we discussed silvicultural issues and the future programme. On the basis of the silvicultural programme this section presents the future management principles. The mangrove forests will continue under the selection system as at present, with minor variations. We shall discuss this in detail at a later stage. For the sal forests the old coppice system of regeneration may not work. Denuded areas suit enrichment plantations and encroached areas agroforestry plantations of light crown fast growing exotics.

Hill Forests are essentially for preservation as part of the natural forests for maintenance of biodiversity. Natural parks and sanctuary areas are in addition. For the rest of the natural forest a system of clear felling followed by artificial regeneration is best. Existing plantations need replacing by faster growing better quality ones following accelerated harvesting. The implications of these principles are given in detail in the next paragraphs.

Hill Forest Teak Plantations

For more than a hundred years these forests are under professional management. The silvicultural system is mostly clear felling followed by artificial regeneration. Teak is the predominant species for the plantations. The history of teak plantation goes back to 1871. BFD in that year raised 3.23 ha (8 acres) of teak plantation at Sitapahar in the Chittagong Hill Tracts. In 1874-75 Sir William Schlich visited the area. Schlich recommended extension of the plantation programme. He, however, preferred a mixture of species instead of relying only on teak. In 1881-82 Sir D. Brandis visited the area and endorsed the plantation programme. There were, however, apprehensions from time to time about the long term effect of extensive teak plantations - changing the ecological status by large scale plantations.

Professor H. G. Champion, the then Silviculturist, Forest Research Institute, Dehra Dun visited the forests in 1933. After detailed inspection, Champion did not object to clear felling and artificial regeneration. He, however, thought that natural regeneration methods should receive greater attention. He believed that labour problem might pose difficulties in extending artificial regeneration. He warned BFD not to rely too much on teak and recommended mixture of species whenever possible. He observed that there was not much danger of ecological deterioration, if there was undergrowth on the forest floor. He found that there was no problem in getting an undergrowth in pure teak plantations. Bamboo establishes itself as undergrowth in teak plantations if the canopy is not too dense.

Professor Champion realised that a number of special factors come into play in these forests. The factors would decide the management prescriptions. He realised big timber must come mainly from the Hill Tracts. He recognized that clear felling coupes offer the most convenient and economic field for operation of heavy logging equipment. Only heavy logging equipment can handle the big sized timber in the Hill Tracts.

Effect on Soil

The question of soil deterioration under teak plantation was the next problem for consideration. BFD undertook an investigation of soil deterioration. There were apprehensions regarding laterisation in teak plantations due to taungya method of plantation. In taungya plantations the tribal people practice jhum cultivation. In 1941 Dr. P.K. Ghosh of Geological Survey of India at the request of the Conservator of Forests, visited Sitapahar, Rangamati and Kassalong Reserves. The long term effect of teak plantations on soil was the subject of his investigation. He took samples of soils from various places and submitted a very interesting report.

Dr. Ghosh found that the most harmful factor in the jhum method of plantation was erosion and destruction of humus. The chemical composition of soil of a teak plantation ranging in age up to 60 years was not appreciably different from that of an evergreen forest. Iron-alumina accumulation in the form of concretions and conglomerates was often prevalent in evergreen forest areas. It was rare in good teak plantations. When such accumulations are found, they represent inheritance from the parent forest soil. He thought it would be premature to generalise from the scanty data that the soil under teak was turning less acid than that under the evergreen forest. He observed that it was not possible to say whether the change, when occurring was fortuitous or the result of teak plantations. Only a large number of such determinations could yield definite information. Dr. Ghosh made detailed examination of Mahallya teak plantations. He observed that the heavy dressing of alkalies from jhuming had not left any permanent effect on the soil; it remained strongly acidic after a year of jhuming. Dr. Ghosh concluded that the danger of lateritic weathering under teak can be largely mitigated by a dense evergreen undergrowth; leguminous plants, being rich humus formers, would be preferable.

From the above there is little chance of soil deterioration provided certain steps are followed. These are: selection of sites, species to match the site and introducing evergreen undergrowth in plantations.

Implications of Monoculture

Another potential problem is large scale plantation monoculture. There is a tendency to exaggerate the potential danger from extensive teak plantations. Sal and teak in their native states form gregarious stands of almost pure crop, without ill effect. The Plan will recommend mixed plantation, where teak would form not more than 75% of the crop. For preservation of biodiversity and natural gene pool, there will be large blocks of natural forest in addition to the parks and preservation plots. These will break up the continuity of extensive plantation areas.

The recommendation is to continue the clear felling system for the management of the Hill Forests. When properly practised, it must suit the silvical condition of Hill Forests. The above discussion dispels any apprehensions regarding adverse effects of the system on environment.

Outlines of Development Programmes

From discussions on the past silvicultural practices in the forests, it is evident that the present state of affairs is highly unsatisfactory. There is a wide gap between the demand and the supply. Estimated round wood demand now is 13.6 million m^3 against a supply potential of 7.9 million m^3 without any development programme. The Government are expecting an economic growth rate of 5% per annum. At this rate the demand in 2013 will be 16.7 million m^3. The forests of Bangladesh have the potential to meet this demand without harming the environment. For this we need special development programmes. Without development efforts, things would slide back and position become worse. The imbalance between the supply and demand would become wider. Such a position would generate socioeconomic instability. It would also harm the environment by putting more pressure on the existing forest resources.

The aim of the Forestry Master Plan is to formulate development patterns to rectify the situation. We shall be presenting two development programmes, viz: Scenario 1 and 2. The development programmes will be generally similar, with minor variations. We shall describe the present situation as the Status Quo position for comparison as bench mark.

Under Scenario 1, BFD will execute the programme. If necessary the MOEF may set up a Semi-Government corporation for the purpose or bifurcate the existing BFD. The development programme will be too big for the existing setup of the BFD.

Under Scenario 2, autonomous corporate bodies will execute the programme under enterprise system. The bodies will be independent and should work on commercial lines.

The Subteam Report on Production gives details regarding the setup of the agencies for programmes under the scenarios.

The development programmes under the different scenarios are outlined below:

Status Quo Scenario

1. Mangrove Forest and Sal Forests

In the Sundarbans after lifting the moratorium, work will continue on the basis of ODA's report. The yield of gewa for the Newsprint Mill will be 133,000 m^3 as per latest interpretation of inventory data. Harvesting of Sundri will be as per ODA's prescription. BFD should remove dead

or dying Sundri trees first. For other trees the silvicultural treatment will be as per working plan prescriptions.

In the sal forests no working scheme exists. BFD is carrying out enrichment plantation and agroforestry plantation under Thana Banayan programme. This will continue as per programme.

Though not part of the mangrove forests, there are extensive mangrove plantations on the coastal belt. Table 6 gives a statement of the plantations. Some of them are more than 25 years old. We have given a tentative felling and replanting programme for these in a later section. We are also recommending new plantation programme of 1,645 ha every year. Appendix 5 gives details of the programme.

2. Hill Forests

Natural Forests - In the Hill Forests the cut will be 1/45 of the natural timber forest in Kassalong, Matamuhuri, Chittagong, Cox's Bazar and Sylhet. There will be no felling in the Sangu reserve. The total annual cut will be 1,979 ha of natural forest.

Long Rotation Plantations - In addition there will be harvesting and replanting of existing long rotation plantations. These are mostly teak plantations. The intention is to plant up the felled natural forest and harvested plantations with teak and associates on a rotation of 45 years.

Appendix 3 gives the areas to be planted up annually for every 5 year period. The table in the Appendix includes both felled natural forest and plantations.

The MAI for the existing plantations is 2.5 m^3/ha. We are showing the same figure for the new plantations, though we expect higher MAI upto 7 m^3/ha, if the BFD carry out thinning and tending.

Medium and Short Rotation Plantations - Besides long rotation plantation, there are medium and short rotation plantations for pulpwood, peeler logs and poles. Appendix 3 gives the planing programme. The rotation for these plantations is 10 years, so there will be no thinning.

Scenario 1 Programme

1. Mangrove Forest

The programme under this Scenario will be similar to the Status quo programme. We recommend the existing management system of the Sundarbans should continue. We suggest cutting of all affected Sundri trees without waiting for them to die. There is now an expert team investigating the problems of Sundarbans. Any change should wait their findings. BFD should consider the problems of Sundarbans in its entirety. Any future project should include forestry, fishery (including shrimp culture), tourism and harvesting of non wood products.

2. Sal Forest

In the sal forests we recommend expansion of the Thana Banayan program. We recommend the following annual programme:

Participatory plantation on encroached and denuded area - 2,986 ha.
Enrichment plantation of poor density forest - 1,150 ha.
Replanting of old sal plantations - 1,050 ha.
Planting in National Parks and Sanctuaries - 650 ha.

Details of the programme are in Appendix 3.

3. Hill Forests

In the hill forests there will be far reaching changes in the management pattern. The aims of management will be two fold. For conservation and maintenance of biodiversity, we intend to preserve more than half of the existing natural timber forest. This is in addition to the parks and sanctuaries. For increasing production, we intend extending the plantation programme and to get higher increment. These steps will substantially increases the supply of timber and other forest products. This will ease the pressure on the remaining natural forests. Increased supply of timber will encourage growth of wood based industries, generate employment and promote growth of national economy.

Programme for Natural Forests - For maintenance of biodiversity and for nature conservation, we are preserving the whole of Sangu reserve and one-half of the remaining timber forests. We intend to fell the timber area in the remaining half and plant it in 20 years. This will mean that we shall annually fell 2,155 ha of high forest and plant it up. The rotation will be 40 years and MAI 7.5 m^3/ha/A. Appendix 3 gives details of the programme.

Programme for Long Rotation Plantation - We intend felling and replanting the existing long rotation plantations over a period of 40 years with teak and associates on a rotation of 40 years with MAI of 7.5 m^3/ha. Appendix 3 gives the plantation programme for the felled natural forest and harvested plantation. We recommend thinning of existing plantations of age 30 and below, and of new plantations as per thinning programme in Appendix 3.

Programme for Medium Rotation Plantations - The Kassalong and Raingkhoing reserves contain 15,080 ha (11,852) ha in Kassalong and 3,228 ha in Raingkhoing) of timber-bamboo area. Then there are 73,759 ha of non forest are in the two reserves, giving a total of 88,839 ha. There are more than 12,000 ha of scrub an non forest land in Matamuhuri reserve, bringing the total area of scattered tree forest and denuded forest in three reserves to over 100,000 ha. To this we can add 50,000 ha of USF land, making the available area for plantation to over 150,000 ha in the Hill Tracts. In addition over 56,000 ha of unproductive reserve forest land exist in the division of Chittagong, Cox's Bazar and Sylhet. We propose using 50,000 ha of this land for medium rotation plantation. Thus the total area for planting comes to more than 200,000 ha. We have taken an MAI of 12.5 m^3/ha/A. With 20 year rotation the annual planting area comes to 10,000 ha. In Appendix 3 we are showing the plantation programme of 10,000 ha starting from 12993. In reality it may not be possible to start the programme before the second year and to plant more than half in the third year. Thus there might be a shortfall of 15,000 ha over the 20 year period. Unworkable sites and roads will come out of this land. This will mean that in the final year of 2013, some of the plantations felled will be 18 years. The area felled also will be less than the target. We have taken these factors into account for yield calculation.

Programme for Short Rotation Plantation - The short rotation plantations will be of 10 years rotation with MAI of 15 m^3/ha. The trees would be largely of pulpwood species. The plantations will be mostly in the USF, near existing pulpwood plantations. There will also be some plantations on the bare and denuded reserve forest areas of Chittagong, Cox's Bazar and Sylhet Divisions. As there are existing pulpwood plantations, the future planting programme depends on the harvesting programme and the potential demand. Appendix 3 gives the annual planting programme by divisions.

Development Scenario 2

In development Scenario 2, the management pattern would differ in some respects. The main difference would be that the executing agency would be autonomous bodies working under the

enterprise concept. The role of the BFD would be confined to policy matters and liaison with the Government, without the right to interfere in any manner with the working of the agency. It has been suggested that such autonomy will result in greater efficiency and much higher outturn.

The Government might have to initiate procedural changes for the purpose land. This might take time. We are presenting the Scenario as a possible alternative, which might be considered for adoption at a future date.

1. Mangrove Forest and Sal Forests

The management pattern in these two areas will be more or less the same as for Scenario 1, except that for sal forests, the role of NGO's will be on a larger scale. Details of the programme are in Appendix 3.

2. Hill Forests

In the hill forests, the programme will further restrict felling of natural timber forest as compared to Scenario 1. This will cause some shortage in the timber supply initially. Till the supply catches up, there may have to be imports. Restriction of felling in natural forests will promote conservation of nature.

Even under Scenario 1, we have proposed preservation of the whole of Sangu reserve and half of the timber forest in the rest of the hill forest zone. This is in addition to the parks and sanctuaries, Scenario 2 simply widens the scope of the programme.

Programme for Natural Forest - Under the programme, we propose to leave most of the forest unfelled. We intend to fell only 10,000 ha out of 41,000 ha of timber forest in Kassalong reserve. There will be no felling elsewhere. We intend planting up the area with teak and associates on a rotation of 30 years. The MAI aimed is 20 m^3/ha.

Programme for Long Rotation Plantation - We are planning to fell the existing long rotation plantations over a period of 30 years and replanting with teak and associate species. The felled areas of Kassalong will also be in the plantation programme. The rotation will be 30 years and the MAI aimed would be 20 m^3/ha.

The felling programme for long rotation plantations will be as in table 17. The replanting programme for the felled plantations as well as for the felled natural forest will be as in Appendix 3. Thinning programme will be as in Appendix 3.

Programme for Medium Rotation Plantations - The programme for medium rotation plantations will be similar to the one under Scenario 1, where we hope to raise 10,000 ha of plantations annually, except in the first two years of the Plan. In 1993, the first year of the Plan, it might not be possible to raise any plantation. In 1994 not more than half the target area will be possible. As under Scenario 1, the 15,000 ha will form part of unworkable area or of roads and nurseries. The rotation will be 20 years but the MAI under this Scenario will be 30 m^3/ha/A instead of 12.5 m^3/ha/A. Thinning programme will be as in Appendix 3.

Programme for Short Rotation Plantations - The programme for short rotation plantation is mainly for production of pulpwood. Appendix 3 gives the annual planting programme with division wise break up. The rotation will be 10 years MAI aimed is 45 m^3/ha.

SPECIES SELECTION FOR PLANTATIONS

General

Except for the mangrove forests of Sundarbans, plantations are the basis of silvicultural rehabilitation programme for the forests of Bangladesh. The bulk of plantations will be in the hill forest zone. Here the annual target will be 18,000 to 19,000 ha in the last year of the Plan. Then there will be additional plantations in the sal forests and coastal areas.

For success of any plantation programme, choice of species is important from the point of view of site and end use. The tree species should be selected according to the requirement of the site. Davidson in his publication on Species and Sites has elaborated the characteristics of different tree species. The publication - FAO Field Document No. 5, April 1985, lists among other things the following characteristics.

- Nitrogen fixing ability, which is important for poor soils
- Soil pH tolerance
- Coppicing ability, which is important for firewood species
- Wood specific gravity and calorific value
- Susceptibility to grazing
- Fire tolerance
- Disease and pest resistance
- Wind firmness
- Stem wood and bio mass production ability

Some of the above characteristics are of importance in specific locations. Then the rotation and end use have to be considered. The last is of importance for economic viability of the programme. These aspects have been considered in some detail in the report

Plant Characteristics

The lists below classify some of the species according to the above characteristics.

1. Nitrogen Fixing Ability

This is a useful quality of certain species to fix atmospheric nitrogen, through a symbiotic relationship, usually with bacterium 'Rhizobium' in nodules on the roots. This is important in tree establishment, particularly on degraded soil. The species below have good nitrogen fixing ability.

- Acacia auriculiformis (Akashmoni)
- Acacia mangium (Mangium)
- Acacia nilotica (Babul)
- Paraserianthes falcataria (Moluccana)
- Albizzia procera (Jat koroi)
- Cajanus cajan (Arhar)
- Calliandra calothyrsus (Calliandra)
- Casuarina equisetifolia (Jhau)
- Leucaena leucocephala (Ipil-ipil)
- Samanea saman (Randi koroi, rain tree)
- Sesbania bi-spinosa (Dhaincha)
- Sesbania grandiflora (Bakphul)
- Sesbania sesban (Sesban)

2. Soil pH Tolerance

Soil pH is a critical factor in matching species to site. The pH of soils may vary from extremely acidic in hill soil to alkaline in laterised soils. The tolerance of species to soil pH is listed below:

- Acacia auriculiformis	pH 3 to 9.5
- Acacia mangium	pH 4.5 to 8
- Eucalyptus camaldulensis	pH 4.5 to 7
- Eucalyptus citriodora	pH 5 to 7.5
- Gmelina arborea	PH 5 to 7.5
- Acacia nilotica	pH 4.5 to 7.8
- Acacia catechu	pH 4.5 to 7.8
- Casuarina equisetifolia	pH 4.5 to 7.8
- Melia azedarach	pH 5 to 6.2
- Azadirachta indica	pH 5 to 6.2
- Artocarpus heterophylla	pH 5 to 7
- Paraserianthes falcataria	pH 5 to 7.5
- Albizzia procera	pH 5 to 7.5
- Cassia siamea	pH 5 to 7.5
- Dalbergia sissoo	pH 5 to 7.5
- Cajanus cajan	pH 5 to 7.5
- Sesbania sesban	pH 5 to 7.5
- Samanea saman	pH 5 to 7.8
- Sesbania grandiflora	pH 5 to 8.2
- Sesbania bispinosa	pH 5 to 9.5
- Calliandra calothyrsus	pH 6 to 7.5
- Leucaena leucocephala	pH 6 to 8
- Tectona grandis	pH 4.5 to 6.5
- Dipterocarpus sp (Gorjan)	pH 4.5 to 6.5

3. Coppicing Ability

For firewood species, this is an important quality. The grading is listed below:

a. Excellent

- Calliandra calothyrsus
- Eucalyptus camaldulensis
- Eucalyptus citriodora
- Leucaena leucocephala
- Samanea saman
- Xylia dolabriformis
- Shorea robusta (Sal)

b. Good

- Albizzia falcataria
- Azadirachta indica
- Cajanus cajan
- Cassia siamea
- Gmelina arborea
- Melia azedarach
- Sesbania grandiflora
- Sesbania sesman (Daincha)

c. Fair

- Albizzia procera
- Dalbergia sissoo

4. Stem Wood Production

High stem wood volume production in a short duration is an important characteristic, particularly in the case of fire wood species, in view of critical shortages of this commodity in many parts of Bangladesh. Estimates of stemwood volume production are given below. using best seed source, proper spacing and improved cultural practices.

Species	MAI (m^3/ha/A)
- Teak (Tectona grandis)	7-10
- Garjan (Dipterocarpus spps)	7
- Acacia nilotica	2 to 8
- Azadirachta indica	3 to 10
- Casuarina equisetifolia	3 to 10
- Cassia siamea	5 to 15
- Calliandra calothyrsus	5 to 15
- Albizzia procera	8 to 12
- Dalbergia sissoo	8 to 15
- Gmelina arborea	10 to 20
- Eucalyptus citriodora	10 to 20
- Acacia auriculiformis	10 to 15
- Eucalyptus camaldulensis	15 to 25
- Sesbania grandiflora	20 to 25
- Acacia mangium	20 to 30
- Albizzia falcataria	20 to 40
- Leucaena leucocephala	20 to 40
- Artocarpus chaplasha	7 to 10

5. Bio-mass Production

For species used as fodder and fuel, the above ground bio-mass production is a measure of the relative performance of the species. Close spacing (down to 1m x 1m) may be used for getting higher bio-mass production. In the list given below wide differences in the production figures will be noted, due to difference in planting density, seed source and site quality.

Species	Above ground bio-mass production (ton per hectare per year)
- Dalbergia sissoo	5 to 10
- Cajanus cajan	10 to 20
- Calliandra calothyrsus	6 to 15
- Sesbania bi-spinosa	12 to 20
- Casuarina equisetifolia	7 to 30
- Eucalyptus camaldulensis	15 to 30
- Sesbania grandiflora	40 to 50

6. Specific Gravity

This is an important characteristic used in determining the purposes for which the wood is used. For fuel wood, sawn timber, poles, implements, tool handles, high specific gravity is desirable. The higher the specific gravity, the greater the amount of wood substance grown on a unit area of land. An indication of wood specific gravity for various spps is listed below:

Species	Range of specific gravity (g/cc)
- Paraserianthes falcataria	0.23 to 0.48
- Sesbania bi-spinosa	0.3 to 0.4
- Cajanus cajan	0.4 to 0.5
- Sesbania grandiflora	0.4 to 0.5
- Gmelina arborea	0.45 to 0.6
- Acacia mangium	0.5 to 0.63
- Artocarpus heterophylla	0.5 to 0.63
- Leucaena leucocephala	0.5 to 0.7
- Melia azedarach	0.5 to 0.73
- Calliandra calothyrsus	0.5 to 0.8
- Eucalyptus camaldulensis	0.54 to 0.65
- Azadirachta indica	0.58 to 0.84
- Albizia procera	0.59 to 0.63
- Acacia auriculiformis	0.6 to 0.74
- Eucalyptus citrodora	0.7 to 0.88
- Casuarina equisetifolia	0.8 to 1.13

7. Calorific Value

This is related to weight and therefore close y related to specific gravity. The calorific value for important fuelwood species is given below in Kilocalorie/kg.

Species	Kilo calorie/Kg
- Acacia auriculiformis	4,800 - 4,900
- Acacia mangium	4,850
- Acacia nilotica	4,800 - 4,950
- Paraserianthes falcataria	2,865 - 3,357
- Albizzia procera	4,900 - 5,000
- Artocarpus heterophylla	4,600
- Azadirachta indica	4,600
- Cajanus cajan	4,600
- Calliandra calothyrsus	4,500
- Cassia siamea	4,500 - 4,600
- Casuarina equisetifolia	4,950
- Dalbergia sissoo	4,900 - 5,200
- Eucalyptus camaldulensis	4,800
- Eucalyptus citriodora	4,750
- Gmelina arborea	4,400
- Leucaena leucocephalas	4,200 - 4,600
- Melia azerdarach	4,600 - 5,200
- Samanea saman	5,200 - 5,600
- Sesbania bi-spinosa	4,500 - 4,600

8. Susceptibility to Grazing and Browsing

Nearly all species are susceptible to grazing and browsing by animals during the seedling stage. Even Eucalyptus leaves and shoots which are normally not browsed, are eaten by starving cattle in Bangladesh during drought period. So protection from grazing and browsing when the plants are young is necessary.

9. Fire Tolerance

The forest is subject to ground fire during the dry months from February to April. There is no incidence of crown fire. In the seedling stage all species are susceptible to ground fire. Adequate fire protection measures are necessary for young plants. Deciduous or semideciduous trees like, teak, Albizzia, Azadirachta indica, Cajanus cajan, Gmelina arborea, Melia azedarach are susceptible only during the dry season to very hot ground fire. Some species e.g. Artocarpus heterophylla, Sal sp., eucalyptus and acacias are adapted to habitat which are regularly burnt in the natural state. These species have evolved generally thick bark which protects the cambium and have systems of dormant buds which are able to replace the foliage entirely after damage by fire. One of the reasons why sal thrives ignoring the regular ground fires is that the young seedlings die back to ground level year after year while the root system develops vigorously. After couple of years a vigorous shoot comes up and gives rise to healthy and vigorous seedlings. Besides sal, the species listed below may be considered to be tolerant to high ground fire after the second growing season:

- Acacia auriculiformis
- Acacia mangium
- Acacia nilotica
- Albizzia procera
- Cassia siamea
- Casuarina equisetifolia (after rough bark has formed)
- Eucalyptus camaldulensis
- Eucalyptus citriodora
- Xylia dolabriformis
- Sat (shorea robusta)

10. Disease and Pest Susceptibility

Loranthus is a serious problem to Gmelina arborea and Parasenianthes falcataria when these are 12 years and above in age. The introduction of these species as a medium or long rotation crop was abandoned because of 'Loranthus' menace. In order to avoid the risk of diseases and pests, plantation of pure species is discouraged. Line or group mixture is advocated when possible.

11. Wind Firmness

Adequate data are not available on the wind firmness character of various species. Generally the damaged done to isolated trees of species is more serious than to trees raised in groups on in plantations. Shallow rooted trees are uprooted by milder storm. However, the damage is considerable in all species during severe cyclone storm or tornado. The informations on some species on their wind 'firmness' is given below:

- Acacia auriculiformis: Shallow rooted plant and wind damage to isolated trees is noticed

- Acacia nilotica:	Top heavy when grown singly and uprooted by wind but normally wind firm when grown in plantations
- Paraserianthes falcataria:	Shallow rooted, brittle and less wind firm
- Artocarpus heterophylla:	Moderately deep rooted and wind firm
- Casuarina equisetifolia:	Generally wind firm and useful as a coastal wind barrier
- Eucalyptus camaldulensis:	Moderately deep rooted, comparatively less wind form in isolation but in plantation, the wind damage is not much
- Eucalyptus citriodora:	Moderately deep rooted, the damage by uprooting is noticed in isolated trees but in plantation such damage is not appreciable.

Choice of Species with Site

Choice of species for different region, rotation and end uses is important. If the site and species do not match, the plantation will either fail or will be very poor with low MAI. While deciding species, rotation and end use will have to be given due consideration. Then problems of site maintenance, ecological and environmental balance and socioeconomic aspects have to be looked into. Otherwise the sustainability of production can not be maintained. On encroached and blank areas. The preference of villager associated with the afforestation programme is important.

There is useful information on matching of species to site in the publication - "Computerised Matching of Tree Species to Sites" by J Davidson and M M Khan, Working Paper No 1 under FAO/UNDP/Project BGD/85/085.

Lists of recommended plants for different types of plantations and different sites appear below.

1. Hill Forests

For the long rotation plantations in the hill forests, the main species should be teak. Teak should however, be on well drained slopes with deep soil. Other species we recommend are: Dipterocarpus turbinatus, Syzygium grandis, Swietenia macrophylla, Chickrassia tabularis, Michelia champaca, Cedrela toona, Hopea odorata, Xylia dolabriformis, Lagerstroemia flosreginae. The last is almost always with teak on the lower flats.

For production of pulpwood and peeler logs in short rotation plantations we recommend Pinus carabea, Paraserianthes falcataria, Bombax ceiba, Gmelina orborea, Anthocephalus chinensis and Eucalyptus camaldulensis.

2. Unclassed State Forests

There are extensive areas of USF in the USF in the hill forest area. Some are under the control of BFD, the rest are under the district administration. For USF under the BFD the species will be same as for reserves. For the rest of the USF, the choice of species will differ. Short rotation species or those with quick economic return will come first. Rubber, cashew nut and horticultural trees come in this category. In case of longer rotation trees there should be underplanting of cash

crop. These may be medicinal plants, spices, canes or tubers. Natural regeneration of bamboo will be encouraged.

In denuded watershed and catchment areas the tree species will be those that provide quick ground cover and afford protection against erosion. Leguminous cover crops will improve the soil in addition to preventing erosion.

3. Inland Forests

Sal forests in the central and northern zone are almost on the verge of extinction. There is a proposal to replace the slow growing sal by fast growing exotics. This is the only alternative for areas under agroforestry or participatory plantations. Here the species should be Eucalyptus camaldulensis and Acacia auriculiformis. In enrichment plantations sal and its associates should receive preference. These are Terminalia sp., Mesua ferrea, Adina cordifolia and Albizzia spp. For national park areas in the sal forests the trees should be decorative, such as Pinus carabea, Emblica officinalis, Poinciana regia or any other decorative and shade giving tree.

4. Littoral Forests

There has been on plantation programme in the littoral mangrove forest except on experimental scale. Plantations of mangrove species exist on the coastal belt. Keora and baen are the only two species in these plantations. On sandy beaches Casuarina equisetifolia and coconut should be tried. There is the possibility of growing terrestrial species on the high land in north eastern part of the Sundarbans Mahogany may be tried.

5. Village Forests and Marginal Land Plantations

Village forests contribute the bulk of the firewood and a significant proportion of timber supply of Bangladesh. Jack and mango are the major species grown in the villages. Other important species for village groves are Syzygium sp., Swietenia macrophylla, Albizzia sp., Samanea sp., Tamarindus indicus, Bombax ceiba, Anthocephalus sp. and Ficus sp. Besides jack and mango there are other fruit trees like bel, lichi, guava and Zizyphus sp. Then there are palms like coconut, date and palmyra. Bamboos form important part of village growing stock and will be grown from rhizomes.

On marginal lands like roadside the important trees are teak, mango, jack, Swietenia sp., Albizzia sp., Samanea sp., Ficus sp., Syzygium sp., Dalbergia sissu, Butena frondosa, Polyalthia longifolia, Eucalyptus camaldulensis and Acacia auriculiformis. Firewood species like Leucaena leucocephalus can grow under the main trees. For sandy soils and beach front Casuarina equisetifolia is suitable.

Provenance Varieties

Some species growing in a wide range of habitats may have varieties with different tolerance to microclimatic and environmental factors. Such factors may be aspects, soil composition and drainage. To get best results from plantations of these species, seeds should be procured from provenances similar to the plantation site. There are seed orchards of seedling origin and clonal origin at Salna, Hiaku, Ukhia, Dulahazara, Khamati, Barshijura, Kaptai and Bagihat. These should be developed and new centres opened at Hazarikhil, Teknaf and Alikadam.

These locations should provide enough provenance variation, if care is taken to choose site with different aspects, drainage and soil composition.

NURSERY TECHNIQUE

General

For establishment of good plantations it is essential to have good planting material capable of giving maximum yield. It is proposed to raise about 20,000 hectares of plantations annually. Good nursery technique is necessary to get satisfactory seedling in time.

Nursery Sites

Forest nurseries can be classified into permanent and temporary types. A permanent nursery will supply seedlings for quite a few years. It has more or less permanent facilities such as office buildings, seed storage shed and regular watering facilities. There are 98 permanent nurseries and training centres already established by the Forest Department and 435 new permanent nursery centres will be established. Besides permanent nurseries there can be temporary nurseries, which are established only for a year or two. The site is abandoned, once the planting is finished over the area for which the nursery was established. One advantage of temporary nursery is that being close to plantation site, the carriage cost is little.

Nursery sites should be selected keeping the following facts in mind. The site should be reasonably level or gently rolling and well drained. It should not be flooded or water logged. Permanent source of water should be available during the dry season. In case of permanent nursery ponds can be dug and fitted with low-lift pumps. Alternatively there can be shallow tubewells. Sprinkler type of irrigation can also be arranged for permanent nursery. The area of the nursery should be large enough to accommodate the number of seedlings which will be required for particular site. There should be enough space available for roads or pathways and drains. Nursery should be easily accessible for transportation of materials and the seedlings from the nursery to the planting site. If possible the site of a nursery should be by the side of a road. The soil should be fertile, sandy loam to loam with pH varying from 5 to 7.5. However, if only poly bag seedlings are raised, the soil can be less fertile provided sufficient good potting soil is available near by and adequate organic manure and chemical fertilizer is added to the soil before it is put in the poly bags.

Preparation and Layout

1. Transplant Nursery Beds

Normally the seed-beds are raised and are of the size of (1.22 m x 12.2 m) to produce about 1600 to 1800 seedlings of which nearly 1210 are chosen for making stumps. Generally two and half beds are enough for planting one ha at 2 m x 2 m.

There should be 40-50 cm space between the beds and 1-2 m wide pathways between the blocks. In permanent nurseries main pathways should be wide enough for vehicles to pass. Drainage canals should be at least 30 cm wide and 30 cm deep on both the sides of the pathway. On level land beds should be laid out normally in east-west directions to provide the seedlings uniform exposure to sun-light. On gentle slopes the beds should be oriented along the contour. The site should be divided into blocks, each block containing about 10-12 seed beds or pot-beds.

Seed-beds are dug up to a depth of 20 to 30 cm. Big lumps are broken and soil is levelled. Roots, grasses and debris removed. Seed-bed is raised by about 12 to 15 cm by heaping the top-soil dug from pathways and drainage canals after the lumps are broken. Border frames with bamboo or saw mills slabs are put to keep the soil of the bed from eroding away. To increase soil fertility, compost or pulverized cow-dung at the rate of 1 m^3 (35 cft) per 10 m^2 of bed, should be added. The compost or cow-dung should be mixed up with the soil by turning over the soil several times

before levelling. If cow-dung or compost is not available 1.5 kg. NPK fertilizer per 10 m^2 of seed-bed may be added. Urea, TSP and MP is added at the rate of 0.5 kg of each for every cu.m. of worked out soil.

2. Poly Bag Beds

The beds should be levelled raised and border frames put as before. The soil in the poly bag should be prepared specially. A third of the soil should be cow-dung or compost and the soil mixed-up thoroughly. In addition to 1.5 kg of NPK (Urea 0.5 kg and TSP 0.5 kg should be furnished for every m^3 of soil mixture. The mixed soil should be stored under shade for a month before putting in bags.

Poly bags should have drainage holes about 0.5 cm from the bottom and holes at the bottom for draining out water. The bags should be shaken while filling and the soil compressed slightly. Inadequate filling of bags should be avoided.

Seed Selection and Collection

The most important prerequisite of any planting program is adequate supply of good quality seeds and other planting materials. High quality planting materials will ensure high quality seedlings, higher survival and faster growth.

Quality seeds are full, firm and of regular shape. Good seeds are collected from good quality mother trees. The seeds should be obtained from seed orchards or seed stands, or plus trees already selected. While collecting the seed the following points should be kept in mind. The tree should be fully grown and the diameter and height growth should be much above average. The trees should be straight and cylindrical with good stem. The tree should be tree from pests and diseases. Seed trees should be away from poor trees of the same species to avoid cross-breeding with poor quality trees.

Seeds or fruits should be collected when they are mature. The first and the last batch of fruits or seeds to mature and fall, are usually of poor quality. These should be discarded, shall and infested seeds should not be collected. Seed is usually collected from ground. While collecting seed the ground should be clear of all grasses, shrubs, leaves and other debris.

A schedule of seed collecting time for different common species with number of seeds par kg is in Table 8 below.

Seeds Testing and Treatment

Seeds should be tested for viability before use. Seeds may be tested by cutting, floatation or by germination method. 50 to 100 seeds may be picked up from each lot at random. The seeds may be cut and the kernel examined. Good seeds are full, firm and free from any bad odour. For floatation test seeds are put in water; good seeds usually sink while the bad ones floats. For germination test some seeds may be picked up from a lot and germinated in seed beds. The number of seeds that germinate everyday are counted until the germination is completed. This is the most reliable test.

For hastening germination most seeds need some treatment. Commonest method is soaking in water for 12 to 48 hours depending upon the nature of the seed coat. This soften the seed coats and the seeds absorb water. This treatment is particularly useful for legumes, pine and gamar. Hard-coated seeds like ipil-ipil, akashmoni etc need hot water soaking. The volume of boiled water should be 4-5 times the volume of seeds.

Table 8 - Seed Collection Time with Number of Seeds per kg

Species	Seed Collection Time	No. of Seeds/kg
Tectona grandis	Nov - Feb	1,500-2,00
Xylia dolabriformis	Dec - Jan	330-400
Acacia auriculiformis	Jan - April	38,000-40,000
Acacia catechu	Dec - Mar	38,000-40,000
Acacia nilotica	April - June	8,000-10,000
Paraserinthes falcateria	May - June	40,000-42,000
Albizzia lebbeck	Jan - Mar	10,000-12,000
Albizia procera	Jan - April	20,000-22,000
Anacardium occidentale	Mar - June	20,000-22,000
Anisoptera glabra	May - June	580-650
Anthocephalus chinensis	Aug-Oct & Jan-Feb	2,600,000
Artocarpus chaplasha	Jan - Aug	1,800-2,000
Azadirachta indica	June - Aug	3,300-3,500
Bombax ceiba	Mar - May	25,000-30,000
Salmilia malabaricum	Feb - Mar	20,000-25,000
Casurina equisetifolia	June - Dec	760,000-770,000
Toona ciliata	April - June	352,000
Chickrassia tabularis	Jan - Feb	100,000
Dalbergia sissoo	Nov - Mar	53,000
Dipterocarpus turbinatus	May - June	160 (with wings)
Erithrina spp.	May - July	-
Gmelina arborea	May - June	1,800
Hevea braziliensis	July - Sep	-
Hopea odorata	May - June	250-275
Lagerastroemia flosreginae	Jan - Feb	160,000-200,000
Leucaena leucocephala	Jan - April	22,000-24,000
Michelia champaca	Sep - Nov	15,000-18,000
Pinus caribaea (Hondurus)	Nov - Jan	6,000-8,000
Shorea robusta	May - July	700-1,000
Swietenia macrophylla	Dec - April	1,600-2,000
Syzygium grande	May - June	1,200-1,500
Tamarindus indica	Feb - April	800-1,000

Some seeds like teak seeds need further treatment. The seeds are soaked in water for about 2 days, then put in a pit 50 to 60 cm deep and 1 meter square. The sides are lined with teak leaves. The seeds are placed in 12 to 15 cm layers and layers separated by straw. Bamboo or plastic pipes with drainage holes are then placed at different layers for watering. Watering is be done daily. The pit is covered with about 12 to 15 cm layer of soil. The seeds are kept in the pit for about 12 to 14 days, removed and sown in the seed beds.

Fine and tiny seeds like eucalyptus, kadam etc are sown in plastic trays. A single layer of perforated plastic sheet is spread over the tray. The tray is partly filled up with sand and soil. The soil is sterilised by heating. The sand should be twice the volume of the seeds. The seed-sand mixture should then be evenly sprinkled over the germination tray. The tray should be watered by submerging in water to a depth more than half the height of the tray every day.

Generally seeds are sown in germination beds. Germination beds are regularly watered. Seedlings are ready for pricking out when the cotyledons have dropped and 1-2 primary leaves have emerged. The seedlings are up-rooted using a dibbling stick. The seedlings are then transferred to a small container, half-filed with water, so that the seedlings do not dry. The up-rooted

seedlings are then transferred to the poly bags or transplant beds. After planting the seedlings soil is pressed firmly around the roots with the index finger, making sure that the root collar is just-level with soil surface. A little water should be poured to ensure that no air pockets are left around the roots.

Seeds for stump planting are often sown directly in nursery beds. The soil is worked, pulverized and cowdung/ compost and chemical fertilizer added. The seed beds are then watered to make the soil moist and the pre-treated seeds are sown. If there is any vacant place, seeds should again be sown in the vacant places. Shade should be provided till the germination is complete. Regular watering is done in the nursery beds.

Sometimes seeds are sown directly in poly bags. The bags are filled with soil watered before sowing the seeds. The seeds are placed on the surface of the moist soil and pressed down with finger to a depth equal to the diameter of the seed. A thin layer of the same soil is then spread over the seeds. The bags should be watered daily to keep the soil moist. It is best to use sprinkler with fine sprays. Shade is provided until the germination is complete.

Care and Maintenance of Seedlings

The young seedlings should be watered with gentle spray. During summer, watering should be done at least once a day. Watering should be done in late afternoon.

Shading is often necessary to protect the young seedlings and germinating seeds from heat and direct sun-shine. Most of the tree species excepting teak, gamar, and dhaki-jam require shade during germination stage. The shading requirement of some of the important species are as follows: Eucalyptus, jhau and pine require no shade after two weeks from pricking out. Acacia auriculiformis, malakana, ipil-ipil usually need no shade once the seedlings are 4-5 cm in height. Mahogany needs shade in the bed when the seeds germinate. All dipterocarpus species require shade throughout the nursery period. Weeding of nursery beds and poly bags should be done regularly. The weeds should be removed when they are very small and after watering the nursery.

In order to harden the seedlings, which require hardening, sorting out and root pruning should be done. Watering should be stopped at least 3-4 days before the seedlings are transported.

Special Treatment with Rhizobium and Mycorhiza

For inoculation with rhizobium of leguminous trees 3 to 10 years old tree roots of these species may be dug out. The root nodules are collected and ground on to a paste. The paste is then added to water in a watering can and the mixture sprinkled into the seedlings. 10 gms of nodule are enough for 1000 plants.

Pines need inoculation with mycorhiza. For this the top soil from a existing pine plantation is collected and mixed with the polybag/potting soil, at the rate of 10% of the total volume. Alternatively the mycorhyza soil is collected and mixed with water. The mixture is sprayed over the pine seedlings. The inoculation is completed soon after germination.

Further details of nursery techniques are available in FAO Working Paper No 20, July 1989 by Dalmacio and Hossain. Summary of recommendations with costs are in Appendix 5.

SILVICULTURE AND AGROFORESTRY

Agroforestry in Sal Forests

In the silvicultural programme for the sal forest, agroforestry has been mentioned. The matter was the main issue in the rehabilitation programme in the study under UNDP/FAO Project BGD/85/085. The Thana Banyan Project now under execution is proceeding along the suggested lines and is largely successful.

Agroforestry is a collective name for land use systems and technologies where woody perennials (trees shrubs, palms, bamboos etc) are grown along with some agricultural crop and/or animal fodder. The combination may be in spatial arrangement or in temporal. In agroforestry systems there are both ecological and economical interactions between different components (Lundgren B; 1982). It may assume different forms in different agroecological zones, according to needs and aspirations of the participating farmers and market demand of their products.

Agroforestry is not new in Bangladesh. It is being practised as taungya system in plantation raising. The homestead production system wherein tree crop, vegetable, cane, murta etc are being grown can also be called agroforestry. In fact, taungya and homestead methods of agroforestry are in practice in rural Bangladesh for decades. But these did not receive due encouragement. Their socioeconomic impacts and poverty alleviation values were not evaluated. The results have been disastrous. Many of the medicinal plants and the cottage industry raw materials are on the verge of extinction.

Interest in agroforestry has, however, been revived after realisation that it is the only recourse left for rehabilitation and recovery of encroached and denuded forest land.

Taungya Plantation

Taungya system is very much similar to jhum cultivation. In taungya plantation, villagers grow agricultural crops eg. paddy, vegetable, cotton, maize etc in forest plantations for two years. The villagers tended the plantation with little cost. After introduction of development programme it became difficult to get enough jhum labours for the implementation of to large scale plantation under taungya system. Besides they have been found involved in illicit fellings of timber trees, encroachment and jhuming. There are reasons for this. No attention was given to the population increase and poor socioeconomic conditions. There was no poverty alleviation programme. Besides the agricultural crop the villagers did not get any share of the tree crop. They did not develop interest in protection of the tree crop.

Before adopting agroforestry for rehabilitation of degraded forest land one should know the reasons for encroachment and denudation. The reasons are mainly poor economic conditions of the people living around the forest, population increase at a high rate leading to landlessness and unemployment. These ultimately lead to pilferage of forest produce and encroachment of forest land, resulting in soil erosion and ultimately degradation of forest land.

To combat the situation the land and man should be rehabilitated together. It is not a difficult task once people understand the production system and its socioeconomic implications. If the villagers understand that agroforestry is to their advantage they will be willing partners and all decisions will be participatory. Once they participate in the decision, they will execute in better.

Participatory agroforestry is being practised in the denuded and encroached sal forests. The plan recommends its extension under both scenarios of development. Details of the programme are in Appendix 3.

Homestead Groves and Marginal Land

In addition to taungya plantations villagers have been practising agroforestry. In the villages, around homestead people have been growing tree crops with vegetables and other short term crop like ginger, lemon, papya, medicinal plants etc. All these can be called agroforestry. For agricultural production people are growing short term crops in sugarcane and banana plantation. In rubber garden and other horticultural plantations short term and mid term crops are being grown now. There is enough scope for improvement.

Unfortunately in the past, there was no economic analysis of this production system and no assessment of its social impact was made. At present due to population increase, it is imperative to think of multiple use of all land for different products. Agroforestry is one such method. Though some research has been done of more research is needed on the interaction of the production system and socioeconomic conditions of the participants.

Application of Agroforestry to USF

To rehabilitate the large areas of denuded, jhumed and very low density degraded land in USF, participatory forestry on a large scale is only the recourse left. Without this system these forest land can not be rehabilitated. Further denudation will cause environmental deterioration and erosion in watershed areas of the Hill Tracts.

An important factor to sustain this sort of production system over large area, is building up of the right kind of organisation and institution. Training and motivation of the participants and their dependents including the females are also very important to sustain the organisation and its activities.

Agroforestry is a production system and social and community forestry are the management systems. One system can not work without the other. Unless the production and the management systems are developed simultaneously, they can not deliver the desired results. All decisions are to be participatory and on long term basis to gain the confidence of the people and make them work joyously.

Multipurpose Tree Species for Different Zones

It is very important to identify tree crops. These should be short term, mid term and long term. Having due consideration to the low productivity of the land where agroforestry will be introduced, it is better, if the tree crops are nitrogen fixing. They should give food, fodder, fuel, timber and stabilise the soil. They should provide allow short term and mid term crops to grow. A list of such trees for different agroecological zones is given below.

Hill Zone	Plain Zone	Coastal Zone
Albizzia lebbek	Dalbergia sisso	Casuarina equisetifolia
Albizzia procera	Eucalyptus camaldulensis	Albizzia lebbek
Phyllanthus emblica	Albizzia lebbek	Albizzia procera
Eucalyptus camaldulensis	Albizzia procera	Sesbania grandiflora
Sesbania grandiflora	Azadirachta indica	Leucaena leucocephala
Elaeocarpus robustus	Mangifera indica	Phyllanthus emblica

Phoenix sylvestris	Phoenix sylvestris	Phoenix sylvestris
Artocarpus heterophylla	Acacia nilotica	Cocos nucifera
Acacia auriculiformis	Artocarpus heterophylla	Acacia nilotica
Leucaena leucocephala	Leucaena leucocephala	Erythrina indica
Canes and bamboos	Canes and bamboos	Canes and bamboos
	Borassus feabellifer	Borassus feabellifer

Strategy to Promote Agroforestry

Current efforts to promote agroforestry have started producing results. Large areas of encroached and denuded land have been brought under woodlot and agroforestry. Both woodlot and agroforestry are of participatory nature. But the systems will not sustain unless the participants are given usufructuary rights under some sort of agreement. The agreement should be atleast for one rotation with provision for renewal.

Along with agroforestry the plan recommends extension of community forestry in homestead and marginal lands. For this the plan supports creation of a separate wing of the BFD to cater to this aspect of forestry.

The report on Participatory Forestry discusses the issue in greater detail.

WATERSHED MANAGEMENT

General

Watershed management means scientific and wise use of land and other resources in watershed areas. This has assumed great importance in any silvicultural development programme because of the following reasons:

- Rapid silting is happening along the river beds in the Hill Forest zone.
- The Kaptai lake is filling up fast;
- Erosion of top soil on steep slopes is increasing;
- Flooding of river valleys is occurring at frequent intervals;
- The Hill Forests are losing productivity, thereby increasing the gap between demand and supply;
- Disturbances to the ecological system; and
- Damage to the biological production system which sustains life.

Watershed management aims at scientific and wise use of land and other resources in watershed and catchment areas. Most of the watershed area of the country lies in the Greater District of Chittagong Hill Tracts. The situation there has become alarming. There are more than 718,000 ha of Unclassed State Forest land in the Hill Tracts. At one time they were full of tree cover. Now most of the area is bare. Frequent jhum cultivation and unregulated cutting of trees are the main causes. Even the reserved forests are deteriorating fast. The abnormal law and order situation in the region is partly responsible for this.

The rapid filling up of the Kaptai lake is causing concern. In 1978-79 silting data were collected from different points of Karnafuli and Maini rivers. The silting rate was more than 30 cm/A. All the silt eventually falls into the lake.

Contributory Causes

Jhum cultivation and irregular cutting of trees may be the main cause. But there are other contributory factors. One important factor is the logging method. Logging by crawler tractors on steep slopes, disturbs the soil too much and leads to erosion. The dragging of logs along ravines causes gully erosion. The present method of burning the logged area before planting induces soil deterioration. It is similar to jhum cultivation. Unregulated cutting of trees on slopes bares the land. Rain then washes away the top soil. Even in some plantation areas, there is erosion due to absence of undergrowth. This happens if the canopy is too dense. Excessive grazing and ploughing on steep slopes are responsible.

Watershed Protection

In a sense the whole of the Hill Tracts is a watershed area. Any watershed management system must take this into account. Scientific watershed management is possible only through sound forestry practice. Forestry Master Plan recognizes this as one of its prime objectives. Accordingly we are recommending the following steps:

BFD should manage the banks of all rivers and streams as watershed areas upto a distance of 50 m to 100 m from the bank. The distance would depend on the width of the river and the slope. There should be no timber extraction from these areas. Dead, diseased or dying trees would be exceptions. Even in these cases conversion will be on site.

BFD should endeavour to cover all bare slopes with Cajanus cajan or with Vatevera zelenoides creeper in the first few years. This will reduce soil erosion and increase fertility.

BFD should take steps to declare all steep slopes as protection areas. There will be no clear felling or jhum cultivation in these areas. These areas should either be protected or worked under selection system. Since a large part of the protection area will be in the USF, there should be provision for participatory forestry. NGOs may help by training people and organizing them. Tribal people should have means of income from short term crops of non wood products. Long term crop should preferably be cash crop trees like rubber, cashew nut or fruit trees.

Watershed management has to be multi-disciplinary approach. BFD should try to integrate its effort with other concerned sectors. It is important to rehabilitate the people living on the land with rehabilitation of the land. Without the goodwill and cooperation of the people on the land any watershed scheme will fail.

COASTAL AFFORESTATION

Originally coastal belts and islands had some sort of mangrove forests. These forests were reclaimed for agriculture and for earning more land revenue under reclamation project. This destroyed the forest and exposed the shore land to cyclones and tidal bores. Many small islands got washed away.

On the 1960's coastal areas of Bangladesh experienced severe cyclones and tidal bores. There were suggestions that development of forest belt along the coastal areas would help. Such forest belt would protect the lives and properties of the people of the area from future disasters. In 1966 the Forest Department started planting trees on the outside of the protective coastal embankments. This was a programme unique to Bangladesh. Till now there are about 113,000 ha of coastal plantations. Mangrove plantations on this scale exist nowhere else. In 1977 the World Bank Mission observed the afforestation activities and in 1978 the Mission recommended the mangrove forestry plantations programme for IDA assistance.

The objective of World Bank aided Mangrove Afforestation Project of Bangladesh (Stage I) was primarily to stabilise accreted lands of the coastal regions. Another objective was to accelerate the process of land accretion in the Bay of Bengal by mangrove plantations (SPARRSO 1983). The programme also planned to improve the socioeconomic condition of the population in the coastal region. This would be through multiple benefits of a belt of forest resources along the coast. Production of wood for fuel and industrial use and creation of employment opportunities were among the objectives.

Plantation work is in progress along the seaward side of the coastal embankment. The programme extends from Khulna to Teknaf (about 500 km). So far plantations exist over an area of about 113,000 ha. The species are mainly keora and baen with sone admixture of other mangrove species. Table 6 lists the area of coastal plantations by 5 year age classes in the four coastal divisions.

Site Classification and Plantations

In designing plantation programme, the varying site condition is to be considered. The sites are divided into:

- Newly accreted islands: These islands are sandy with a very thin layer of clay on top. The first coloniser that appears naturally is uri-grass (Uryza coaractata). The first coloniser is very important, not only for stabilizing the island and adding organic matter to the soil but also for survival of the keora seedlings, to be planted later.

- Areas available front of coastal embankment: These areas are mostly part of the mainland. The soil is cly/ clayey-10 gm/ clayey/ clay-loamy-clay with mounds here and there. In some cases, these areas do not get tide water even during spring high tide.

- Sand dunes mostly along the shore land.

The newly accreted islands where uri-grass appeared were planted up with keora (Sonneratia apetala). Plantation was raised on any new accretions only after uri-grass came.

The area available in front of coastal embankment are rather critical areas. The areas which do not get inundated with tide, are essentially saline in nature but at the same time unsuitable for any littoral species. So narrow channels were dug to let tide water enter and keep the area moist. The channels were kept free and clean. The dug up earth was heaped in mounds. Acacia nilotica was planted on the mounds to fix the loose earth and to keep the channels free for easy flow of tide water. This technique was introduced in Char-Bata of Noakhali and Sitakunda and Mirsharai of Chittagong Coastal Divisions. Generally keora does well in these locations. Kankra can be grown only later when there is some shade for the seedlings during early years. In areas with supply of finer silt and high salinity baen does well. In areas outside the embankment gewa, sundri and goran be introduced. In some areas which gets dry keora starts dying and terrestrial trees can be grown.

Sand Dunes Along the Shore Land

Sand dunes are to be stabilized first before any planting programme can be taken up. To fix the sand Ipomea creeper (found in Cox's Bazar beach) should be grown. Where Ipomea is not available, brush wood should be fixed on the sand dune through peg driving. The brush wood should be placed at right angle to the wind direction. Once the dunes are fixed, Casuarina plantation at close spacing should be started so that the plantations can afford protection against tidal up surge. The minimum width of the plantation, to make it effective against tidal up-surge, should be least, hundred meter.

Plantation on Embankment

Plantation on embankment is to stabilise the land. In fact coastal afforestation started with departmental plantation of Acacia nilotica on the embankment. Babul was not the right species because it sends lateral roots and because it is not very deep rooted. It develops big heavy crown and can not with stand strong wind. In the face of cyclone it gets up-rooted easily and the places where the trees get up-rooted, breaches occur on the embankment.

The tree plantating on the embankment should be done on participatory basis through the local people and with multiple use of deep rooted species like ipil-ipil, date palm and coconut. On the inward side there can be lemon,papaya etc which do not disturb the soil. In addition live fences of arhar and daincha can be raised. Towards the sea ward side some clear space has to be left between the embankment and coastal plantation to prevent crabs reaching the embankment.

Introduction of New Species in Plantation

Almost 80% of the coastal plantations are of keora. In the older plantations, where the soil is undergoing changes, other species in mangrove succession, should introduced. Towards the sea-ward side goran and gewa can also be introduced. In Char Lathimara under Patuakhali district and in Hatia, gewa has come up naturally.

Goran with massive root system would stabilise the soil, increase the rate of siltation and prevent scouring by current and waves. In older formations, in front of the coastal embankments sundri can introduced just after the keora established, as keora is never regenerates itself on its site.

Plant Spacing and Thinning

Some of the most important objectives of coastal afforestation, were to establish a protective forest belt which would protect embankments and the lives and properties of the people living behind. To accelerate siltation there should be dense planting and no thinning till other species establish themselves. In coastal afforestation clear conception about spacing and species matching are important factors. Research is needed on these factors.

Protection of Urigrass (Oryza coaractata)

Urigrass is salt tolerant. It is the first coloniser on a newly accreted island. It not only adds organic matter to the sandy soil, but helps further siltation and assists in stabilising the sandy accretions. It is noticed that buffaloes eat up the urigrass. In the peripheral zone of the islands buffaloes cause damage by tramping. Measures should be taken to protect the urigrass. In fact plantation, can not be started on a new accretion of sand where urigrass has not appeared.

Golpatta Plantation

Golpatta is a very useful trunk-less palm. The leaves are used for thatching. It is harvested in late autumn to early summer every year. Only the mid-leaf with one supporting leaf is left after harvest. The other leaves appear from the rhizome. It grows on the banks and slopes of all water-ways and keeps the area fairly moist. It is found to grow on the banks and slopes of all water-ways. Golpatta seeds are collected in February and nurseries are raised. The seedling are transplanted during the next planting season along the lower edges of streams big and small and also on the sloping ground of estuaries. It grows better from moderately saline to fresh water zone. The first golpatta plantations were raised under Bhola and Patuakhali Divisions. It is doing well.

SEED PRODUCTION AND TREE IMPROVEMENT IN BANGLADESH

General

Large tracts of Bangladesh forests excepting the Sundarbans and sal forests are worked under the clear felling system followed by reforestation. All hill forests of Chittagong, Chittagong Hill Tracts and Sylhet are in this category.

A substantial amount of coastal land is planted every year mainly with Sonneratia apetala and Avicennia officinalis. So far, about 1.23 million hectares of coastal and hill plantations have been established. In addition, the Upazila afforestation project aims to establish 20,250 ha of block plantations and about 17,7000 km of strip plantations within five years.

In the hill forests the aim is for plantation to replace natural forests as the source of supply of different categories of forest products. The main problem in this is, however, the low growth rate of plantations.

In Bangladesh the yield from existing plantations is about 2.5 m^3/ha/A. With proper tending, thinning and prevention of pilferage the yield would probably increase to about 7.5 m^3/ha/A. Even this is low by international standards. For Scenario 2 the plan assumes MAI figures of 20 m^3/ha/A, 30 m^3/ha/A and 45 m^3/ha/A for rotations of 30, 20 and 10 years respectively. Such high yields can be attained only through tree improvement programme.

Production of Seed

Seeds are the only propagating material being used in the plantation programme. Present practice of collecting the seeds of indigenous tree species is mainly from forest floor and rarely from the selected trees. In most cases seeds are not physiologically mature or genetically superior.

Seed collection requires special knowledge on tree phenology. An untrained, technical person cannot collect good seeds. Seed collection, often by the villagers cannot ensure quality material.

Forest trees of Bangladesh do not seed uniformly every year as observed in many forests of the tropical countries (Dogra, 1981). Tectona grandis, Dipterocarpus spp, Hopea odorata, Albizzia spp, Shorea robusta, Gmelina orborea, Anthocephalus chinensis, Lagerstroemia speciosa, Cerella toona, Artocarpus chaplasha and Heritiera fomes have good and bad seed years. It has been observed that Hopea odorata and Quercus spp, usually have good seed year once in 2 or 3 years. The unpredictable nature of seed production often leads to mass collection of inferior seeds during some years.

The handling, grading and storage of seed are important steps in plantation forestry. The species which produce seeds during November to March are, in general, dormant and have more longevity than those produced during May to August. Tectona grandis, Swietenia macrophylla, Toona ciliata, Terminalia sp, Albizzia sp, Acacia sp, Amoora sp, Schima wallichi, Pterygota alata, etc are of the first group. Dipterocarpus sp, Shorea robusta, Syzygium sp, Michelia champaca, Chickrsia tabularis, Azadirachta indica, Baringtonia acutangula, Swintonia floribunda belong to the second group. Seeds of Shorea robusta and different species of Dipterocarpus have short viability. Healthy big size seeds of Tectona grandis show better germination which justify the requirement of proper handling and seed grading in nursery practices.

Besides timber trees, bamboo is another major economic crop of Bangladesh forests. Bamboo produced seeds, generally, after a long interval. The inter-seeding period is species specific and usually 20-45 years. Melocanna baccifera and Bambusa tulda are major bamboo species of Bangladesh forests. That have 30-40 years and 20-30 years inter-seeding period respectively.

Bamboo seed generally complete germination within 5 to 10 days of sowing. Moreover the longevity of seeds varies from species to species and generally it is upto 1 to 2 months. Scarcity of viable seed is therefore acute. Research on this aspect is urgently needed.

To fulfill the above requirements a National Forest Seed Centre was established in 1986 under the umbrella of the Bangladesh Forest Research Institute (BFRI). The centre is responsible for setting up a unified national system for procurement, registration, handling, storage, testing and distribution of quality forest tree seeds and seeds of others such as bamboos, canes, woody shrubs and ground cover legumes and grasses.

The plan recommends a large scale afforestation programme with both indigenous and exotic species. Priority has also been given to the fast growing and short rotation species. Moreover, plantations under community and village forestry programmes are rapidly expanding. For the above plantation programmes large quantities of seeds and seedlings are required and are summarized in the Report of Forest Research Specialist.

Every year the plantation area under each species is not the same. It depends mainly on the availability of seeds and "on-the -spot" decision of the District Forest Officers. However, the it is difficult to give the species-wise annual seed requirement. A guesstimate of average seed requirement per unit area is given in Appendix 5. The table below gives the seed production capacity of important species.

Table 9 - Particulars of Seed Production Capacity

Species	Seed Tree kg	Local	Imported	Type of Seed Com.	M.T.	S.O.
Dipterocarpus turbinatus	35-50	+	-	+	+	-
Syzygium grande	30-50	+	+	+	+	+
Tectona grandis	5-10	+	-	+	+	+
Gmelina orborea	4-8	+	-	+	+	+
Shorea robusta	-	+	-	+	+	-
Swietenia macrophyulla	-	+	-	+	-	-
Artocarpus chaplasha	8-10	+	-	+	+	-
Eucalyptus camaladulensis	1-2		+	-	-	-
Acacia auriculiformis	2-9	-	+	-	-	-
Paraserianthes falcataria	9-4	+	-	+	-	-
Albizzia procera	5-7	+	-	+	+	-
Artocarpus species	10-15	+	-	+	+	-
Hopea odorata	8-10	+	-	-	+	-
Toona ciliata	1-2	+	-	+	+	-
Swintonia floribunda	1-2	+	-	-	+	-
Chuckrassia tabularis	9-4	+	-	+	+	-
Bombax ceiba	5-8	+	-	-	+	-
Sonneratia apetala	-	+	-	-	+	-
Lagerstroemia speciosa	2-9	+	-	+	-	-
Anhocephalus chinensis	0-5	+	-	+	+	-
Azadirachta indica	-	+	-	-	+	-
Cassia siamea	9-4	+	-	-	+	-
Melia azedarach	-	+	-	-	+	-
Alstonia scholaris	0.5-1	+	-	-	+	-
Casuarina equisetifolia	-	+	-	+	+	-
Dalbergia sisso	-	+	-	-	+	-
Acacia nilotica	-	+	-	-	+	-
Samanea saman	-	+	-	-	+	-

Note: Com = Commercial' means seed collected from the floor; MT = Mother Tree; S.O. = Seed Orchard; '+' means available; '-' = means not available.

Seed Orchards and Seed Trees

Significant increase in plantation yield can come only through genetically improved trees. Some increase, however, is possible from existing seed trees, if seed is collected from healthy and sound trees of selected performance. For this since 1979, provisional plus tree (PPT) selection was started for Tectona grandis, Gmelina arborea, Dipterocarpus trubinatus and Syzygium grande. A total of 2267 Provisional plus tree (PPT) of 50 different species have been selected from different forest areas to preserve trees of outstanding desirable characters for collection of scion materials and seeds for immediate requirements. Most of these selected clones of the 13 major species have been used in clonal orchards. A total of 375 ha of clonal and seedling orchards of 20 species have been raised in different Seed Orchard Centres between 1979 and 1985 Table 9. Clonal orchards of Gmelina orborea, Syzygium grande and Tectonaa grandis are now in full production and seeds from these orchards are being used for routine planting programmes. The seed orchards are both seedling orchards and clonal orchards.

Open-pollinated progeny tests of Tectona grandis using 24 clones have been established in 1985. According to the latest available data Some showed good survival percentage and growth. Further research is necessary.

No control crossing programme has yet been initiated. However, an artificial pollination study was completed on Daemonorops jankensianus (Rattan) for increasing seed setting. The study revealed that artificial pollination through dusting of pollens increased the seed production five times in comparison to the control.

Vegetative Propagation

The development of techniques of vegetative propagation for forest species is one of the important aspect tree improvement. Many valuable plants produce little (e.g. Podocarpus nerifolium, Quarcus sp.) amount of seeds. This pints to need for study on vegetative propagation. Many trees can be propagated from vegetative shoots, thus reproducing their genotype exactly. When the technology of macropropagation is successfully developed clones can be easily duplicated and planted together in isolation to produce genetically predictable seeds. The seed orchards technique is based on this principle. Studies have been completed on the development of vegetative propagation techniques for 15 major tree species of Bangladesh.

The age of root-stock may affect the success of grafting. Generally the survival is higher when the scion is grafted on to a young root stock. Success of union was found to be good, in most of the species, when the age of root stock is about one year. Older rootstocks (more than two years) showed poor ability to form a graft union. It has been noted that species having thick bark (e.g. Tectona grandis and Gmelina arborea) yield better success in both bud and shoot grafting practices. It has also been observed that the shoot tips are good scion materials for grafting in Tectona grandis, Gmelina orborea and Xylia dolabriformis, in contrast to Hopea odorata where the woody shoot below the tip makes a good scion. Success of grafting varies with the origin of the scion. Further study is needed on this aspect.

With a few exceptions, grafts have been found to be suitable method of clonal propagation of forest trees of Bangladesh. However, graft-incompatibility, which has been a problem in tree improvement programmes in many countries, could pose a problem in the future.

Table 10 - Particulars of Provisional Plus Trees (PPT) and Seed Orchards

Species	No. of PPT Selected	Extent of Orchard (ha)
Tectona grandis	319	130
Gmelina arborea	242	40
Syzygium grande	150	39
Dipterocarpus turbinatus	256	52
Dipterocarpus costatus	10	0
Dipterocarpus pilosus	10	0
Shorea robusta	130	0
Swietenia mahagoni	54	19
Artocarpus chaplasha*	92	7*
Anthocephalus chinensis	82	9
Albizzia procera*	144	4*
Albizzia lebbeck	5	0
Albizzia chinensis	5	0
Albizzia lucida	5	0
Paraserianthes falcataria	27	0
Albizzia richardiana	10	0
Toona ciliata	34	0
Swintonia floribunda	48	0
Zylia dolabriformis	39	9
Michelia champaca	37	6
Eucalyptus citriodora	10	3
Hopea odorata	88	18
Chuckrassia tabularis	55	4
Anisoptera glabra	39	0
Bombax ceiba	49	2
Avicennia alba	4	0
Fragrea budrunga	24	2
Artocarpus heterophyllus	35	0
Casuarina equisetifolia	10	0
Sonneratia apetala	9	0
Lagerstroemia speciosa	30	9
Acacia auriculiformis*	10	4*
Acacia mangium	10	0
Cassia siamea*	10	2*
Alstonia scholaris	25	0
Bischofia javanica	15	0
Trewia nudiflora	10	0
Mangifera sylvatica	30	0
Aphanamixis polystachys	10	0
Melia azedarach	20	0
Azdiracta indica	15	0
Lophoperalum fibriatum	5	0
Mesua ferrea	5	0
Pongamia pinnata	5	0
Diospyros embryopteris	10	0
Tamarindus indica	5	0
Acacia nilotica	5	0
Careya arborea	5	0
Samanea soman	16	0
Cassia fistula	4	0
Eucalyptus camaldulensis*	0	4*
Eucalyptus tereticornis*	0	4*
Pinus caribaea*	0	10*
Total	2267	375

Note: "*" is Seedling Seed Orchard, rest are Clone Seed Orchard

Seed orchards in Bangladesh are young and thus graft-incompatibility perhaps has not yet shown. up. So tree breeders in Bangladesh will have to wait for some time to determine whether research will be necessary on this aspect.

In the meantime, rooting of cuttings and air layering methods should be tried extensively to propagate the trees in order to overcome potential graft-incompatibility in the ramets. Sometimes it is difficult to get rooting cuttings of many forest trees (e.g. Dipterocarpus turbinatus, Shorea robusta, Anthocephalus chinensis, Hopea odorata). Particularly with trees selected for breeding, which are normally old the prospect of rooting is poor with present technology. Rooting hormones can be tried. Tissue culture practices could be another alternative approach in clonal propagation and breeding.

The cuttings of Gmelina arborea start flowering within one and a half year of planting provided the scions are collection from mature trees. In Tectona grandis, it takes about 9-10 years for a seedling to flower whereas a ramet (bud graft) from a mature tree comes to flower early. Syzygium grandis plant generally start flowering after 10 to 18 years of age, but a ramet (grafts, layers) take only 4 to 5 years for seeding. The grafted ramets of Alstonia scholaris showed flowering in the same year. Thus, vegetative propagation not only enables us to replicate the genotype but also ensures early seeding - a step which could be successfully used in forestry.

Tissue Culture

Traditional forest tree improvement programmes are long-term and require large areas of land for testing of selected genotypes and for production of seedlings for reforestation. Among the species which have been successfully propagated by rooted cuttings, problems such as reduced vigour and plagiotropism have been observed in the ramets of Dipterocarpus turbinatus, Hopea odorata, Lagerstroemia speciosa and Michelia champaca.

Some species of thin-walled bamboos Melocanna baccifera and Dendrocalamus longispathus are difficult to propagate by cuttings.

In such situations, cell tissue or organ culture offers considerable potential for rapid and economical propagation of selected prototypes. The capacity for mass propagation from tissue culture has good potential. In India, has estimated that by sub-culturing, 500 viable plants can be obtained from a single bud of 100 years old mature Tectona grandis plant. Some tropical trees such as Artocarpus heterophyllus, Azadirachta indica and different species of bamboos have been successfully propagated by tissue culture technique.

There is no full fledged biotechnological laboratory in the country. Different Universities and Research Institutes, such as Dhaka University (DU), Bangladesh Rice Research Institute (BRRI), Bangladesh Forest Research Institute (BFRI), Bangladesh Tea Research Institute (BTRI), Bangladesh Agriculture Research Institute (BARI), Bangladesh Jute Research Institute (BJRI), Bangladesh Sugar Research and Technical Institute (BSR&TI), and Bangladesh Institute of Nuclear Agriculture (BINA) are aware of the potential benefits of tissue culture and its application to tree improvement.

The BFRI is the only institute which is engaged in the tissue culture research on forest species. There are no other private institutes in the country conducting tissue culture research.

The ongoing tissue culture research programme of BFRI is mainly on the micro-propagation of bamboos. The importance of propagation is well known. BFRI has future plan to conduct research on forest species improvement through studies on somaclonal variation and by stress physiology under in-vitro conditions.

With regard to vegetative propagation limited facilities are available and needs further expansion.

Biotechnology

The promises of biotechnology are attractive for forestry. One of the major apparent advantages is to be able to modify and select new tree lines in a very short time, as compared to the time needed using conventional methods.

Gene Insertions - Many agronomic crops have well-known pure lines with many excellent qualities that can be further improved by one or a few specific qualitative changes. In contrast to substitution of the desired genes, these changes can perhaps be produced by inserting one or a few specific genes using biotechnological techniques, without disrupting the rest of a highly selected genome.

Forest trees differ from agronomic crops, in several important respects. At present, tree breeding has produced no such highly selected well-understood pure lines, and few clones are available that are valuable enough and sufficiently understood to be candidates for gene-by-gene fine-tuning. Typical breeding lines are still in their first to third generations, and most have abundant genetic variability that is in early stages of being sorted. The precise addition of one or two genes to this already rich genome would generally add very little to the near-term value of the line.

There are a few exceptions to the above cautious view. One is the possibility of inserting a genetic element that turns off the development of sexual organs. This would have several beneficial effects. First, a sexual part of such clones could be kept separate and fully fecund, so that these clones could then contribute to ongoing breeding lines. Second, the substantial proportions of photosynthate that are allocated to male and female organs would be partly and perhaps (in some clones) mostly redirected to harvestable wood in the lower part of the bole (Libby, 1987a). Finally, small in situ genetic conservation reserves that are or that become surrounded by large plantations of domesticated trees of the same species are in danger of genetic swamping. But if the domesticated trees produce little or no pollen and few or no seeds, then small genetic conservation reserves will be contaminated to a lesser and perhaps acceptable degree.

Hybrids - The role of hybrid trees remains uncertain in forestry. Currently, interspecific hybrids seem to be useful in poplars (Populus spp.) and eucalyptus, but hybrids have had only limited usefulness in the many other combinations of races and species of trees that have been tried. Biotechnology offers the possibility of combining completely unrelated taxa, and some of these may prove to be remarkably useful; but the prognosis is that the great majority of these hybrids will be little more than curiosities.

Genes in Culture - Trees may contribute genes that are useful for producing industrial or medicinal chemicals in culture, or perhaps when inserted in other organisms. A current example is the possibility of finding the tissue or genes that produce taxol, a chemical with cancer-fighting properties. Then, instead of cutting and grinding up yew (Taxus spp.) trees, a practice that may encourage poaching some yew species to the point of endangerment or even extinction, this valuable chemical may be produced in yew tissue culture or perhaps in a surrogate organism such as a yeast.

In addition to direct applications of biotechnology, the techniques developed in this and other branches of technology can be applied to make selections and to characterize or identify trees better or more accurately. Only a few examples from a much longer list are available.

Future Programme on Tree Improvement

Bangladesh is a thickly populated country and it is impossible to increase the productivity through expansion of forest land. With the increasing population growth shortage of tree products is becoming acute. In Bangladesh, natural forests have already diminished considerably, natural regeneration is also poor and thus large scale replanting with genetically improved trees have become essential to obtain the maximum productivity of the available forest lands.

Research and knowledge of forest genetics can be effectively used in the plantation practice to raise superior trees so that they can give faster growth, better tree from and wood quality, and product uniformity. Quick and permanent genetic gains can be achieved, in short periods, by using preliminary basic information on natural variability for selection by rapid screening, fast evaluation, conservation and multiplication of superior germplasm and by utilization of these selected clones directly in the plantation operation. With this end in view, BFRI has undertaken the following tree improvement programmes.

As a long term plan for the breeding and vegetative propagation methods to improve the productivity of the forest plantations the following programmes are recommended.

- To assess the breeding value of the provisional plus trees by determining the performance of their progeny by different parameters and ultimately to find the best provisional plus trees.

- To find out how much gain can be obtained from different parameters if those provisional plus trees are selected for inclusion in the seed orchards.

- Use this information for removing undesirable clones from the existing seed orchards. Trees can look different when grown in different areas. The genes carried by the trees are similar, but the environment is different, i.e. the geno types are similar (but not identical), and the phono types are different.

- Studies on fluting hereditability of teak.

- Selection and conversion of seed stands of indigenous and exotic species in natural forests and plantations and maintenance of seed stand register.

- Scientific management viz. weeding intensity, cover crop, manuring, girdling, artificial pollination of existing seed orchards.

- Development of improved seed sources of plantable mangrove species.

- Establishment of demonstration plots by using genetically superior seeds from seed orchards.

- Rehabilitation of 375 ha of existing seed orchards from 1993 to 1998.

- Conversion of 130 ha of previously selected plantations to seed-stands from 1993 to 1998.

- Establishment of additional 1000 ha of clonal/ seedling seed orchards of selected plantation species and MPT's from 1993 to 2003.

- Selection and conversion of 1000 ha new seed stands of various species recommended for plantations including exotics from 1993 to 2003.

- Progeny trials of PPTs from 1993 to 2013.

- Scientific verification and further selection of PPTs from 1993 to 1998.
- Centralisation of clones in clonal banks from 1993 to 1998.
- Seed collection, processing, grading, storage certification and distribution should be the exclusive responsibility of Seed Orchard Division of FRI from 1993 to 2003.
- Studies on the natural variation, identification, selection and conservation of such genetic races.
- Development to mass macropropagation technique of elite for clonal forestry practice.
- Studies on the reproductive biology of major forest species for future breeding programme.
- Studies on mutation breeding and development of outstanding clones through screening.
- Tissue culture research on bamboo, rattan, canes and selected tree species including experiments for mass propagation and evaluation of desired somaclonal variants.

In conclusion it is emphasised that for the successful implementation of the scenario 2 silvicultural programme, it is essential to develop high yielding tree varieties.

FUTURE PLANTATION SILVICULTURE

General

Scientific plantation silviculture is essential for proper development of forestry in Bangladesh. Except for the mangrove forests of Sundarbans, some form of plantations exist in all categories of the forests of the country. The sal forests were originally under coppice system. Most of the root stock in the sal forests have lost coppicing power. The only way to regenerate these forests is by raising plantations. Even if the FD could reproduce the sal, over large part of the area sal has to make room for fast growing light crowned species. This is essential for practice of agroforestry, whereby villagers can grow field crop in association with tree crop. A short rotation is also necessary so that villagers do not have to wait too long for the returns.

In the hill forests clear felling system followed by artificial regeneration remains the main system of silviculture for over hundred years. The total plantation area in the country as per records is 331,766 ha of which 112,966 ha are coastal plantations and 21,086 ha in the sal forests zone, leaving 197,714 ha in the hill forest. Most of the plantations in the sal forests are non existent. In the hill forests only 121,964 ha of long rotation plantations are traceable. In addition there are some recently created short rotation pulpwood, peelerwood and firewood plantations.

The major problem with plantations, particularly the long rotation plantations, has been lack of tending and thinning operations. Large areas of plantations have been left uncared for. This has resulted in the area of existing plantations being much less than that on record. The growing stock on the rest of the areas has disappeared due to neglect or pilferage. Even in the plantation areas which are traceable, there are signs of gross neglect. There has been no thinning on most of the plantations. This has resulted in loss of increment. The dense crown has prevented growth of undergrowth. Due to absence of ground cover often there is erosion of top soil. All this has contributed to very low MAI of the order of 2.5 m^3/ha/A. This could increase to 7.5 m^3/ha/A if there was tending and thinning. The rotation in the olden days was over 60 years. In actual practice there are some teak trees more that a hundred year old. Recently the BFD has reduced the rotation to 45 years. Even this is slightly on the higher side. We are reducing the rotation

to 40 and 30 years for our two scenarios. Accordingly the plan proposes felling the existing long rotation plantations over a period of 40 years or 30 years depending on the scenario. The annual plantation programme for different scenarios is in Appendix 3.

Implementing Agency for Establishment of Plantation

It will appear that for the hill forest alone there will be about 19,000 ha of plantations annually under Scenario 1 and 18,000 ha under Scenario 2 during the last year of the Plan. There will be additional plantations in the sal forests and coastal areas. To ensure the success of such huge plantation programmes, special steps will be needed. The organizational set up for the programme is in the subteam report. Scenario 1 will be executed by Government and Semi-Government agencies, Scenario 2 by autonomous agencies. Whoever executes the programme, public cooperation is vital for success. Cooperation of villagers is necessary not only for agroforestry but for protection of plantation elsewhere too. We recommend creation of village cooperatives for the purpose. They may be paid monthly remuneration and be entitled to share of thinning and final felling.

The plantating method will be from stumps in case of teak and jarul, with spacing of 1.85 m by 1.85 m. In case of most other species the planting will be poly bag seedlings at spacing of 2.77 m by 2.77 m. The wider spacing will result in economy in number of seedlings. Poly bag seedlings will be one year old. These seedlings will bigger and result in saving on weeding costs. For faster growth we recommend use of fertiliser particularly on impoverished soil.

Regarding site preparation we discourage use of fire. This, however, may be difficult to enforce. The hill people are used to clear the ground by fire for growing agricultural crop in between the line of young tree seedlings.

Proper thinning has been neglected in the past. This should not happen in future. Thinning schedule for different types of plantations is in Appendix 3.

Survey of Future Plantation Areas

For success of any plantation programme matching of species to site is important. The silvicultural characteristics of different species and suitability for different sites have been discussed in earlier sections. For proper site matching, a survey of the plantation area is necessary. This should be two years before the plantation programme, so that seed requirements and nursery work can be assessed well ahead. The survey should include topographical features, such as aspect, slope and drainage. Then it should incorporate physio-chemical characteristics of the soil as far as possible. All these should be recorded in the Plantation Journal. The survey data will help in choice of species.

There is useful information on matching of species to site in the publication - "Computerised Matching of Tree Species to Sites" by J Davidson and M M Khan, Working Paper 1 under FAO/UNDP Project BGD/85/085.

Nursery and Plantation Technique

Nursery technique has been dealt with in a previous selection. Details with costs are in Appendix 5.

Adequate nursery stock is vital to successful implementation of any plantation programme. The nursery stock for plantations in Government forest would mostly come from BFD nurseries.

Maintenance of permanent nurseries in forests like the ones at Kaptai, Dulahazara etc are no longer maintained. Nurseries are mostly raised in areas close to the plantations. Forest Extension there are some 98 nurseries and more will be established (345) to cover every thana. For the expanded plantation programme additional nurseries are needed. The number of beds for the implementation of the plantation programme is shown in Appendix 6.

In addition there will be further development of a Forest Extension Nursery and Training Centres (FENTC) up grading of 36 existing FENTCS and maintenance of 95 existing FENTCS. They will supply seedlings and take up training of staff and people. In the private sector nursery raising is gaining popularity mainly through the efforts of NGOs. In some areas, forest extension service is also extending cooperations. But these growers need training in seed selection, storage, seed-treatment, soil-preparation etc. There are over 650 private nurseries supplying fairly good seedlings. Private nurseries are preferred for horticultural and decorative.

Specialized Plantations

Besides plantations of regular forest trees, there will be plantations of specialized crop. Horticultural plantations have been considered under village and homestead forests and under planting on marginal land. For specialized crop like rubber there is BFIDC. The activities of this sector of the BFIDC should be merged with the organization executing the plantation programme in hill forests. The scope of rubber plantation should be expanded. More big gardens should be set up, with peripheral small gardens of 1-2 ha by villagers. The peripheral gardens should get know-how and planting stock from the big gardens. They should also be able to sell their latex to big gardens. This is particulary recommended of rehabilitation of the USF in Hill Tracts.

Besides rubber, there can be cashew nut plantation in the USF and coconut plantations in the coastal areas. Medicinal plants, cane and murta also deserve attention. The Report on Non Wood Forest Products deals with the matter.

Lastly there are urban and roadside plantations. In urban plantations there has to be coordination with landscape design. For plantings along highways the decorative and utility values have to be combined. Some form of participatory enterprise with the villagers of the locality is desirable.

Plantation Journals and RIMS

The system of maintaining regular plantation journals has been neglected for the past few years. This has led to serious gap of information and uptodate data concerning plantations. It is essential that the journals are maintained regularly and inspecting officers record their observations during field visits. In addition all relevant data should be transmitted to the computer information system at Head Quarter. This is the RIMS centre. The RIMS should be continually updated.

Plantation Economics

We have outlined two silvicultural development programmes under Scenario 1 and Scenario 2. The major portion of the development programmes are raising and tending of plantations. The yields of these plantations will be higher than the low yields of existing plantations. Appendix 6 gives the total cost of the plantation programmes under the two scenarios. The cost figures exclude overheads and interest charges. Overheads are included in Institutional costs. Detailed financial analysis of the plantation programmes under both the scenarios after allowing for interest charges and overheads are in the Report on Economics. It will appear that the plantation programmes under both the scenarios are financially viable.

SILVICULTURE DEVELOPMENT PROGRAMME AND IMPLICATIONS

General

In an earlier section we have pointed out that the present state of affairs cannot continue indefinitely. Unless something is done soon, things will deteriorate. The forest area will shrink and growing stock will diminish further. The moratorium has failed to work and unauthorised removal of wood is going on. Over sixty percent of sal forest is under the possession of encroachers. In the Hill Tracts USF land is denuded and eroded due to frequent jhum cultivation. Failing to get livelihood from the USF the tribal population are now practising jhum in reserved forests. This is causing environmental degradation in the catchment area of the Kaptai lake.

All this points to the urgency of the situation. The plan has presented the outlines of two scenarios. It is up to the Government to opt for any of the scenarios. In case of Scenario 2, the executing agency will be corporate bodies under the enterprise system. For Scenario 1 the executing agencies will be Government and Semi-Government bodies. Details of the organizational set up are in the Subteam Report on Forest Production and also in the Report on Forest Management.

Silvicultural Problems and Yearwise Programmes

Silvicultural problems have become more complicated than in the past. On the one hand demand for forest products is increasing. Simultaneously the supply is dwindling due to pilferage, encroachment and poor management. On the other hand environmental degradation is accelerating.

The silvicultural development programme to rectify the situation has been outlined in previous sections. Yearwise breakdown of the silvicultural programme is in Appendix 6. Yearwise plantation programme is in Appendix 3. We reiterate below the highlights of the programme.

1. **Hill Forests**

- Pilot scale models with different species mixture on USF and other denuded areas earmarked for participatory forestry should be taken up and the benefits properly explained to the participants. Participation and motivation of the people should also be arranged for security of plantations.

- Under Scenario 1, one-half of the existing natural timber forest will be felled during the next 20 years. This excludes the Sangu reserve and the Park and Sanctuaries. In Scenario 2 excepting 1000 ha of Kassalong, all high forest would be protected for the sake of biodiversity, maintenance of gene pool and seed collection. The clear felled areas will be planted up.

- All old plantations with low MAI should be planted with species matching the site and end-uses. Research may be needed to find out the matching species. Research is also essential for evolving high yielding varieties of trees of plantation. Large scale nursery programme as in Appendix 6 is necessary.

- All encroached jhumed and blanks should go under short/medium rotation participatory system. The short term and mid term inter crops should be planted to increase the benefits of the participants and to increase the opportunity cost of the land. The denuded land should be covered with multipurpose leguminous crops. In fact all eroded land should be subjected to soil improvement treatment. Where gully formation has taken place, they

should be plugged. This will conserve both soil and moisture. The banks of the deep gullys may be covered with Vetevera creepers.

- The rotation for future plantation are as follows. For scenario 1 rotation will be 40, 20 and 10 years respectively for long, medium and short rotation crop. For scenario 2 the rotations will be 30, 20 and 10 years. The long and medium rotation crop will be mainly for timber production. The short rotation species will be for pulpwood, gamar, malakana and Pinus carabea are recommended.

2. Sal Forests

- The major problem here is encroachment. About two third of the sal forest are under encroachment and lying barren. Participatory forestry is the only recourse left to recover these land and rehabilitate the land and the man together. The programme has already been launched and is working well. Research on (i) socioeconomic variables, (ii) cropping pattern, (iii) landuses and (iv) marketing of the products should be undertaken. Research should be done along with the participants and the field staff.

- Research on introduction of exotics to replace sal should be done.

- Agronomic research should be undertaken to find out what crops will give maximum benefit to land and man.

3. Sundarbans Forest

- Here the main problems are lack of gewa regeneration and sundri die-back. Research is needed are to find out salt tolerant trees to replace sundri. Some mainland species already introduced in other saline areas can also be tried.

- The present silviculture system, the selection-cum-improvement felling on a 20 years felling cycle can continue. Gewa is a hardy species. It also coppices well. Research should be made to find if gewa regeneration can be made through coppice. Just after Partition there were some experiments on gewa regeneration by coppice. No records are available. The experiment is worth repeating in all the three saline zone.

- Enrichment plantation on large blanks and new accretions may be taken up with local species after studying the regeneration conditions of different species in the 125 sample plots already laid out.

- Thinning intensity of different species should be studied. Different degrees of canopy opening will have impact on regeneration and salt accumulation on surface.

4. Coastal Afforestation

Coastal afforestation is a new work in Bangladesh and needs research. The more important programmes are listed below:

- Site and species matching: Some of the old sites in Noakhali are considered to be suitable to support species like gewa and sundri. In Chittagong, infront of the coastal embankment where the soil was clayey goran should be introduced.

- The impact of urigrass (Oryza coaractata) on the new accretions should be studied to find out how much of (a) organic matter it adds to the soil, (b) how much of silt it catches every year and (c) its role in land stabilization.

- The canals dug to take tide water inside the mainland to keep the area moist and flooded during high tide appears to have been abandoned without noting the results. This was the suitable method of regenerating the Mirsharai and Sitakunda areas where coastal afforestation has already demonstrated its utility.

- Research should be taken up to see how shrimp culture and coastal afforestation can go side by side.

- Large scale keora defoliator has already destroyed some keora plantations. Preventive measures should be taken.

- Golpatta was introduced in Bhola, Patuakhali and Companigonj under Noakhali Division. Studies on their further natural regeneration and their impacts in protecting banks should be made.

- On sandy beaches cashew nut and coconut planting programme should be taken and impacts studied.

Demand and Supply

Under existing conditions of our economy, we estimate the annual demand in terms of round wood is 13.2 million m^3. It includes logs, poles, pulpwood and fuelwood. It works out to about 0.12 m^3 per capita. The development goal set by the Government is 5% annual growth rate in gross domestic products. To support this development target, the nation will consume 16.5 million m^3 of wood annually by the year 2012. Incidentally the current supply is estimated at 7.9 million m^3.

The demand and supply figures have been worked out by other member of the Subteam. To assess the demand vis-a-vis the supply the Plan used the demand figures as above for the low demand Scenario 1. For Scenario 2 we have used high consumption figures based on accelerated rate of economic growth. These figures are higher than those for neighbouring countries and should be treated with caution. Along with Scenario 1 and 2 figures, the plan gives figures for the existing Status Quo position.

The Master Plan analyzed the data for four categories of wood products, viz: sawlogs, poles, pulpwood and fuelwood. A specialist for bamboos analyzed separately data for bamboos. Data for village bamboo production are from village survey.

The Status Quo situation is only a bench mark for comparison with the development scenarios. We have presented the yield under different scenarios for 20 year period. One should realise that trees take time to grow. Even if BFD starts the development programme in the first year of the Plan, there can be no substantial increase of supply within the short span of 20 years. The real increase would take place after 30 or 40 years depending on the rotation. We have not indicated this increased supply after 30 or 40 years. But one should keep this in mind to correctly appreciate the future potential of development.

Under Scenario 1, the supply in the year 2013 comes to 14.3 million m^3. However, the medium rotation plantations which start in 1994 or 1995 would not reach full production before 2015. The increase on this account alone would then be 1.6 million m^3 per year. Yield from existing plantations would also increase due to better tending and thinning. For existing plantation yield we have used MAI figure of 2.5 to 4.0 m^3/ha/A. With proper tending and thinning the yield would be much higher. Again if saw mill conversion factor improves, this will be equivalent to additional supply of 1.5 to 2 million m^3.

From the long term point of view the supply will increase substantially when the newly created plantations of teak approach maturity. We estimate that yield of teak and other long rotation plantations alone would amount to 1.0 million m^3. So we are confident that even under Scenario 1, it would be possible to meet the shortfall to a large extent. If there are genetic improvements from research then the future yield will be much more.

Under Scenario 2, the supply by the year 2013 would amount to 25.3 million m^3. This is more than the demand under normal growth rate. We should, however, point out that Scenario 2 assumes very high demand and also high MAI rates, viz: 20 m^3/ha for long rotation (30 years) crop like teak and associates, 30 m^3/ha again for shorter rotation (20 years) teak and associates and finally 45 m^3/ha for very short rotation crop (10 years). Such high rates of MAI are possible, but it would take a lot of time and effort to attain them. For comparison under Scenario 1, the MAI's aimed are 7.5, 12.5 and 15 respectively. The yields figures shown under Scenario 2 may be attainable, but there might be some reservation against the immediate adoption of these figures.

Demand and supply figures for different scenarios are in Appendix 4.

Conservation and Maintenance of Biodiversity

We have so long stressed on the development of supply vis-a-vis demand. For a country with limited land resource and rising population, it is imperative that the production is increased. In our development programmes, we have shown that it is possible to do so without causing damage to the environment. In actual practice the environmental damage is now acute, due to pressure on the meagre forest resources and unauthorised removal of forest product.

We shall first consider the hill forest zone, where the danger of environmental deterioration is greatest.

Apart from the status quo situation, which is presented as a bench mark, we have presented two alternative development scenarios. In both the scenarios more than half of the natural timber forest in the hill forest zone will be preserved. This is in addition to 110,223 ha of parks and sanctuaries in the country, where there will be absolute protection. In both the development scenarios, all felling in the natural timber forest will cease after twenty years.

Besides the natural timber forests, there are extensive areas of non productive reserve forest areas. Jhum cultivation and encroachment has denuded these areas. Then there are over 700,000 ha of USF land which are bare and subject to erosion. Many of these form the catchment and watershed area of the rivers and streams falling into the Kaptai lake. It is essential that these areas are put under tree cover. We should, however, consider the interest of the tribal population. We should see that any afforestation programme of the USF does not affect them unnecessarily. Association of the local people will ensure this. They should share in any benefit from the afforestation. As trees take time to mature, there should be short term crop of Non wood products along with the tree crops.

We also recommend associating the local population for security of the plantation. BFD should encourage formation of village cooperatives from people in the neighbourhood of forests. These cooperatives would take over protection of forests and plantations in lieu of periodic payments and a share in final crop. This would be no problem for short rotation crop like agroforestry plantations. Even in longer rotation programmes we are recommending association of local people for protection and tending operation. BFD should tell local people about the benefits they would get.

We shall now consider the mangrove forest and the sal forests. In the mangrove forest of Sundarbans, the selection system will continue. There will be coastal plantations where people can

participate. The programme of coastal plantation will go on. BFD should not allow felling of old plantations unless there are new plantations on the sea ward side.

For the sal forests, where more than 65% of the forest is encroached or denuded, we have suggested enrichment and agroforestry plantations on a large scale. BFD should associate NGO's in the programme to get people's confidence.

Tree Improvement Programme

It has been stressed earlier that the existing plantation yields are very low by International Standards. Some improvement is possible by proper application of silvicultural technique and by better management. But for real development tree improvement programme is vital, particularly for scenario 2. The programme has been described in an earlier section.

Promotion of Non Wood Products

Non wood products are neglected in most forestry programmes. Except for bamboo and golpatta there are no harvesting rules for others. But some products like rattans, medicinal plants, honey, bees wax, lac, murta and hogla can provide short term income. This is important for villagers cooperating in Participatory Forestry. The plan recommends that the promotion of Non wood products receives due attention from BFD. The report on Non Wood Products will be of help in this regard.

RECOMMENDATIONS

General

The forests of Bangladesh are shrinking fast. Even what is left is deteriorating. Along with the depleting resources there is ever increasing demand leading to further imbalance. This eventually leads to illicit removal of forest products causing environmental deterioration. The situation will get worse unless BFD takes immediate steps to overcome the shortage. The Plan outlines development programmes under two scenarios. It is upto the MOEF to opt for one of the two. In this section we shall present some recommendations for execution of the development programme.

Implementation Programme

The Master Plan presents the programme at the macro level. For its implementation the BFD should have an implementation cell. The cell will recast the working plans in the light of the Plan. It will lay down the silvicultural system and plantation programme by forest blocks. It will coordinate foreign assistance programme with donor agencies. Though the implementation cell is an immediate necessity, there should be a long term body to monitor implementation. Some institutional changes will also be necessary the implementation.

Public Participation

The major weakness of forestry programmes in Bangladesh has been the inability to secure the participation of the villagers and the community at large. This has led to large scale encroachment and pilferage. BFD can stop this only by getting public cooperation. A start has been made under the Thana Banayan Programme in this regard. The results so far have been encouraging.

Our development programme for the hill forests calls for extensive plantation programme. The annual target is 3,560 to 5,500 ha of long rotation, 10,000 ha of medium rotation and more than

3,000 ha of short rotation plantations. Plantation programmes on such a large scale cannot succeed without the active participation and cooperation of the people in the neighbourhood. Public cooperation is also necessary for afforestation of the USF in the Hill Tracts.

There are over 700,000 ha of USF land, which is now mostly degraded. The tribal people living on these areas can not now make their living by practising jhum cultivation on the degraded land. Both in the interest of conservation and for providing livelihood to the tribals, the BFD should bring the USF land under tree cover.

Research Organizations

In both the Scenarios we have recommended growing high MAI trees. This will call for research. There is hardly any research now, on plant improvement through genetic engineering and tissue culture. The BFRI and universities should expedite research on these lines. There should also be research on pest control. The Sundarbans forests deserve special consideration. The problem of ecological succession needs study. BFD should find out if terrestrial species can grow in the drier parts of the forest.

Better plantation and nursery technique, proper use of fertiliser, plant growth hormones and pesticides need investigation.

Extension of Village Forests and Marginal Land Trees

We have referred to these elsewhere in the report. The Report on Participatory Forestry gives details of the programme. Here we shall reiterate the importance of these in supplementing small wood and fuel wood supply in rural areas. BFD should encourage the people for planting date palms and coconut palms in village and marginal lands.

Afforestation of the USF and Coastal Areas

We have stated about this in the body of the report. We would reiterate the apart from providing living to tribal population these areas form the catchment area of the Kaptai lake. Any programme has to take into consideration both these aspects on a priority basis. BFD should try to introduce cash crop like rubber, cashew nut, palm oil in the hilly areas and coconut, date palms in coastal belt.

Conservation of Core Areas and Watershed Areas

In our development programme under Scenario 1 we have excluded more than half of the hill forest from harvesting. In Scenario 2 the excluded area is lager. We strongly recommend that the excluded forests are treated as core areas for protection. We have stressed on the need for protection of watershed and catchment areas.

Maintenance of Biodiversity

For a country with limited land resource and rising population, it is imperative that the production is increased. In the development programmes, it has been shown that it is possible to do so without causing damage to the environment. In actual practice the environmental damage is now acute, due to pressure on the meagre forest resources and unauthorised removal of forest product. The programmes under both the scenarios will help in Maintenance of Biodiversity.

APPENDIX 1
ABBREVIATIONS, TERMS AND CONVERSION FACTORS

SILVICULTURE

APPENDIX 1
ABBREVIATION, TERMS AND CONVERSION FACTORS

LIST OF ABBREVIATIONS AND LOCAL TERMS

ADB	- Asian Development Bank
AF	- Acquired Forest
BARC	- Bangladesh Agricultural Research Council
BASIC	- A Software Program
BCIC	- Bangladesh Chemical Industries Corporation
BCSIR	- Bangladesh Council for Scientific and Industrial Research
BSCIC	- Bangladesh Small and Cottage Industries Corporation
CAI	- Current annual increment
Char	- Land formation on river bank on sea coast
CHT	- Chittagong Hill Tracts
cm	- Centimetre
dBase	- Data Base Software Program
DBH	- Diameter Breast Height
FAO	- Food and Agriculture Organization of the United Nations
FD	- Forest Department
FIDC	- Forest Industries Development Corporation
FMP	- Forestry Master Plan
FRI	- Forest Research Institute
gm	- Gram
GOB	- Government of Bangladesh
ha	- Hectare
Jhum	- Shifting Cultivation
kg	- Kilogram
Khas Forest	- Forest Land Owned by Revenue Department of Government
Khet Land	- Private Land
km	- Kilometre
km^2	- Square kilometre
KNM	- Khulna Newsprint Mill
KPM	- Karnafuli Paper Mill
m	- Metre
m^3	- Cubic Metre
m^3/ha/Yr	- Cubic metre per hectare per year
MAI	- Mean annual increment
mm	- Millimetre
MOEF	- Ministry of Environment and Forest
MT	- Metric Tonne
NGO	- Non Government Organization
No.	- Number
ODA	- Overseas Development Agency
PF	- Protected Forest
PF	- Public program of tree planting on land outside forest
REB	- Rural Electrification Board
RF	- Reserved Forest
Tk	- Taka
UNDP	- United Nations Development Program
VF	- Vested Forest
WAPDA	- Water and Power Development Authority

APPENDIX 2
BACKGROUND INFORMATION

PROJECT 372001/20
FORESTRY MASTER PLAN
BANGLADESH TA 1355-BAN

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: JANUARY 1993

SILVICULTURE

APPENDIX 2
BACKGROUND INFORMATION

TABLE OF CONTENTS

1. AGGREGATED PHYSIOGRAPHIC UNITS OF BANGLADESH

We are listing below the composition of the aggregated physiographic units.. The LRA Report 2 FAO (1988) gives the descriptions of the individual units. In Figure 1, we are giving a map showing their geographical distribution.

a. **Estuarine Floodplain** (FE). This comprises the saline portions of the Ganges Tidal Floodplain, the Young Meghna Estuarine Floodplain and the Young Chittagong Coastal Tidal Floodplain.

b. **Meander Floodplain, Gangetic** (FMg). This is made up of the Ganges River Floodplain and the non-saline part of the Ganges Tidal Floodplain.

c. **Meander Floodplain, non-Gangetic** (FMn). This consists of the Tista, Karatoya-Bangali, Lower Punarbhaba, Brahmaputra, Meghna River and Surma-Kushiyara Floodplains, together with the Lower Atrai Basin, the old Meghna Estuarine Floodplain and the Old Chittagong Coastal Tidal Floodplain.

d. **Bils** (b). This embraces the Gopalganj-Khulna Bils and the Arial Bil.

e. **Quaternary Terraces** (T). Barind and Madhupur Tracts.

f. **Tertiary High Hills** (Hh). The high hill ranges of the Northern and Eastern Hills, comprising the Tipam and Surma formations.

g. **Tertiary Low Hills** (Hl). The low hills of the Northern and Eastern Hills, made up of the Dupi-Tila formation.

h. **Sandy Beach Ridges** (C). This is composed of the sandy beaches and beach ridges of the Chittagong Coastal Plain, and related sites on St. Martin's Coral Island.

i. **Piedmont Terrace Fans** (Pf). This comprises the Northern and Eastern Piedmont Plains and associated river floodplain ridges, plains and basins including those of the Chittagong Coastal Plain.

j. **Himalayan Piedmont Plain** (Pp). This consists of part of an old Tista alluvial fan extending from the foot of the Himalayas, and designated in the LRA reports as the Old Himalayan Piedmont Plain.

Legend to Figure 1: FE = Estuarine floodplain, FMn = Meander floodplain, non Gangetic, FMg = Meander floodplain, Gangetic, B = Bils, T = Quaternary terraces, Hh = Tertiary high Hills, C = Sandy beach ridges, Pf = Piedmont terrace fans, Pp = Himalayan piedmont plain.

2. SOIL TYPES OF BANGLADESH

The list below gives the General Soil Types of Bangladesh. The location of the types is in the map attached.

a. **Himalayan piedmont soils**

- non-calcareous brown floodplain soils
- black terai soils

b. **Meander floodplain soils, Gangetic**

- Calcareous brown floodplain soils
- calcareous dark grey floodplain soils
- non-calcareous grey floodplain soils, non saline

c. **Meander floodplain soils, non-Gangetic**

- Calcareous grey floodplain soils
- non-calcareous grey floodplain soils, non saline
- non-calcareous dark grey floodplain soils
- peat
- non-calcareous alluvium

d. **Estuarine floodplain soils**

- non-calcareous grey floodplain soils, non saline
- acid sulphate soils
- calcareous alluvium

e. **Quaternary terrace soils**

deep terrace soils

- deep red brown terrace soils
- brown mottled terrace soils
- deep grey terrace soils

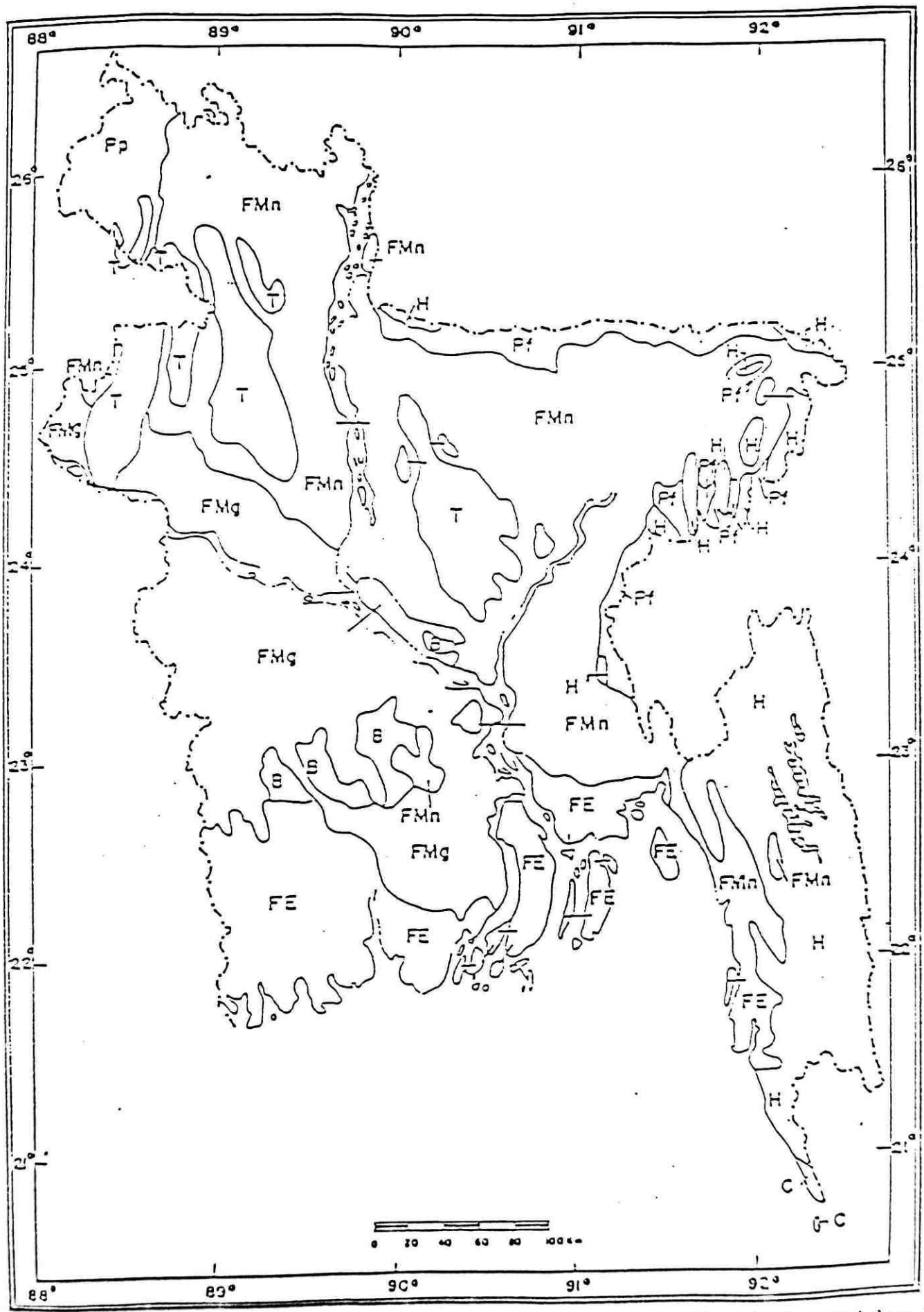

Figure 1 - Map of Bangladesh, showing aggregated physiographic units (adapted from FAO 1988), legends are in following page

shallow terrace soils

- shallow red brown terrace soils
- shallow grey terrace soils

valley soils

- grey valley soils

f. **Terrace fan soils**

- grey piedmont soils
- acid basin clays

g. **Low hill soils**

- brown hill soils

h. **High hill soils**

- brown hill soils

Descriptions of the general soil types are in LRA Report 2, Agroecological Regions of Bangladesh (FAO, 1988). The map in Figure 2 shows the different soil types of Bangladesh.

Legend for Figure 2: 1a = Calcareous Alluvium (non-saline) Soils, 1b = Calcareous Alluvium (seasonally saline) Soils, 2 = Non-calcareous Alluvium Soils, 3 = Calcareous Grey Floodplain Soils, 4 = Calcareous Dark Grey Floodplain Soils, 5a = Noncalcareous Grey Floodplain Soils (non-saline), 5b = Noncalcareous Grey Floodplain Soils (seasonally saline), 6 = Noncalcareous Brown Floodplain Soils, 7 = Noncalcareous Dark Grey Floodplain Soils, 8 = Noncalcareous Dark Grey Floodplain Soils and Peat, 9 = Black Terai Soils, 10 = Acid Basin Clays, 11 = Acid Sulphate Soils, 12 = Grey Piedmont Soils, 13 = Brown Hill Soils, 14 = Shallow and Deep Grey Terrace Soils, 15 = Deep Red-Brown Terrace Soils.

3. AREA STATEMENT OF FORESTS

3a. Legal Status, ha

Table 1 - Legal Status, ha

	Reserved Forests	Acquired Forests	Protected Forests	Vested Forests	Unclassed State	Khas	Total
HILL FOREST	594,383	11,004	32,303	2,636	721,344	-	1,361,670
CHT (North)	159,379	-	-	-	153,063	-	312,442
CHT (South)	82,161	-	-	-	172,721	-	254,882
Bandarban USF	40,198	-	-	-	78,592	-	118,790
Pulpwood Bandarban	-	-	-	-	58,236	-	58,236
Lama	-	-	-	-	75,149	-	75,149
USF Rangamati	12,801	-	-	-	89,694	-	102,495
Jhum Control	12,903	-	-	-	9,600	-	22,503
Pulpwood Kaptai	29,279	-	-	-	-	-	29,279
Khagrachari USF	1,409	-	-	-	82,073	-	83,482
Chittagong	82,307	5,096	19,873	2,636	-	-	109,912
Cox's Bazar	104,103	1,241	12,430	-	-	-	117,774
Sylhet	69,843	4,667	-	-	2,215	-	76,725
INLAND FOREST	68,140	31,198	2,689	19,985	-	-	122,012
Dhaka	26,221	-	-	-	-	-	26,221
Tangail	22,460	27,287	-	-	-	-	49,747
Mymensingh	13,467	-	-	15,019	-	-	28,486
Dinajpur	5,037	387	-	4,681	-	-	10,105
Rangpur	763	1,697	263	-	-	-	2,723
Rajshahi	192	11	2,426	276	-	-	2,905
Comilla Extn	-	1,696	-	-	-	-	1,696
Dhaka Extn (South)	-	-	-	9	-	-	9
Kushtia Extn	-	8	-	-	-	-	8
Bogra Extn	-	7	-	-	-	-	7
Faridpur Extn	-	10	-	-	-	-	10
Jessore Extn	-	9	-	-	-	-	9
Botanical Garden, Dhaka	-	86	-	-	-	-	86
LITTORAL FOREST	656,579	6	-	-	-	101,526	758,11
Sundarbans	557,285	-	-	-	-	-	577,285
Bhola CA	2,236	-	-	-	-	24,304	26,540
Patuakhali CA	8,571	-	-	-	-	13,293	21,864
Noakhali CA	35,741	6	-	-	-	54,618	90,365
Chittagong CA	32,746	-	-	-	-	9,311	42,057
Total	1,319,102	42,208	34,992	22,621	721,344	101,526	2,241,973

Abbreviations: CHT - Chittagong Hill Tracts, USF - Unclassed State Forest, Extn - Extension, CA - Coastal Afforestation
Includes Matamuhuri Reserve.

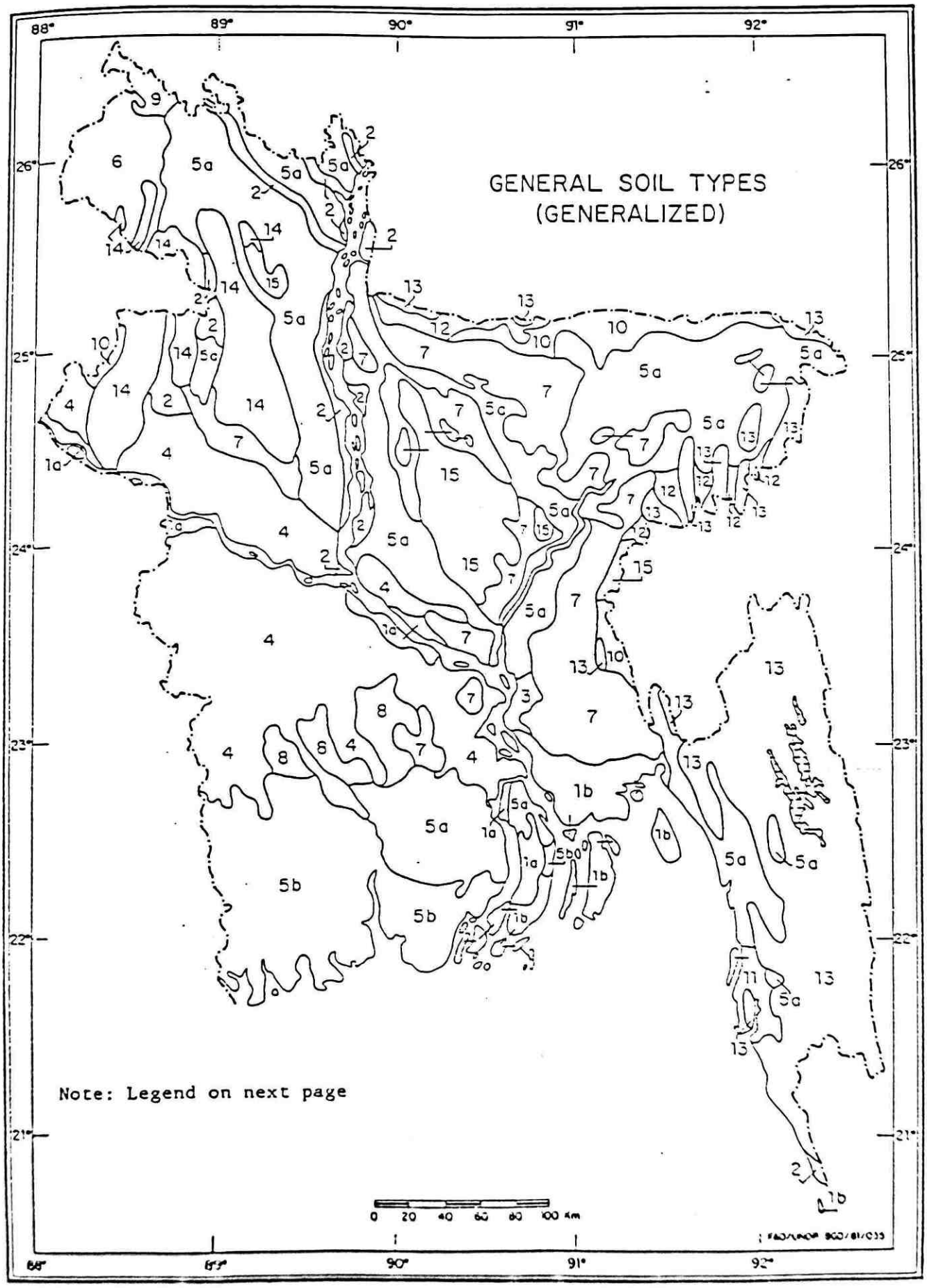

Figure 2 - Map of Bangladesh Showing Soil Types

3b. Forest Types

Table 2 - Area of Hill Forest (ha)

Division	Natural forest medium to good density	Natural forest poor density	Scattered trees & denuded	Mainly bamboo	Plantations incl. failed plantation	Jhum & enchroach-ment	Up-productive incl. blanks	Parks & Sanctuary	Water areas	Other inc. USF	Total
CHT (North)	41393	11832	3525	12635	22376	16622	4078	42087	4831	153063	312442
CHT (South)	1451	3601	6494	13606	22599	31783	586	-	1727	173035	254882
Bandarban USF	3800	7300	4200	14791	6878	3430	-	-	400	77991	118790
Bandarban Pulpwood	-	-	-	-	8722	-	-	-	-	49514	58236
Lama	-	-	-	-	2331	-	-	-	-	72818	75149
USF, Rangamati	-	-	7577	-	5224	-	-	-	-	89694	102495
Jhum Control	-	-	--	-	15364	-	-	-	-	7139	22503
Kaptai Pulpwood	-	-	-	-	18169	-	-	-	-	11110	29279
Khagrachari	-	-	-	-	1409	-	-	-	-	82073	83482
Chittagong	15788	22736	15616	-	33426	12535	200	7761	-	-	109912
Cox's Bazar	20135	6840	10763	16338	40406	3913	-	13344	6030	-	117774
Sylhet	2749	-	9413	13826	20810	2510	5115	1095	18992	2215	76725
Total	85316	52359	57593	71196	197714	70793	11779	64237	31980	713652	1361670

Table 3 - Area of Sal Forest (ha)

Division	Natural forest medium to good density	Natural forest poor density	Scattered trees & denuded	Mainly bamboo	Plantations incl. failed plantation	Jhum & enchroach-ment	Up-productive incl. blanks	Parks & Sanctuary	Water areas	Other inc. USF	Total
Dhaka	-	8664	3436	-	3099	5000	1000	5022	-	-	26221
Tangail	-	12517	18570	-	3631	3593	3000	8436	-	-	49747
Mymensingh	-	4787	1455	-	9147	11336	1761	-	-	-	28486
Dinajpur	-	1512	-	-	2249	5828	463	52	-	-	10105
Rangpur	-	50	-	-	1746	927	-	-	-	-	2723
Rajshahi	-	-	129	-	1214	1536	26	-	-	-	2905
Comilla	-	-	1696	-	-	-	-	-	-	-	1696
Total	-	27531	25386	-	21086	28220	6250	13510	-	-	121883

Table 4 - Area of Littoral Forest (ha)

Division	Natural forest medium to good density	Natural forest poor density	Scattered trees & denuded	Mainly bamboo	Plantations incl. failed plantation	Jhum & enchroach-ment	Up-productive incl. blanks	Parks & Sanctuary	Water areas	Other inc. Khas land	Total
Sundarbans	374899	-		-	-	-	-	32326	17000	-	577285
Bhola C/A	-	-	-	-	24232	-	-	-	-	2268	26540
Patuakhali C/A	-	-	-	-	17816	-	-	-	-	4048	21864
Noakhali C/A	-	-	-	-	38172	-	-	-	-	52193	90365
Chittagong C/A	-	-	-	-	32746	-	-	-	-	9311	42057
Total	374899	-	-	-	112966	-	-	32326	17000	67820	758111

4. SUMMARY OF INVENTORY RESULTS

Table 5 - Area of Forest Types of Kassalong and Raingkhiong as per 1963 and 1983 Surveys

Ground Cover	Forestal 1963		BGD/79/017	
	Kassalong	Raingkhiong	Kassalong	Raingkhiong
Timber types	52689	20325	46395	7116
Mixed timber - bamboo	23509	6933	14878	3228
Mixed bamboo - timber	31972	17519	23525	6194
Bamboo types	41366	27907	12653	13606+
Plantations*	5013	2011	14330	8873
Non-forested areas**	3711	372	46960	36624
Non-productive areas	893	1060	330	486
Water and swamps	5377	977	5377	977
Total	164527	77104	164448	77104

* The Forestal figures for plantations refer to established plantations plus the area of proposed plantations scheduled to be established upto 1965. The BGD/79/017 figures represent the situation in 1981, the clearings and logged areas of 1982-84 having been classified as recent clearings and logging areas under "Non-forested areas".

** The tremendous increase in non-forested areas in both the reserves during the 20 year period is alarming.

\+ All muli bamboo.

Muli areas were not surveyed in 1963 as muli was in flower.

The area figures need further revision in the light of latest findings. The revised are figures valid for 1990 are given in Table 5 below. The yield figures for different forest types are from Forestal Report.

Table 6 - Revised Area and Volume Figures of Kassalong and Raingkhiong

Ground Cover	Kassalong			Rainkhiong		
	Area ha	Vol ha m^3	Total Vol, 1000 m^3	Area ha	Vol ha m^3	Total Vol 1000 m^3
Timber types	41393	136.6	5654.3	1167	171.5	200.1
Timber - bamboo	11852	112.9	1335.8	3228	122.0	393.8
Bamboo - timber	23525	54.0	1270.3	6194	46.2	286.2
Bamboo types	12653	17.3	218.9	13606	20.2	274.8
Plantations*	22376	-	-	18759	-	-
Non-forested	41876	-	-	31833	-	-
Non-productive	893	-	-	486	-	-
Water and swamps	4831	-	-	977	-	-
Total	159379		8479.3	76300		1154.9

2. Sitapahar Reserve

Most of the original natural forest has been replaced by plantations which dates as far back as 1871 and some of these valuable plantations have been lost due to construction of Kaptai dam and subsequent flooding. Area classification given below is according to latest data.

Table 7 - Area Statement of Sitapahar Reserve

Cover types	Area in ha
Natural forest	
High forest, large crown	284
High forest, small crown	373
Brush with scattered trees	300
Plantation till 1990	3740
Agriculture, inundation, settlement	750
Total	5447

3. Sangu and Matamuhuri Reserves

Along with the other forests of Chittagong Hill Tracts, there was inventory survey of the Sangu and Matamuhuri reserves during 1961 and again in 1984. The table 7 below gives the results of the two surveys.

Table 8 - Area of Forest Types of Sangu and Matamuhuri Reserves

Type	1961 inventory		1984 inventory	
	Area (ha)	%	Area (ha)	%
High Forrest medium-good density	7100	9.5	8700	11.7
High Forest poor density	18450	24.8		
Low immature forest poor density	14530	22.7	47840	64.2
Low forest medium-good density	2380			
Mainly Bamboo	31260	42.0		
Shifting cultivation (Jhum)	30	0.5	17100	23.0
Grass land (along reserves) agriculture, settlement	270	0.4	380	0.5
Water	480	0.6	480	0.6
Total	74500	100.0	74500	100.0

A study of the foregoing table reveals the present position of these reserves. We give below the summary of the study.

a. Since 1961 the productive forest land has decreased by approximately 17180 ha and area under jhum has increased by 17070 ha in these two reserves. The plantation areas have increased to about 5037 ha in Matamuhuri reserve by 1990.
b. Shifting cultivation (jhuming) is the main cause of the continuous retrogression of the high forest and bamboo types. The 1961 survey delineated only 30 ha as jhum, This increased to nearly 17100 ha in 1984.

4. Chittagong and Cox's Bazar Divisions

Project/FAO/BGD/85/085 carried out inventory survey of the forests. The table below incorporates the result of the inventory.

Table 9 - Area Classification and Volume for Chittagong and Cox's Bazar Forests

Forest Type	Chittagong Division			Cox's Bazar Division		
	Area ha	Vol ha m^3	Total Vol, m^3	Area ha	Vol ha m^3	Total Vol m^3
Large Crown High Forest	7456	90.2	672531	12891	115.6	1490200
Small Crown High Forest	22037	45.6	1004887	17883	57.2	10229.8
Disturbed Garjan Forest	510	89.1	45441	521	120.4	62728
Brush and Scattered Trees	22468	24.4	548219	3205	37.7	120829
Total m^3			2271078			2696665

Source. FAO Inventory

The areas for different forest types have changed to some extent since the date of the inventory. We give below the latest figures as available from the working plans.

(a) Chittagong Division

Available land base excluding Game Sanctuaries, 1991

	(NF) Natural Forest (ha)	(ST) Scattered Trees (ha)	(P) Plantations (ha)	(D) Denuded (ha)	Total (ha)
RF,PF,VF,AF	20,599	11,540	23,090	24,255	76,484
Game Sanctuary	4,811	2,733	1,684	1,469	10,697
Total	15,788	8,807	21,406	22,786	68,787
% of Total	23%	13%	31%	33%	100

The rest of the land is unavailable due to encroachments.

(b) Cox's Bazar Division

Available land base excluding Game Sanctuaries and agriculture, 1991

	(N) Natural Forest (ha)	(ST) Scattered Trees (ha)	(P) Plantations (ha)	(D) Denuded (ha)	Total (ha)
RF,PF	11,835	2,754	24,210	6,501	57,903
Game Sanctuary	12,602	0	0	0	12,602
Total	24,438	2,754	24,210	6,501	45,301
% of Total		6%	53%	33%	100%

The rest of the land is unavailable due to encroachments.

5. Sylhet Forest Division

Project FAO/BGD/85/085 completed the inventory survey of the Sylhet forests in 1988. The table below summarises the results of the survey.

Table 10 - Area Classification and Volume for Sylhet Forests

Forest Type	Area (ha)	Vol m^3/ha	Total Vol m^3
Large Crowned High Forest	796	90.3	71878
Small Crowned High Forest	1953	64.3	119719
Scattered Trees	2629	25.0	65725
Total m^3			257322

Here again the latest area distribution has changed as shown below:

(N) Natural Forest	(ST) Scattered Trees	(P) Plantations	(D) Denuded	Total
2749	9413	20810	5115	

(N) Natural Forest	(ST) Scattered Trees	(B) Bamboo	(P) Plantations	(D) Denuded	(O) Other	Total
2749	9413	13826	20810	5115	24812	76725

Other (O) area includes Parks, Encroached, Water and USF.

Table 11 - Area of Forest Types of Sundarbans and Merchantable Volumes

Forest types	Area (sq km)	Volume ('000'cu m)
Sundri + other species mixed with sundri	2083	6798
Gewa + other species mixed with gewa	1808	1793
Keora + other species mixed with keora	33	476
Others (Passur, kankra, dhundal, baen	32	1579
Total	3956	10646

Notes: Total standing volume (10 cm top diameter underbark) of Sundri (dbh > 17 cm), Gewa (dbh > 12 cm) and Keora (> = 30 cm) of sound timber only.

Source: Chaffey, et. al. 1985 Forest Inventory of the Sundarbans, Bangladesh.

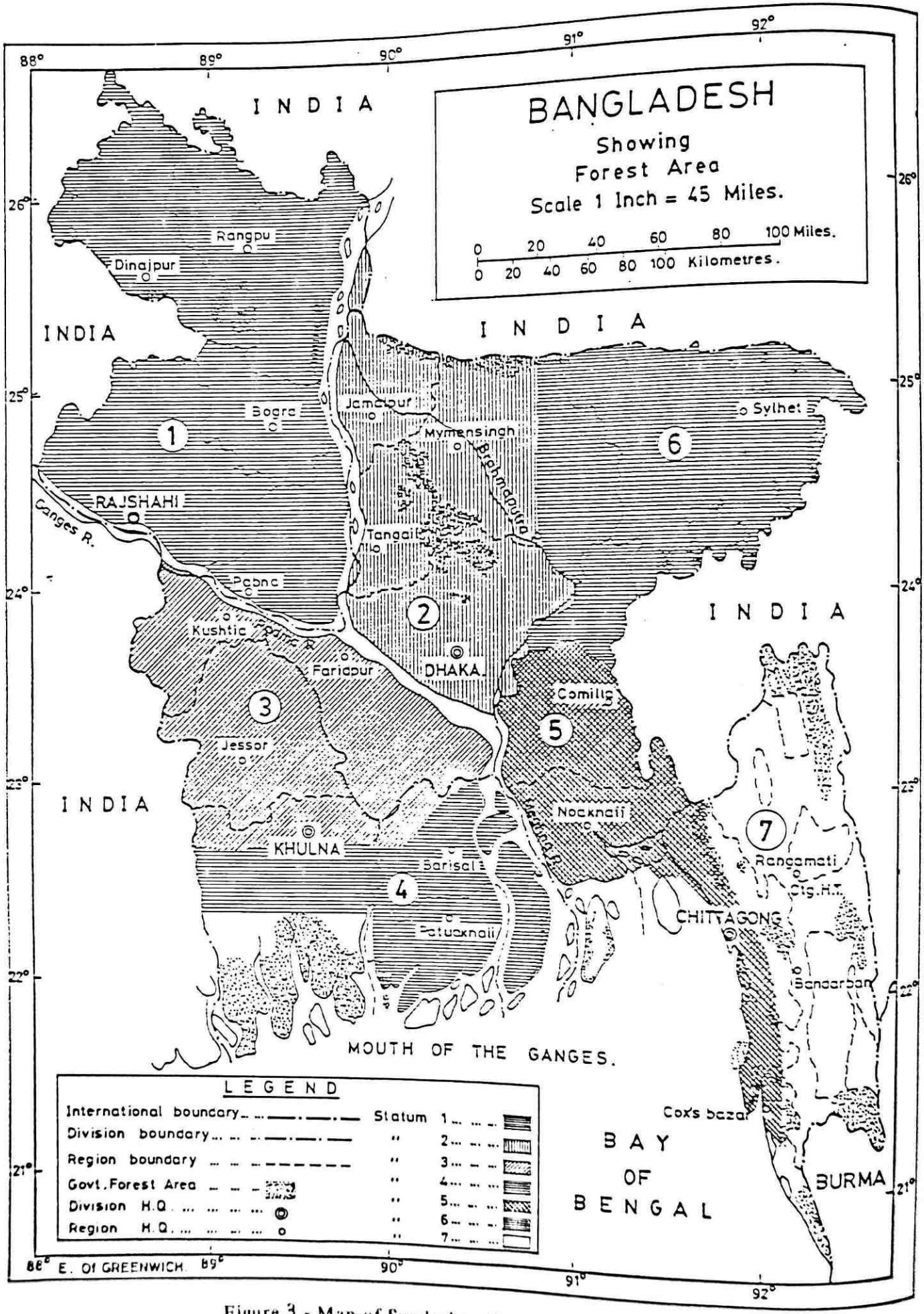

Figure 3 - Map of Sundarban Showing Salinity Zones

APPENDIX 3
PLANTATION AND THINNING PROGRAMMES

SILVICULTURE

APPENDIX 3
PLANTATION AND THINNING PROGRAMMES

TABLE OF CONTENTS

1. STATEMENT OF ANNUAL PLANTATION PROGRAMME

Table 1 - Statement of Area to be Planted up Annually in Hill Forests (Status Quo)

Rotation Year	MAI (m^3/ha)	Forest Reserve or Division	1993-98 Area	1998-03 Area	2003-08 Area	2008-13 Area
45	2.5	Kassalong NF	946	946	946	946
		Matamuhuri NF	358	358	358	358
		Chittagong NF	351	351	351	351
		Cox's Bazar NF	263	263	263	263
		Sylhet NF	61	61	61	61
		Kassalong P	216	259	320	978
		Raingkhiong P	143	119	211	551
		Sitapahar P	410	70	64	100
		Matamuhuri P	-	-	143	144
		Chittagong P	122	225	111	252
		Cox's Bazar P	133	168	302	310
		Sylhet P	190	77	222	332
		Jhum Control P				670
		Total Long Rotation Plantation	3193	2897	3352	5359
10	10	Chittagong SP	350	500	550	500
		Cox's Bazar SP	935	160	935	900
		Sylhet SP	60	600	500	500
		Bandarban SP	-	980	765	1000
		Kaptai SP	1000	1385	1240	1000
		Rangamati SP	-	215	155	200
		Total Short Rotation Plantation	2345	3840	4140	4100

Abbreviations:
NF - Natural Forests, P - Existing Plantations of long rotation.
SP - Plantations of Short rotation

Table 2 - Statement of Annual Planting Area in the Hill Forests (Scenario-I)

Rotation Year	MAI (m^3/ha)	Forest Reserve or Division	1993-98	1998-03	2003-08	2008-13
			Area	Area	Area	Area
40	7.5	Kassalong NF	1000	1000	1000	1000
		Matamuhuri NF	400	400	400	400
		Chittagong NF	395	395	395	395
		Cox's Bazar NF	295	295	295	295
		Sylhet NF	65	65	65	65
		Kassalong P	216	259	320	970
		Raingkhiong P	143	119	211	551
		Sitapahar P	480	70	64	100
		Matamuhuri P	-	-	143	144
		Chittagong P	122	225	111	252
		Cox's Bazar P	133	168	302	310
		Sylhet P	190	77	222	383
		Jhum Control P	-	-	-	670
		Total Long Rotation Plantation	3439	3073	3528	5535
20	12.5	Kassalong D	5000	5000	5000	5000
		Raingkhiong D				
		Matamuhuri D				
		Chittagong D	2500	2500	2500	2500
		Cox's Bazar D				
		Sylhet D				
		USF	2500	2500	2500	2500
		Total Medium Rotation Plantation	10000	10000	10000	10000
10	15	Chittagong SP	100	100	300	300
		Cox's Bazar SP	200	200	300	300
		Sylhet SP	100	100	200	200
		Bandarban SP	200	300	600	600
		Kaptai SP	300	400	800	800
		Rangamati SP	200	300	600	600
		Khagrachari SP	250	350	600	700
		Total Short Rotation	1350	1750	3400	3500

Abbreviations:
NF - Natural Forests, P - Existing Plantations of long rotation.
SP - Plantations of Short rotation, D - Denuded areas.

Table 3 - Annual Plantation Area in Hill Forest (Scenario 2)

Rotation Year	MAI (m^3/ha)	Forest Reserve or Division	1993-98 Area	1998-03 Area	2003-08 Area	2008-13 Area
30	20	Kassalong NF	500	500	500	500
		Kassalong P	475	1290	1050	844
		Raingkhiong P	260	762	992	1079
		Sitapahar P	480	165	66	10
		Matamuhuri P	143	286	287	144
		Chittagong P	458	675	130	661
		Cox's Bazar P	603	635	365	556
		Sylhet P	872	245	224	149
		Jhum Control P	672	-	752	675
		Total Long Rotation Plantation	4463	4558	4366	4618
20	30	Kassalong D	5000	5000	5000	5000
		Raingkhiong D				
		Matamuhuri D				
		Chittagong D	2500	2500	2500	2500
		Cox's Bazar D				
		Sylhet D				
		USF	2500	2500	2500	2500
		Total Medium Rotation Plantation	10000	10000	10000	10000
10	45	Chittagong SP	250	250	250	250
		Cox's Bazar SP	250	250	350	350
		Sylhet SP	250	250	500	500
		Bandarban SP	700	1000	1000	1000
		Kaptai SP	500	750	1000	1000
		Rangamati SP	250	250	250	250
		Total Short Rotation Plantation	2200	2750	3350	3350

Abbreviations:
NF - Natural Forests, P - Existing Plantations of long rotation, SP - Plantations of Short rotation, D - Denuded areas.

Table 4 - Annual Area of plantations in ha in Sal Forests under Participatory System on Encroached & Denuded Forest (Scenario-1 and 2)

Rotation in Years	MAI m^3	Forest Reserve or Division	1993-98 Area	1998-03 Area	2003-08 Area	2008-13 Area
6-8	15	Rajshahi Div.	84	84	84	84
		Rangpur Div.	48	48	48	48
		Dinajpur Div.	314	314	314	314
		Dhaka Div.	471	471	471	471
		Tangail Div.	1258	1258	1258	1258
		Mymensingh Div.	727	727	727	727
		Comilla Div.	84	84	84	84
Subtotal			2986	2986	2986	2986

Table 5 - Annual area of Enrichment Sal Plantation of Natural Poor Density Forests (Scenario-1 and 2)

Rotation in Years	MAI m^3	Forest Reserve or Division	1993-98 Area in ha	1998-03 Area in ha	2003-08 Area in ha	2008-13 Area in ha
20	12.5	Rajshahi Div.	-	-	-	-
		Rangpur Div.	10	-	-	-
		Dinajpur Div.	70	75	75	75
		Dhaka Div.	350	350	350	350
		Tangail Div.	500	500	500	500
		Mymensingh Div.	220	225	225	225
		Comilla Div.	-	-	-	-
Subtotal			1150	1150	1150	1150

Spacing: 1.85 x 1.85 m (6'x 6')

Table 6 - Replanting of Old Sal Plantation (Scenario-2)

Felling cycle in yrs	MAI m^3	Forest Reserve or Division	1993-98 Area	1998-03 Area	2003-08 Area	2008-13 Area
20	30	Rajshahi Div.	60	60	60	60
		Rangpur Div.	87	87	87	87
		Dinajpur Div.	112	112	112	112
		Dhaka Div.	154	154	154	154
		Tangail Div.	182	182	182	182
		Mymensingh Div.	455	455	455	455
		Comilla Div.	-	-	-	-
Subtotal			1050	1050	1050	1050

Spacing: 1.85 x 1.85 (6'x 6')

Table 7 - Annual Sal Plantation Area in ha in National Parks & Game Sanctuaries (Scenario-1 and 2)

Division	Name of Park/ Game Sanctuaries	1993-98 Area	1998-03 Area	2003-08 Area	2008-13 Area
Dhaka Div.	National Park, Bhowal	250	250	250	250
Tangail Div.	Madhupur National Park	399	399	399	399
Dinajpur Div.	Ramsagar National Park	1	1	1	1
Subtotal		650	650	650	650

Spacing: 2.775 x 2.775 or as required in the blanks.

Table 8 - Coastal Afforestation Annual Area Statement in ha (Status Quo) New Plantation 32900 ha, MAI 7.0 m^3

Name of the Division	1993-98	1998-2003	2003-08	2008-13	MAI	Rotation Years
Patuakhali Div.	110	110	110	110	7.0	25 (tentative)
Bhola Div.	200	200	200	200		
Noakhali Div.	885	885	885	885		
Chittagong Div.	450	450	450	450		
Subtotal	1645	1645	1645	1645		

Replanting at the rate of 910 ha/ year in 10 years time Period to complete the replanting of 9100 ha.

Table 9 - Coastal Afforestation Annual Area Statement in ha (Scenario 1 and 2)

Scenario-1: MAI 7.0 m^3 Rotation 25 years (tentative)					
Area-50,000 ha		1993-98	1998-03	2003-08	2008-13
	Patuakhali	200	200	200	200
	Bhola	110	110	110	110
	Noakhali	1740	1740	1740	1740
	Chittagong	450	450	450	450
Subtotal		2500	2500	2500	2500
Scenario-2: MAI 7.0 m^3 Rotation 25 years (tentative)					
Area-60,000 ha		1993-98	1998-03	2003-08	2008-13
	Patuakhali	200	200	200	200
	Bhola	110	110	110	110
	Noakhali	2240	2240	2240	2240
	Chittagong	450	450	450	450
Subtotal		3000	3000	3000	3000

There will not any change in MAI or yield under the different scenarios except the increase in plantation areas from Status quo to Scenario-1 and Scenario-2.

It is very important to decide the future of the plantation as well as the future of land stability and introduction of other species. It may be emphasised that the land can never stabilize in 25 years time. Plantation area under scenario-2, can be increased, if, in the meantime, more accretions take place.

2. EXISTING PLANTATIONS

Under Scenario 1 and 2 thinning for existing plantations will be as of new plantations.

3. NEW PLANTATION

Thinning, Rotation, MAI and per Tree Volume under Different Scenarios

Table 10 - Status Quo MAI = 2.5 m^3; Rotation 45 years

Species andNo. of Plants	Year of Thinning	No of Trees Remaining	No of Trees Removed	Average Vol per tree
Teak - 3,000	5th	1,500	1,500	-
	20th	450	1,150	0.06
	45th	-	450	0.18
Other - 1,370	10th	-	-	-
	20th	500	730	0.5
	45th	-	600	0.13
Pulp-wood MAI - 10 m^3 - No thinning				

Table 11 - Scenario-I, MAI 7.5 m^3; Rotation 40 years

Species and No. of Plants	Year of Thinning	No of Trees Remaining	No of Trees Removed	Average Vol per tree
Teak - 3,000	5th	1,500	1,500	-
	10th	750	750	0.09
	20th	350	400	0.20
	30th	200	150	0.40
	40th	-	200	0.60
Other - 1,370	10th	900	470	0.06
	20th	600	300	0.15
	30th	300	300	0.25
	40th	-	300	0.40

Table 12 - Scenario-I MAI 12.5 m^3; Rotation 20 years

Species and No. of Plants	Year of Thinning	No of Trees Remaining	No of Trees Removed	Average Vol per tree
Teak - 3,000	5th	1,500	1,500	-
	10th	800	700	0.10
	15th	500	300	0.18
	20th	-	500	0.26
Other - 1,370	10th	900	470	0.10
	15th	500	400	0.17
	20th	-	500	0.24
Pulp-wood MAI - 15 m^3; Rotation 10 years - No thinning				

Table 13 - Scenario-2 MAI 20 m^3; Rotation 30 years

Species and No. of Plants	Year of Thinning	No of Trees Remaining	No of Trees Removed	Average Vol per tree
Teak - 3,000	5th	1,500	1,500	-
	10th	750	750	0.19
	15th	350	400	0.50
	20th	200	150	0.94
	30th	-	200	1.20
Other - 1,370	10th	900	470	0.12
	15th	600	300	0.25
	20th	300	300	0.50
	30th	-	300	1.06

Table 14 - Scenario 2, MAI 30 m^3; Rotation 20 years

Species and No. of Plants	Year of Thinning	No of Trees Remaining	No of Trees Removed	Average Vol per tree
Teak - 3000	5th	1,500	1,500	-
	10th	750	750	0.18
	15th	300	450	0.50
	20th	-	300	0.80
Other - 1,370	10th	900	470	0.12
	15th	500	400	0.25
	20th	-	500	0.70
Pulp-wood MAI - 45 m^3; Rotation 10 years				

Table 15 - Scenario-I Sal Enrichment Plantation, MAI - 12.5 m^3

Species	Spacing	Year of Thinning	No of Trees Remaining	No of Trees Removed	Average Vol per Tree
Sal	1.85 x 1.85m	5th	1,500	1,500	0.04 (fuel)
	(6' x 6')	10th	800	700	0.10
		15th	500	300	0.18
		20th	60	440	0.26
Replanting of old plantations					
Sal	1.85 x 1.85m	5th	1,500	1,500	0.04 (fuel)
	(6' x 6')	10th	800	700	0.10
		15th	500	300	0.18
		20th	60	440	0.26

Table 16 - Scenario-2 MAI - 30 m^3; Felling cycle 20 years

Species	Spacing	Year of Thinning	No of Trees Remaining	No of Trees Removed	Average Vol per Tree
Sal	1.85 x 1.85m	5th	1,500	1,500	0.06 (fuel)
	(6' x 6')	10th	800	700	0.10
		15th	500	300	0.35
		20th	60	440	0.60

APPENDIX 4
ROUNDWOOD SUPPLY AND DEMAND

SILVICULTURE

APPENDIX 4
ROUNDWOOD SUPPLY AND DEMAND

Table 1 - Status Quo Potential Wood Supply by Source and Demand (000 m^3/A)

Item	Source*	1993	1998	2003	2008	2013
Sawlog	Natural	381	386	391	401	421
	Long Rot Pl	93	93	82	137	262
	Med Rot Pl	-	-	13	19	26
	PP	6	6	6	10	10
	Village Forest	745	819	901	991	1090
	USF	60	50	40	30	20
	Total Supply	1285	1354	1433	1588	1829
	Demand	4686	5148	5613	6109	6639
Pulpwood	Natural	133	133	133	133	133
	Long Rot Pl					
	Short Rot Pl	151	211	345	367	385
	PP					
	USF					
	Total Supply	284	344	478	500	518
	Demand	257	321	377	441	505
Poles	Natural	41	41	41	41	41
	Long Rot Pl	31	31	28	46	87
	Med Rot Pl	-	-	-	25	27
	PP	76	76	76	100	139
	USF	6	5	4	3	2
	Village Forest					
	Total Supply	154	153	149	215	296
	Demand	267	285	299	313	328
Fuelwood	Natural	193	196	200	206	211
	Long Rot Pl	22	30	25	24	54
	Med Rot Pl	44	50	49	320	480
	PP	124	123	124	159	221
	USF	1825	1725	1625	1525	1425
	Village Forest	3971	4370	4806	5288	5817
	Total Supply	6179	6494	6829	7522	9208
	Demand	8272	9045	9847	10682	11553
All Kinds	Natural	748	756	765	781	806
	Long Rot Pl	146	154	135	207	403
	Med. Rot Pl	44	50	62	364	533
	Short Rot Pl	151	211	345	367	385
	PP	206	205	206	269	370
	USF	1891	1780	1669	1558	1447
	Village Forest	4716	5189	5707	6279	6907
	Total Supply	7902	8345	8889	9825	10851
	Demand	13482	14799	16139	17545	19025

* PP - Public Programme. Strip Plantation, Agroforestry, Wood Lot and Khet Land. Break down of the yields under PP are in table 15. USF - Unclassed State Forest

Table 2 - Status Quo Yield from Public Programmes (m^3/A)

Item/Source	1993	1998	2003	2008	2013
Sawlog					
Strip	6,000	7,200	8,400	9,600	9,600
Agroforestry	-	-	-	-	-
Woodlot	-	-	-	-	-
Private Homestead	745,000	819,000	901,000	991,000	1,090,000
Total	751,000	826,200	909,400	1,000,600	1,099,600
Pole					
Strip	28,080	28,080	28,080	48,880	48,880
Agroforestry	8,000	8,000	8,000	10,400	10,400
Woodlot	40,000	40,000	40,000	40,000	80,000
Private Homestead	-	-	-	-	-
Total	76,080	76,080	76,080	99,280	139,280
Fuelwood					
Strip	51,120	51,120	52,920	84,120	85,920
Agroforestry	12,000	12,000	12,000	15,600	15,600
Woodlot	60,000	60,000	60,000	60,000	120,000
Private Homestead	3,971,000	4,370,000	4,806,000	5,288,000	5,817,000
Total	4,094,120	4,493,120	4,930,920	5,447,720	6,038,520
Total, All Sources	4,915,200	5,395,400	5,916,400	6,547,600	7,277,400

Table 3 - Scenario 1 Potential Wood Supply by Source and Demand (000 m^3/ A)

Item	Source*	1993	1998	2003	2008	2013
Sawlog	Natural	381	386	391	401	421
	Long Rot Pl	121	122	191	191	163
	Med Rot Pl	5	10	14	19	926
	PP	6	5	7	8	11
	Village Forest	745	820	901	1090	1198
	USF	60	50	40	30	20
	Total Supply	1318	1393	1544	1739	2739
	Demand	4934	5427	5970	6567	7223
Pulpwood	Natural	133	133	133	133	133
	Long Rot Pl					
	Short Rot Pl	160	260	495	515	522
	PP					
	Village Forest					
	USF					
	Total Supply	293	393	628	648	655
	Demand	280	408	508	615	723
Poles	Natural	41	41	41	41	41
	Long Rot Pl	37	38	35	55	98
	Med Rot Pl	19	19	18	160	233
	PP	76	76	147	224	456
	Village Forest	-	-	-	-	-
	USF	6	5	4	3	2
	Total Supply	179	179	245	483	830
	Demand	267	285	299	313	328
Fuelwood	Natural	193	196	200	206	211
	Long Rot Pl	22	30	25	24	54
	Med Rot Pl	23	54	153	448	830
	PP	196	195	280	321	644
	Village Forest	3983	4385	5166	6030	6890
	USF	1825	1725	1625	1525	1425
	Total Supply	6242	6585	7449	8554	10054
	Demand	8166	7699	7637	7969	8445
All Kinds	Natural	748	756	765	781	806
	Long Rot Pl	180	190	251	270	315
	Med Rot Pl	47	83	185	627	1989
	Short Rot Pl	160	260	495	515	522
	PP	278	276	434	553	1111
	Village Forest	4728	5202	6067	7120	8088
	USF	1891	1780	1669	1558	1447
	Total	8032	8550	9866	11435	14278
	Demand	13647	13819	14414	15464	16719

* PP - Public Programme: Strip Plantation, Agroforestry, Wood Lot and Khet Land, Break down of the yields from Pp are in table 18. USF - Unclassed State Forest

Table 4 - Scenario 1 Yields from Public Programmes

Item/Source	1993	1998	2003	2008	2013
Sawlog					
Strip	6,000	7,200	8,400	9,600	9,600
Agroforestry	-	-	-	-	-
Woodlot	-	-	-	-	-
Private Homestead.	745,000	820,000	901,000	1,090,000	1,198,000
Total	751,000	827,200	909,400	1,099,600	12,076,000
Pole					
Strip	28,080	28,080	101,980	101,980	155,080
Agroforestry	8,000	8,000	21,560	21,760	41,120
Woodlot	40,000	40,000	100,000	200,000	260,000
Private Homestead	-	-	-	-	-
Total	76,080	76,080	223,940	323,740	456,200
Fuelwood					
Strip	51,120	52,920	137,221	139,035	192,120
Agroforestry	24,000	24,000	32,640	32,640	61,680
Woodlot	120,000	120,000	150,000	300,000	390,000
Private Homestead	3,983,000	4,385,000	5,166,000	6,030,000	6,890,000
Total	4,178,120	4,581,920	5,485,861	6,501,675	7,533,800
Total, All Sources	5,005,200	5,484,400	6,619,201	7,925,015	9,197,600

Table 5 - Scenario 2 Potential Wood Supply by Source and Demand (000 m^3/ A)

Item	Source	1993	1998	2003	2008	2013
Sawlog	Natural	270	280	294	315	348
	Long Rot Pl	317	341	380	460	459
	Med Rot Pl	10	10	14	19	2726
	PP	19	17	46	58	141
	Village Forest	745	820	901	1136	2190
	USF	60	50	40	30	20
	Total Supply	1421	1518	1675	2018	5884
	Demand	5146	7666	10185	12704	15223
Pulpwood	Natural	133	133	133	133	133
	Long Rot Pl	-	-	-	-	-
	Short Rot Pl	160	270	989	1237	1507
	PP					
	Village Forest					
	USF					
	Total Supply	293	270	1122	1370	1640
	Demand	462	688	929	1178	1449
Poles	Natural	30	30	30	30	30
	Long Rot Pl	37	46	55	72	135
	Med Rot Pl	19	19	18	200	304
	PP	76	76	800	1748	2583
	Village Forest	-	-	-	-	-
	USF	6	4	4	3	2
	Total Supply	168	175	907	2053	3054
	Demand	267	285	329	345	379
Fuelwood	Natural	120	122	127	133	138
	Long Rot Pl	27	27	30	29	39
	Med Rot Pl*	44	314	621	1058	1836
	PP	123	123	1128	1163	3684
	Village Forest	3983	4385	5700	7050	7950
	USF	1825	1725	1625	1525	1425
	Total Supply	6122	6696	9231	10958	15072
	Demand	9625	10798	12203	14036	15072
All Kinds	Natural	553	565	584	611	649
	Long Rot Pl	381	414	465	561	633
	Med Rot Pl	73	343	653	1277	4866
	Short Rot Pl	160	270	989	1237	1507
	PP	218	216	1974	2969	6408
	Village Forest	4728	5205	6601	8186	10140
	USF	1891	1779	1669	1558	1447
	Total Supply	8004	8792	12935	16399	25650
	Demand	15500	19437	23646	28263	32175

* PP - Public Programme: Strip Plantation, Agroforestry, Wood Lot and Khet Land, Break down of the yields from PP are in Table 21. USF - Unclassed State Forest

* coastal afforestation programmes.

Table 6 - Scenario 2 Yields from Public Programmes

Item/Source	1993	1998	2003	2008	2013
Sawlog					
Strip	6,000	7,200	14,169	25,369	107,583
Agroforestry	-	-	-	-	-
Woodlot	-	-	-	-	-
Private Homestead	745,000	820,000	901,000	1,136,000	2,190,000
Total	751,000	827,200	915,169	1,161,369	2,297,583
Pole					
Strip	28,080	28,080	346,880	859,857	1,350,909
Agroforestry	8,000	8,000	87,800	319,928	53,594
Woodlot	40,000	40,000	220,000	440,310	702,540
Private Homestead	-	-	-	-	-
Total	76,080	76,080	823,480	9,528,651	2,584,898
Fuelwood					
Strip	51,120	83,970	532.890	1,191,850	1,749,120
Agroforestry	12,000	12,000	131,700	480,000	596,100
Woodlot	60,000	60,000	330,000	660,000	930,000
Private Homestead	3,983,000	4,385,000	5,700.000	7,050.000	7,950,000
Total	4,106,120	4,540,970	6,863,340	9,550,600	11,633,970
Total, All Sources	4,933,200	5,444,250	8,601,989	11,664,620	16,516,451

APPENDIX 5
PLANTATION METHODS AND COSTS

PROJECT 372001/20
FORESTRY MASTER PLAN
BANGLADESH TA 1355-BAN

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: JANUARY 1993

SILVICULTURE

APPENDIX 5
PLANTATION METHODS AND COSTS

TABLE OF CONTENTS

1. STATUS QUO PROGRAMMES

1a. Long Rotation

Rotation: 45 yrs

Teak and Jarul: 5 bed for 1 hectare
Stump (Root shoot cutting)

No of seedling required 3000 nos/ ha - Teak
7000 nos/ ha - Jarul

Nursery

Raising of Nursery, maintenance of previous year nursery for current year planting, Beating up to current year plantation in the following year and maintenance of previous year nursery for current year vacancy filling — Tk.1,800.00

Plantation Raising

No of plants required = 6' x 6' = 1.85 x 1.85 m

Teak and Jarul:
Teak 3000 nos stumps/ ha; Jarul - 7000 nos.

a. Teak plantation raising (per ha) spacing 6'x6' (1.85 x 1.85 m) including survey, layout, site preparation, fire breaks, fertilizer etc. — Tk. 4,000.00
Labour cost: 3550.00
Material cost: 450.00

b. Beating up of planting with Teak stump 1 year old plantation (20% = 600 nos.) — Tk. 200.00
Labour cost: 175.00
Material cost: 25.00

4,200.00
say 4,500.00

Maintenance of Plantation per ha

a. Weeding & cleaning (3 nos) 1 yr old plantation: (per hectare Tk.750.00) — Tk. 2,250.00
b. Weeding & cleaning (3 nos) 2 yrs old plantation: — 2,250.00
c. Weeding & cleaning (1 no) 3 yrs old plantation: — 750.00
d. Double steam, climber cutting in the 4th year per ha: — 1,500.00

6,750.00

Rotation 45 yrs

Poly bags

Spacing: 2.775 x 2.775 m - 1370 nos. of seedling/ ha.

Poly bag size 25.4 x 15.25 cm

a. Raising of nursery in polybags for the following years plantation including fertilizer — Tk. 3,460.00
Labour cost : 2,450.00
Material cost: 1,010.00

b. Maintenance of previous year poly nursery for current year - Planting, labour — 250.00

c. Raising of polybags nursery for beating up current year plantation (20%) — 700.00
Labour cost : 500.00
Material cost: 200.00

d. Maintenance of previous years polybags for vacancy filling (20%) during the current year; Labour — 50.00

4,460.00

Polybags (per ha)

Plantation with polybags seedlings including survey, layout, site preparation, pit digging (30.5 x 30.5 x 30.5 cm) fire breaks, fertilizer applications, spacing 2.75 x 2.75 x 2.75 m — Tk. 6,225.00

Labour cost : 5,525.00
Material cost: 700.00

Maintenance of Plantation

a.	Weeding & cleaning (3 nos) 1 yr old plantation	Tk. 2,250.00	
b.	Weeding & cleaning (3 nos) 2 yrs old plantation	2,250.00	
c.	Weeding & cleaning (1 no) 3rd old plantation	750.00	
d.	Double stem & climber in 4th year		750.00
			6,000.00

1b. Short Rotation Plantation

Rotation: 10 yrs

Seedling will be raised in polybags, size of polybag (2.54 cm x 15.25 cm)

Raising of seedlings in poly bag for 9' x 9' (2.775 x 2.775 m) — No 1370 seedlings per ha

Labour cost : 3,250.00
Material cost: 1,627.00

Tk. 4,875.00

(Raising Nursery & its maintenance)

Plantation Raising

Plantation raising 9' x 9' (2.775 x 2.775 m) including survey, layout, site preparation, fire breaks, fertilizers etc.

Labour cost : 6,175.00
Material cost: 750.00

Tk. 6,925.00

Maintenance

a.	Weeding & cleaning 1st year (3 weeding)	Tk. 2,250.00
b.	Weeding & cleaning 2nd year (3 weeding)	2,250.00
c.	Weeding & cleaning 3rd year (1 weeding)	750.00
		Total : 5,250.00

1c. Coastal Plantation

a.	Nursery raising (5 bed per ha)	Labour cost: 155.00 Material cost: 15.00 Unit cost: 170.00	Tk. 850.00
b.	1st yr. vacancy filling in 1st year 1st yr old plantation 1.3 bed/ha.	Unit cost: 170.00	221.00
c.	2nd yr. nursery vacancy felling 1.3 bed/ha.	Unit cost: 170.00	221.00
d.	3rd yr. vacancy felling 1.3 bed/ha	Unit cost: 170.00	221.00
			Sub-total: 1,513.00

Plantation Raising

No of seedlings = sav 4,350 nos

a.	Plantation raising including survey, demarkation by fixing RCC pillars (spacing 1.5 x 1.5m)	Labour cost: 1875.00 Material cost: 125.00	Tk. 2,000.00
b.	Replanting of vacancies in Keora & Bean plantation during the planting year		Tk. 600.00

c. Beating up of Keora & Bean plantation (for the needed area only)

i)	1st year old plantation	600.00	Total Tk. 600.00
ii)	2nd year old plantation	600.00	Total Tk. 600.00
iii)	3rd year old plantation	600.00	Total Tk. 600.00
			Total Tk. 4,400.00

1d. Enrichment Plantation in Sal Forests

Nursery raising cost

For Sal = Tk. 3.00 per seedlings
Other spp = Tk. 2.00 per seedlings
Per ha. cost = Tk. 9,000.00 for Sal
Other spp = Tk. 6,000 per ha

It includes raising, maintenance of seedling in one year etc.

For Plantation

No of Seedling per ha. required 6' x 6' (1.85 x 1.85 m)
spacing = 3,000 no of seedling per ha.

For Sal

Plantation with Sal poly bags seedlings including survey, layout, site preparation, Pit digging (30.5 x 30.5 x 30.5 cm), fertilizer etc.
Spacing: 1.85 m x 1.85 m
(No of seedings = 3000/ ha) Tk. 5,000.00

Labour cost: 4,438.00
Material cost: 562.00

For Other Species

Plantation with other than Sal in polybags including survey, layout, site preparation, Pit digging (30.5 x 30.5 x 30.5 cm), fertilizer etc. Tk. 5,000.00

Spacing (1.85 x 1.85m), No of seedling = Tk. 3,000.00
Cost = Tk. 5,000.00

Maintenance

a. Weeding & cleaning of 1st yr old plantation = (3 nos.) Tk. 2,250.00
b. Weeding & cleaning 2nd yr old plantation = (2 nos.) 1,500.00
c. Weeding & cleaning 3rd yr old plantation = (1 no.) 750.00
Tk. 4,500.00

2. SCENARIO 1 PLANTATION PROGRAMME

2a. Long Rotation Teak and Jarul

Rotation: 40 yrs

Nursery: 5 bed for 1 Hectare

No of seedlings: 3000 nos/ ha

Stump

Raising of Nursery, maintenance of previous year nursery for current year planting. Beating up of current year plantation is the following year and maintenance of previous year nursery for current year vacancy filling.

Labour cost = Tk. 2,000.00
Material cost = Tk. 300.00
Tk. 2,300.00

Plantation Raising

Spacing 6' x 6' (1.85 x 1.85m)

No of stumps required: 3000 nos.

a. Teak plantation raising (per ha) spacing 6'x6' (1.85 x 1.85m), including survey layout, site preparation, fire breaks, fertilizer applications etc.

Labour cost = Tk. 4,438.00
Material cost = Tk. 562.00
Tk. 5,000.00

b. Beating up with Teak stump 1 year old plantations (20% = 600 nos.)

Labour cost = Tk. 220
Material cost = Tk. 30
250.00
Total = Tk. 5,250.00
say = 5,500.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (3 nos) 1 yr old plantations	Tk.2,850.00	
b.	Weeding and cleaning (3 nos) 2 yrs old plantation	2,850.00	
c.	Weeding and cleaning (2 nos) 3 yrs old plantation	1,900.00	
d.	Double stem, climber cutting in the 4th year per hectare		1,875.00
			Sub-total = Tk. 9,475.00
e.	Fertilizer application in 3rd year	Labour cost =	Tk. 330.00
		Material cost =	Tk. 400.00
			730.00
			Total Tk.10,205.00

Plantation raising & maintenance
Grand Total = 18,000.00

Thinning Programme

a.	1st Thinning 5/ 6 year old Teak plantation		Tk. 2,225.00
		Labour cost =	Tk. 2,160.00
		Material cost =	Tk. 65.00
b.	2nd Thinning at the age of 10/ 12th year		Tk. 2,225.00
		Labour cost =	Tk. 2,160.00
		Material cost =	Tk. 65.00
c.	3rd Thinning at the age of 20/ 22th year		Tk. 2,000.00
		Labour cost =	Tk. 1,950.00
		Material cost =	Tk. 50.00
d.	4th Thinning at the age of 30/ 32th year (onlt marking)		Tk. 1,500.00
		Labour cost =	Tk. 1,450.00
		Material cost =	Tk. 50.00
			Sub-total = Tk. 6850.00

2b. Long Rotation Other Species

Poly bags; Spacing: 9'x 9'(2.75 x 2.75m) = 1,370 no seedlings/ hectare

Nursery

Polybag size: 25.4 x 15.25 cm

a.	Raising of Nursery in Polybags for the following year plantation including fertilizer, maintenance of previous year polybags for current year planting, raising of seedlings for beating up current year plantation (20%), and maintenance of previous year polybags for vacancy filling (20%)		
		Labour cost =	Tk. 4,365.00
		Material cost =	Tk. 1,210.00
			Tk. 5,575.00

Plantation

a.	Plantation with polybag seedling of 1 year old including survey, layout, site preparation, Pit digging (30.5 x 30.5 x 30.5 cm), fire breaks, inspection paths, fertilizer application etc. at spacing 2.75 x 2.75 m.		
		Labour cost =	Tk. 6,900.00
		Material cost =	Tk. 900.00
		including fertilizer	Tk. 7,800.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (3 nos) 1 yr old plantations	Tk.2,850.00	
b.	Weeding and cleaning (3 nos) 2 yrs old plantation	2,850.00	
c.	Weeding and cleaning (2 nos) 3 yrs old plantation	1,900.00	
d.	Double stem, climber cutting in the 4th year per hectare		1,875.00
			Total = Tk. 9,475.00

Fertilizer application

Fertilizer application at the 3rd year

Labour cost =		Tk. 730.00
Material cost =		Tk. 330.00
		Tk. 400.00

Thinning programme

a.	1st Thinning at the age of 10/ 12 yrs	2,000.00	
b.	2nd Thinning at the age of 20/ 22 yrs	2,000.00	
c.	3rd Thinning at the age of 30/ 32 yrs	1,500.00	
		Total = Tk. 5,500.00	

2c. Medium Rotation

Rotation = 20 yrs

Teak and Jarul: Stump

No of seedlings = 3,000 nos. 5 beds/ ha

Raising of Nursery, maintenance of previous year nursery for current year planting, Beating up of current year plantation in the following year and maintenance of previous year nursery of current year vacancy filling

Labour cost =	2,000.00
Material cost =	300.00
	Tk. 2,300.00

Plantation Raising

Spacing 6' x 6' (1.85 x 1.85 m); No of stumps required = 3,000 ha

a. Teak plantation raising (per ha) spacing 6' x 6' (1.85 x 1.85 m), including survey, layout, site preparation, fire breaks, fertilizer applications etc.

Labour cost =	4,438.00
Material cost =	562.00
	Tk. 5,000.00

b. Beating up with Teak stump, 1 yr, old plantation (20% = 600 nos)

Labour cost =	220.00
Material cost =	30.00
	250.00
Total =	Tk. 5,250.00
	say 5,500.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (3 nos) 1 yr old plantations	Tk.2,850.00
b.	Weeding and cleaning (3 nos) 2 yrs old plantation	2,850.00
c.	Weeding and cleaning (2 nos) 3 yrs old plantation	1,900.00
d.	Double stem, climber cutting in the 4th year per hectare	1,875.00
e.	Fertilizer application in 3rd year	

Labour cost =	Tk. 400.00
Material cost =	Tk. 500.00
	900.00
	Total Tk.10,375.00

Thinning

a.	1st Thinning at the age of 5th year	
b.	2nd Thinning at the age of 10th year	2,225.00
c.	3rd Thinning at the age of 15th year	2,225.00
		1,000.00
		Total = Tk. 5,450.00

2d. Medium Rotation Other Species

MAI = 15 m^3
5 Bed/ Hectare

Polybag size: 25.4 x 15.25 cm

Spacing: 9' x 9' (2.775 x 2.775 m)
No of seedling required: 1370 nos

a. Raising of Nursery, polybags for the following year plantation including fertilizer, maintenance of previous year polybags for current year planting, Bering of seedlings for beating up current year plantation (20%), and maintenance of previous year polybags for vacancy filling (20%)

Labour cost =	4,365.00
Material cost =	1,210.00
	Tk. 5,575.00

b. Raising of plantation with polybag seedlings of 1 yr. old including survey, layout, site preparation, Pit digging, (30.5 x 30.5 x 30.5 cm), fire breaks, inspection paths, fertilizer application etc. at spacing 2.775 x 2.775 m

Labour cost =	6,900.00
Material cost = including fertilizer	900.00
	Tk. 7,800.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (3 nos) 1 yr old plantations	Tk.2,850.00	
b.	Weeding and cleaning (3 nos) 2 yrs old plantation	2,850.00	
c.	Weeding and cleaning (2 nos) 3 yrs old plantation	1,900.00	
d.	Double stem, climber cutting in the 4th year per hectare		1,875.00
e.	Fertilizer application on 3rd year		

Labour cost =	Tk. 400.00
Material cost =	Tk. 500.00
	900.00
Grand Total =	Tk.10,375.00

Thinning Programme

a.	1st Thinning at the age of 10th year	Tk. 2,225.00
b.	2nd Thinning at the age of 15th year	Tk. 1,000.00
		Total = Tk. 3,225.00

2e. Short Rotation

Rotation = 10 yrs

Spacing: 9' x 9' (2.775 x 2.775 m)
No of seedling required: 1370 nos

No of seedling 1370 nos per hectare

Nursery

a. Raising of Nursery in Polybags for the following year plantation including fertilizer, maintenance of previous year polybags for current year planting, raising of seedlings for beating up current year plantation (20%), and maintenance of previous year polybags for vacancy filling (20%)

Labour cost =	Tk. 4,365.00
Material cost =	Tk. 1,210.00
	Tk. 5,575.00

Plantation

a. Plantation with polybag seedling of 1 year old including survey, layout, site preparation, Pit digging (30.5 x 30.5 x 30.5 cm), fire breaks, inspection paths, fertilizer application etc. at spacing 2.75 x 2.75 m. No of seedling required per hectare 1370 nos.

Labour cost =	Tk. 6,900.00
Material cost = including fertilizer	900.00
	Tk. 7,800.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (3 nos) 1 yr old plantations	Tk.2,850.00
b.	Weeding and cleaning (3 nos) 2 yrs old plantation	2,850.00
c.	Weeding and cleaning (2 nos) 3 yrs old plantation	1,900.00
d.	Fertilizer application at 3rd yrs	

Labour cost =	Tk. 400.00
Material cost =	500.00
	900.00

e. Double stem, climber cutting and cleaning (1 no.) — 1,875.00

Total = Tk.10,375.00

2f. Enrichment Plantation

Rotation: 20 yrs (Felling cycle)

Nursery Cost for Enrichment Plantation

a. For Sal seedlings = Taka 3.75 per seedlings
b. Other Species = Taka 2.50 per seedlings

Plantation Raising

Spacing 6' x 6' (1.775 x 1.775 m)
No of seedling required = 3,000 nos.

a. Plantation with Sal polybags, including survey, layout, site preparation, Pit digging (30.5 x 30.5 x 30.5 cm), fertilizers etc.; Spacing = 1.775 x 1.775 m

Labour cost = Tk. 5,548.00
Material cost = Tk. 702.00
Tk. 6,250.00

Maintenance of Plantation per hectare

a. Weeding and cleaning (3 nos) 1 yr old plantations — Tk.2,850.00
b. Weeding and cleaning (3 nos) 2 yrs old plantation — 2,850.00
c. Weeding and cleaning (2 nos) 3 yrs old plantation — 1,900.00

Tk. 7,600.00

Thinning Programme

a. 1st Thinning at the age of 5th year

Tk. 2,225.00
Labour cost = Tk. 2,160.00
Material cost = Tk. 65.00

b. 2nd Thinning at the age of 10th year

Tk. 2,225.00
Labour cost = Tk. 2,160.00
Material cost = Tk. 65.00

c. 3rd Thinning at the age of 15th year

Tk. 2,000.00
Labour cost = Tk. 1,950.00
Material cost = Tk. 50.00

Total = Tk. 6450.00

2g. Coastal Afforestation

Keora & Baen

Spacing 5' x 5' (1.5 x 1.5m)
No of seedlings = 4350 nos.
say 4500 nos.

Nursery Raising

a. 5 bed per hectare (Unit cost: Tk.213.00 x 5) — Tk. 1,065.00

Labour cost = Tk. 194.00
Material cost = 19.00

b. 1st yr vacancy filling in 1 yr old plantation (1.3 bed) — 277.00

c. 2nd yr vacancy filling in 2nd yrs old plantation (1.3 bed) — 277.00

d. 3rd yr vacancy filling in 3rd yrs old plantation (1.3 bed) — 277.00

Tk. 1,896.00
say Tk. 1,900.00

Plantation raising

a. Plantation raising including survey, demarkation by fixing RCC Pillars etc. (spacing 1.5 x 1.5 m) — Tk. 2,500.00

Labour cost = Tk. 2,344.00
Material cost = 156.00

b. Repeating of vacancies in Keora & Bean plantation during the planting year (needed area) — 750.00

c. Beating up of Keora & Bean plantation (for the needed area only)

i)	1 yr old plantation 750.00;	Total =	750.00
ii)	2 yrs old plantation 750.00;	Total =	750.00
iii)	3 yrs old plantation 750.00;	Total =	750.00
			3,000.00

Total per hectare cost = Tk. 7,400.00

3. SCENARIO 2 PLANTATION PROGRAMMES

3a. Long Rotation Teak and Jarul

Teak = 6'x 6' (1.85 x 1.85m) Rotation: 30 years
Jarul = 4' x 4'(1.22 x 1.22m)

Raising

Raising of Nursery, maintenance of previous year nursery for current year planting. Beating up of current year plantation is the following year and maintenance of previous year nursery for current year vacancy filling.

Labour cost =	Tk.	2,600.00
Material cost =	Tk.	400.00
	Tk.	3,000.00

Plantation Raising

Spacing 6' x 6' (1.85 x 1.85m) — No of Teak stumps required: 3000 nos. Jarul: 6800 nos.

a. Teak plantation raising (per ha) including survey layout, site preparation, fire breaks, fertilizer applications etc.

Labour cost = Tk. 5,770.00
Material cost = Tk. 730.00

Tk.6,500.00

b. Beating up with Teak/Jarul stump 1 year old plantations (20% = 600 nos.) — 325.00

Total = Tk. 6,825.00
say = 7,000.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (4 nos) 1 yr old plantations	Tk.	4,940.00
b.	Weeding and cleaning (3 nos) 2 yrs old plantation		3,705.00
c.	Weeding and cleaning (2 nos) 3 yrs old plantation		2,470.00
d.	Application of fertilizer (1 no) 3 yrs		950.00
	Labour cost = Tk.430.00		
	Material cost = 520.00		
e.	Double stem, climber cutting in the 4th year per hectare		2,440.00

Total = Tk. 14,505.00
say Tk. 14,500.00

Thinning Programme

a.	1st Thinning at the age of 5th years =	Tk. 2,892.00
b.	2nd Thinning at the age of 10th year =	Tk. 2,892.00
c.	3rd Thinning at the age of 15th year =	Tk. 2,600.00
d.	4th Thinning at the age of 20th year =	Tk. 520.00

Total = Tk. 8,904.00
say Tk. 8,900.00

3b. Long Rotation

Poly bags; Spacing: 9'x 9'(2.775 x 2.775m) = 1,370 no seedlings/ hectare
Rotation: 30 yrs

a. Raising of Nursery in Polybags for the following year plantation including fertilizer, maintenance of previous year polybags for current year planting, raising of seedlings for beating up current year plantation (20%), and maintenance of previous year polybags for vacancy filling (20%)

Labour cost = Tk. 5,675.00
Material cost = Tk. 1,575.00

Tk. 7,250.00

Plantation

a. Plantation with polybag seedling of 1 year old including survey, layout, site preparation, Pit digging fire breaks, inspection paths, fertilizer application etc. at spacing 2.775 x 2.775 m.

Labour cost = Tk. 8,970.00
Material cost = 1,170.00

Tk. 10,140.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (4 nos) 1 yr old plantations	Tk.	4,940.00
b.	Weeding and cleaning (3 nos) 2 yrs old plantation		3,705.00
c.	Weeding and cleaning (2 nos) 3 yrs old plantation		2,470.00
d.	Application of fertilizer at the age of 3 yrs (1 nos.)		950.00
	Labour cost =	Tk.	430.00
	Material cost =		520.00
e.	Double stem, climber cutting in the 4th year per hectare		2,440.00

Total = Tk.14,505.00
say 14,500.00

Thinning programme

a.	1st Thinning at the age of 10 yrs =	2,892.00
b.	2nd Thinning at the age of 15 yrs =	2,892.00
c.	3rd Thinning at the age of 20 yrs	520.00

Total = Tk. 6,304.00
say Tk. 6,300.00

3c. Medium Rotation Teak and Jarul

Rotation = 20 yrs

Teak: 6'x 6'(1.85 x 1.85m) = 3,000 no of seedling
Jarul: 4'x4'(1.22 x 1.22m) = 7,000 no of seedling

a. Raising of Nursery, maintenance of previous year nursery for current year planting, Beating up of current year plantation in the following year and maintenance of previous year nursery of current year vacancy filling

Labour cost = Tk. 2,600.00
Material cost = 400.00

Tk. 3,000.00

Plantation Raising

Spacing Teak 6'x 6' & Jarul 4'x 4'
No of stumps required = 3,000 ha & 7,000 ha.

a. Plantation with polybags seedlings of 1 yr old including survey, layout, site preparation, Pit digging, fire breaks, fertilizer applications etc. at spacing.

Labour cost = Tk. 5,770.00
Material cost = 730.00

b. Beating up with Teak & Jarul stump, 1 yr, old plantation (20% = 600 nos)

Tk. 6,500.00

325.00
Total = Tk. 6,825.00
say 7,000.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (4 nos) 1 yr old plantations	Tk.	4,940.00
b.	Weeding and cleaning (3 nos) 2 yrs old plantation		3,705.00
c.	Weeding and cleaning (2 nos) 3 yrs old plantation		2,470.00

d.	Application of fertilizer (1 no.) 3 yrs old plantation		950.00	
		Labour cost =	430.00	
		Material cost =	520.00	
e.	Double stem, climber cutting in the 4th year per hectare		2,440.00	
				Total Tk. 14,505.00 Say Tk.14,500.00

Thinning

a.	1st Thinning at the age of 5th year	Tk.	2,893.00	
b.	2nd Thinning at the age of 10th year		2,893.00	
c.	3rd Thinning at the age of 15th year		1,300.00	
				Total = Tk. 7,086.00 say Tk. 7,100.00

3d. Medium Rotation

Poly bags

Rotation: 20 yrs
Spacing: 9'x 9' (2.775 x 2.775m)
No of seedlings: 1370 nos.

a.	Raising of Nursery, polybags for the following year plantation including fertilizer, maintenance of previous year polybags for current year planting, Raising of seedlings for beating up current year plantation (20%), and maintenance of previous year polybags for vacancy filling (20%)			
		Labour cost = Tk.	5,675.00	
		Material cost =	1,573.00	
				Tk. 7,248.00
b.	Raising of plantation with polybag seedlings of 1 yr. old including survey, layout, site preparation, Pit digging, (30.5 x 30.5 x 30.5 cm), fire breaks, inspection paths, fertilizer application etc. at spacing 2.775 x 2.775 m			
		Labour cost = Tk.	8,970.00	
		Material cost = including fertilizer	1,170.00	
				Tk.10,140.00

Maintenance of Plantation per hectare

a.	Weeding and cleaning (4 nos) 1 yr old plantations	Tk.	4,940.00	
b.	Weeding and cleaning (3 nos) 2 yrs old plantation		3,705.00	
c.	Weeding and cleaning (2 nos) 3 yrs old plantation		2,470.00	
d.	Application of fertilizer (1 no) 3 yrs old plantation		950.00	
	Labour cost =	Tk.	430.00	
	Material cost =		520.00	
e.	Double stem, climber cutting in the 4th year per hectare		2,440.00	
				Total Tk.14,505.00 say Tk. 14,500.00

Thinning Programme

a.	1st Thinning at the age of 10th year	Tk. 2,893.00	
b.	2nd Thinning at the age of 15th year	Tk. 1,300.00	
			Total = Tk. 4,193.00

3e. Short Rotation

Rotation = 10 yrs
Spacing: 9' x 9' (2.775 x 2.775 m)
No of seedling required: 1370 nos

No of seedling 1370 nos per hectare

Nursery

a.	Raising of Nursery in Polybags for the following year plantation including fertilizer, maintenance of previous year polybags for current year planting, raising of seedlings for beating up current year plantation (20%), and maintenance of previous year polybags for vacancy filling (20%)		
	Labour cost =	Tk. 5,675.00	
	Material cost =	Tk. 1,573.00	
			Tk. 7,248.00

Plantation

a. Plantation with polybag seedling of 1 year old including survey, layout, site preparation, Pit digging (30.5 x 30.5 x 30.5 cm), fire breaks, inspection paths, fertilizer application etc. at spacing 2.775 x 2.775 m. No of seedling required per hectare 1370 nos.

Labour cost = Tk. 8,970.00
Material cost = 1,170.00

Tk. 10,140.00

Maintenance of Plantation per hectare

a. Weeding and cleaning (4 nos) 1 yr old plantations Tk. 4,940.00
b. Weeding and cleaning (3 nos) 2 yrs old plantation 3,705.00
c. Weeding and cleaning (2 nos) 3 yrs old plantation 2,470.00
d. Fertilizer application at 3rd yrs 1,170.00
Labour cost = Tk. 520.00
Material cost = Tk. 650.00
e. Double stem, climber cutting and cleaning (1 no.) (Labour) 2,438.00

Total = Tk.14,723.00
say Tk. 14,725.00

3f. Enrichment Plantation in Sal Forests

Rotation: 20 yrs (Felling cycle)

Nursery Cost for Enrichment Plantation

a. For Sal seedlings = Tk.4.88 per seedlings
b. Other Species = Tk. 3.25 per seedlings

Plantation Raising Cost

Spacing 6' x 6' (1.85 x 1.85 m)
No of seedling required = 3,000 nos.

For Sal

a. Plantation with Sal polybags, including survey, layout, site preparation, Pit digging (30.5 x 30.5 x 30.5 cm), fertilizers etc.

Labour cost = Tk. 7,212.00
Material cost = Tk. 913.00

Tk. 8,125.00

For Other Species

a. Plantation with Sal polybags, including survey, layout, site preparation, Pit digging (30.5 x 30.5 x 30.5 cm), fertilizers etc.

Labour cost = Tk. 7,212.00
Material cost = Tk. 913.00

Tk. 8,125.00

Maintenance of Plantation per hectare

a. Weeding and cleaning (4 nos) 1 yr old plantation Tk. 4,940.00
b. Weeding and cleaning (3 nos) 2 yrs old plantation 3,705.00
c. Weeding and cleaning (2 nos) 3 yrs old plantation 2,470.00
d. Application of fertilizer (1 no) 3rd year
Labour cost = Tk. 520.00
Material cost = 650.00

1,170.00

Total Tk. 12,285.00

Thinning Programme

a. 1st Thinning at the age of 5th year Tk. 2,893.00
b. 2nd Thinning at the age of 10th year Tk. 2,893.00
c. 3rd Thinning at the age of 15th year Tk. 2,600.00
Labour cost = Tk. 2,535.00
Material cost = Tk. 65.00

Total = Tk. 8,386.00

3g. **Coastal Afforestation**

Keora & Baen Spacing 5' x 5' (1.5 x 1.5m)
No of seedlings = 4350 nos.
say 4500 nos.

Nursery Raising

a.	Raising of nursery				Tk. 1,385.00
		Labour cost =	Tk.	252.00	
		Material cost =	Tk.	25.00	
		Unit cost =		Tk. 277.00	
b.	1st yr vacancy filling in 1 yr old plantation (1.3 bed)			Tk. 360.00	
c.	2nd yr vacancy filling in 2nd yrs old plantation (1.3 bed)		Tk.	360.00	
d.	3rd yr vacancy filling in 3rd yrs old plantation (1.3 bed)		Tk.	360.00	
					Tk. 2,465.00
					say Tk. 2,500.00

Plantation raising

a.	Plantation raising including survey, demarkation by fixing RCC Pillars etc. (spacing 1.5 x 1.5 m)		Tk.	3,250.00	
		Labour cost =	Tk.	3,047.00	
		Material cost =		203.00	
b.	Repeating of vacancies in Keora & Bean plantation during the planting year (needed area) Unit cost = 975.00			Tk. 975.00	
c.	Beating up of Keora & Bean plantation (for the needed area only)				
	i) 1 yr old plantation 975.00;	Total =		975.00	
	ii) 2 yrs old plantation 975.00;	Total =		975.00	
	iii) 3 yrs old plantation 975.00;	Total =		975.00	
					7,150.00
				Total per hectare cost =	Tk. 9,650.00

4. PLANTATION RAISING AND THINNING SUMMARY

Status Quo

Long Rotation: 45 years	Teak & Jarul Stump	
Raising of nursery, plantation raising and maintenance	=	Tk. 13,040.00
Poly Bags		
Raising of nursery, plantation raising and maintenance	=	Tk. 16,685.00
Short Rotation Plantation: 10 years		
Raising of nursery, plantation raising and maintenance	=	Tk. 17,050.00
Coastal Afforestation		
Raising of nursery raising by polybags, plantation raising and maintenance	=	Tk. 5,913.00
Enrichment Plantation in Sal Forest		
For Sal: Raising of nursery, plantation raising and maintenance	=	Tk. 18,500.00
For other Species: Raising of nursery, plantation raising and maintenance	=	Tk. 15,500.00

Scenario 1

Long Rotation: 40 years

Stump planting:		
Raising of nursery, plantation raising and maintenance	=	Tk. 24,850.00
Thinning	=	Tk. 6,850.00
		Tk. 24,850.00
Poly Bags		
Raising of nursery, plantation raising and maintenance	=	Tk. 23,580.00
Thinning	=	Tk. 5,500.00
		Tk. 29,080.00

Medium Rotation Plantation: 20 years

Raising of nursery, plantation raising and maintenance	=	Tk. 18,175.00
Thinning	=	Tk. 5,450.00
		Tk. 23,625.00
Poly Bags		
Raising of nursery, plantation raising and maintenance	=	Tk. 23,750.00
Thinning	=	Tk. 3,225.00
		Tk. 26,975.00

Short Rotation Plantation: 10 years

Poly Bags		
Raising of nursery, plantation raising and maintenance	=	Tk. 23,750.00

Enrichment Plantation

For Sal:		
Raising of nursery, plantation raising and maintenance	=	Tk. 25,600.00
Thinning	=	Tk. 6,450.00
		Tk. 32,050.00
Other Species:		
Raising of nursery, plantation raising and maintenance	=	Tk. 21,350.00
Thinning	=	Tk. 6,450.00
		Tk. 27,800.00
Coastal Afforestation:		
Raising of nursery, planting and maintenance	=	Tk. 9,300.00

Scenario 2

Long Rotation: 30 years

Stump planting:		
Raising of nursery, plantation raising and maintenance	=	Tk. 24,850.00
Thinning	=	Tk. 8,900.00
		Tk. 33,400.00
Poly Bags		
Raising of nursery, plantation raising and maintenance	=	Tk. 31,890.00
Thinning	=	Tk. 6,300.00
		Tk. 38,190.00

Medium Rotation Plantation: 20 years

Raising of nursery, plantation raising and maintenance	=	Tk. 24,500.00
Thinning	=	Tk. 7,100.00
		Tk. 31,600.00

Poly Bags

Raising of nursery, plantation raising and maintenance	=	Tk. 31,888.00
Thinning	=	Tk. 4,193.00
		Tk. 36,081.00

Short Rotation Plantation: 10 years

Raising of nursery, plantation raising and maintenance	=	Tk. 32,115.00

Enrichment Plantation

For Sal:

Raising of nursery, plantation raising and maintenance	=	Tk. 35,050.00
Thinning	=	Tk. 8,386.00
		Tk. 43,436.00

Other Species:

Raising of nursery, plantation raising and maintenance	=	Tk. 30,160.00
Thinning	=	Tk. 8,386.00
		Tk. 38,546.00

Coastal Afforestation:

Raising of nursery, plantation raising and maintenance	=	Tk. 12,150.00

5. THINNING PROGRAMME OLD LONG ROTATION HILL PLANTATION

1. Scenario 1

Under Status quo scenario there will be no thinning. But under Scenario 1 some good can be done to some of the plantations where the stems have not, as yet, become whipy and the plantations are also relatively young. That is why old plantations from age classes 25 - 29 downward have been included in the thinning program. In any case, it has been recommended that all the plantations raised in the hilly regions will be felled within the next 40 years starting from the older plantations and replanted under scenario 2 and in 30 years under scenario 2. Since the older plantations will be felled first, thinning can not give them much benefits. It is the younger plantations which will be felled later on, and can derive some benefits. Here the arrear thinning will be completed in 10 years.

2. Scenario 2

The thinning cycle will be reduced to 5 years. So most of the younger age plantations will get the benefits of two thinnings and at the same time some intermediate return in the form of some timber, poles and fuel.

3. Thinning in pulpwood, agroforestry and woodlot plantations

There will be no thinning in the pulp-wood plantations because they will be felled on the 10th year. Some of the older plantations of Gamar and Albizia falcateria which are more then 10 years old should be felled because firstly they have been infested with Loranthus and borer attack respectively and secondly both the K.P.M. and S.P.P.M. are now running terribly short of soft-wood.

As for agro-forestry and wood-lot plantations with peoples involvement should be felled as scheduled before i.e. 6 - 8 years.

Sal Forest

20 years felling cycle in sal coppice and 6 to 8 years rotation for Agro-forestry and Wood-lot Plantations, MAI 20 m^3 in the encroached and denuded land.

The low density sal coppice forest is to be replaced gradually through plantation and is to be managed under coppice with standard. The standards (60 in numbers) are to be removed in two instalments, 30 on the 40th year and the balance 30 on the 60th year. These standards will be of seed origin and they will gradually spread seeds to the forest.

The replanting of the existing plantations will be done in 20 years and will be managed under coppice with standards, in the same manner as the low density forests. There will be no felling in the National Parks and game sanctuary areas. The plantation spacing will depend on the blanks. The average spacing is assumed to be 2.775 x 2.775 m. It can be even more or this uniform spacing may not be possible to maintain. The planting in many cases, may be scattered.

Agro-forestry and Wood-lot Plantation

There will be no thinning in Agro-forestry and Wood-lot plantations. If necessary some branch pruning in the wood-lot plantations may be done by the participants. This will give them some additional fuel.

APPENDIX 6
SILVICULTURE PROGRAMME

SILVICULTURE

APPENDIX 6
SILVICULTURE PROGRAMME

Table 1 - Felling and Planting Programme (Status Quo)

Forest Type	Items of Work	Unit Cost in Tk	1993-98	1998-03	2003-08	2008-13	Area 20 yre
	FELLING		Area 5 yr	Area 5 yr	Area 5 yr	Area 5 yr	
Littoral Forest	Selection Felling		93.725	93.725	93.725	93.725	374.900
	Clear felling Coastal Pl		3.234	3.099	21.988	32.215	60.536
Hill Forest	Clear Felling Natural Forest		9.895	9.895	9.895	9.895	39.580
	Clear Felling Long Rot Pl		6.070	4.590	6.865	16.900	34.425
	Clear Felling Short Rot Pl		5.472	18.480	14.360	14.823	53.135
Sal Forest	Clear Felling Med Rot Pl			5.394	4.147	8.475	18.016
	PLANTING						
Littoral Forest	Coastal Pl		8.225	8.225	8.225	8.225	32.900
Hill Forest	Total Long Rot Pl		(15.965)	(14.485)	(16.760)	(26.795)	(74.005)
	Stump Pl		9.175	8.760	10.210	18.950	47.095
	Poly Bag Pl		6.790	5.725	6.550	7.845	26.910
	Total Med Rot Pl						
	Stump Pl						
	Poly Bag Pl						
	Short Rot Pl Poly Bag Rot 10 yr MAI 10 m^3		11.725	19.200	20.700	20.500	72.125
Sal Forest	Parks etc. Pl						
	Sal Pl						
	Other Pl						
All Forests	Total Area Planted		35.915	41.910	48.385	55.520	179.030

Long Rot = Long Rotation Plantaton. Med Rot = Medium Rotation Plantation. Shrot Rot = Short Rotation Plantation. Pl = Planting.

Table 1a - Nursery Work and Raising Seedlings (Status Quo)

Forest Type	Item of Work	1993-1998		1998-2003		2003-2008		2008-2013		Total	
	Nursery Programme	Plantation area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Plantation area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Plantation area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Plantation area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Plantation area in ha. 20 yr.	No. of Nursery beds or Seedlings in Poly Bags
Littoral Forest	Raising Seedlings for Coastal Plantation	8.225	41.125 beds	8.225	41.125 beds	8.225	41.125 beds	8.225	41.125 beds	32.900	164.500 beds
Hill Forest	Raising Seedlings for Long Rotation Plantation	9.175	45.875 beds	8.760	43.800 beds	10.210	51.050 beds	18.950	94.750	47.095	235.475 beds
		6.790	9.51 million polybags	5.725	8.01 million polybags	6.550	9.17 million polybags	7.845	10.98 million polybags	26.910	37.67 million polybags
	Raising Seedlings for Short Rotation Plantation	11.725	16.42 million polybags	19.200	26.88 million polybags	20.700	29.98 million polybags	20.500	28.70 million polybags	72.125	100.98 million polybags

Table 2 - Felling and Planting Programme (Scenario 1)

Forest Type	Items of Work	Unit Cost in Tk	1993-98	1998-03	2003-08	2008-13	Area 20 yr
	FELLING		Area 5 yr	Area 5 yr	Area 5 yr	Area 5 yr	
Littoral Forest	Selection Felling		93,725	93,725	93,725	93,725	374,900
	Clear felling Constal Pl		3,234	3,099	21,988	32,215	60,536
Hill Forest	Clear Felling Natural Forest		10,775	10,775	10,775	10,775	43,100
	Clear Felling Long Rot Pl		6,420	4,590	6,865	16,960	34,425
	Clear Felling Short Rot Pl		5,470	18,480	14,366	14,823	53,141
Sal Forest	Clear Felling Med Rot Pl		-	5,394	4,147	8,475	18,016
	PLANTING						
Littoral Forest	Coastal Pl		12,500	12,500	12,500	12,500	50,000
Hill Forest	Total Long Rot Pl		(17,195)	(15,365)	(17,640)	(27,675)	(77,875)
	Stump Pl		9,896	8,461	9,755	16,500	44,618
	Poly Bag Pl		7,299	6,904	7,885	11,169	33,257
	Total Med Rot Pl		(50,000)	(50,000)	(50,000)	(50,000)	(200,000)
	Stump Pl		31,250	31,250	31,250	31,250	125,000
	Poly Bag Pl		18,750	18,750	18,750	18,750	75,000
	Short Rot Pl Poly Bag		6,750	8,750	17,000	17,500	50,000
Sal Forest	Sal Enrichment Pl		10,340	10,340	10,340	10,340	41,360
	Other Enrichment Pl		10,340	10,340	10,340	10,340	41,360
	Parks etc. Pl		3,250	3,250	3,250	3,250	13,000
	Sal Pl						
	Other Pl						
All Forests	Total Area Planted		110,375	110,545	121,070	131,605	473,595

Long Rot = Long Rotation Plantation, Med Rot = Medium Rotation Plantation, Shrot Rot = Short Rotation Plantation, Pl = Plantation.

Table 2a - Nursery Work and Raising Seedlings (Scenario 1)

Forest Type	Item of Work	1993-1998		1998-2003		2003-2008		2008-2013		Total	
	Nursery Programme	Pl area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Pl area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Pl area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Pl area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Pl area in ha. 20 yr.	No. of Nursery beds or Seedlings in Poly Bags
Littoral Forests	Raising Seedlings for Constal Plantation	12,500	62,500 beds	12,500	62,500 beds	12,500	62,500 beds	12,500	62,500 beds	50,000	250,000 beds
Hill Forest	Raising Seedlings for Long Rotation Plantation	9,896	49,480 beds	8,461	42,305 beds	9,755	48,775 beds	16,500	82,500 beds	44,612	223,060 beds
		7,299	10.22 million polybags	6,904	9.66 million polybags	7,885	11.04 million polybags	11,169	15.64 million polybags	33,257	46.56 million polybags
	Raising Seedlings for Medium Rotation Plantation	31,250	156,250 beds	31,250	156,250 beds	31,250	156,250 beds	31,250	156,250 beds	125,000	625,000 beds
		18,750	26.25 million polybags	18,750	26.25 million polybags	18,750	26.25 million polybags	18,750	26.25 million polybags	75,000	105.00 million polybags
	Raising Seedlings for Short Rotation Plantation	6,750	9.45 million polybags	8,750	12.25 million polybags	17,000	23.80 million polybags	17,500	24.50 million polybags	50,000	70.00 million polybags
Sal Forest	Raising of Seedlings for Sal Enrichment Plantation	10,340	31.02 million polybags	10,340	31.02 million polybags	10,340	31.02 million polybags	10,340	31.02 million polybags	41,360	124.08 million polybags
		10,340	14.48 million polybags	10,340	14.48 million polybags	10,340	14.48 million polybags	10,340	14.48 million polybags	41,360	57.92 million polybags
	Raising of Seedlings for Parks etc.	3,250	4.88 million polybags	3,250	4.88 million polybags	3,250	4.88 million polybags	3,250	4.88 million polybags	6,500	19.52 million polybags
	Sal Pl & others		2.28 million polybags		2.28 million polybags		2.28 million polybags		2.28 million polybags	6,500	9.12 million polybags

Pl = Plantation

Table 3 - Felling and Planting Programme (Scenario 2)

Forest Type	Items of Work	Unit Cost in Tk	1993-98	1998-03	2003-08	2008-13	Area 20 yr
	FELLING		Area 5 yr	Area 5 yr	Area 5 yr	Area 5 yr	
Littoral Forest	Selection Felling		93,725	93,725	93,725	93,725	374,900
	Clear felling Coastal Pl		3,234	3,099	21,988	32,215	60,536
Hill Forest	Clear Felling Natural Forest		2,500	2,500	2,500	2,500	10,000
	Clear Felling Long Rot Pl		19,815	20,290	19,330	20,590	80,025
	Clear Felling Short Rot Pl		5,472	18,480	14,366	14,823	53,141
Sal Forest	Clear Felling Med Rot Pl		-	5,394	4,147	8,475	18,016
	PLANTING						
Littoral Forest	Coastal Pl		15,000	15,000	15,000	15,000	60,000
Hill Forest	Total Long Rot Pl		(22,315)	(22,790)	(21,830)	(23,090)	(90,025)
	Stump Pl		11,904	13,205	14,575	13,902	53,586
	Poly Bag Pl		10,411	9,585	7,255	9,188	36,439
	Total Med Rot Pl		(50,000)	(50,000)	(50,000)	(50,000)	(200,000)
	Stump Pl		31,250	31,250	31,250	31,250	125,000
	Poly Bag Pl		18,750	18,750	18,750	18,750	75,000
	Short Rot Pl Poly Bag		11,000	13,750	16,750	16,750	58,250
Sal Forest	Sal Enrichment Pl		(25,930)	(25,930)	(25,930)	(25,930)	(103,720)
	Sal Enrichment		12,965	12,965	12,965	12,965	51,860
	Other Enrichment		12,965	12,965	12,965	12,965	51,860
	Parks etc. Pl-Sal-Other		3,250	3,250	3,250	3,250	13,000
All Forests	Total Area Planted	-	127,495	130,722	132,760	134,020	524,995

Long Rot = Long Rotation Plantation. Med Rot = Medium Rotation Plantation. Shrot Rot = Short Rotation Plantation. Pl = Planting.

Table 3a - Nursery Work and Raising Seedlings (Scenario 2)

Forest Type	Item of Work	1993-1998		1998-2003		2003-2008		2008-2013		Total	
	Nursery Programme	Pl area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Pl area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Pl area in ha. 20 yr	No. of Nursery beds or Seedlings in Poly Bags	Pl area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags	Pl area in ha. 5 yr.	No. of Nursery beds or Seedlings in Poly Bags
Littoral Forest	Raising Seedlings for Coastal Plantation	15,000	75,000 beds	15,000	75,000 beds	15,000	75,000 beds	15,000	75,000 beds	60,000	300000 beds
Hill Forest	Raising Seedlings for Long Rotation Plantation	11,904	59,520 beds	13,205	66,025 beds	14,575	72,875 beds	13,902	69,510 beds	53,586	267,930 beds
		10,411	14.58 million polybags	9,585	13.42 million polybags	7,255	10.16 million polybags	9,188	12.86 million polybags	36,439	51.02 million plybags
	Raising Seedlings for Medium Rotation Plantation	31,250	156,250 beds	31,250	156,250 beds	31,250	156,250 beds	31,250	156,250 beds	12,500	625,000 beds
		18,750	26.25 million polybags	18,750	26.25 million polybags	18,750	26.25 million polybags	18,750	26.25 million polybags	75,000	105.00 million polybags
	Raising Seedlings for Short Rotation Plantation	11,000	15.4 million polybags	13,750	19.25 million polybags	16,750	23.45 million polybags	16,750	23.45 million polybags	58,250	81.55 million polybags
Sal Forest	Raising of Seedlings for Sal Enrichment Plantation	12,965	38.90 million polybags	12,965	38.90 million polybags	12,965	38.90 million polybags	12,965	38.90 million polybags	51,860	155.60 million polybags
		12,965	18.15 million polybags	12,965	18.45 million polybags	12,965	18.15 million polybags	12,965	18.15 million polybags	51,860	72.60 million polybags
	Raising of Seedlings for Parks etc.	3,250	4.88 million polybags	3,250	4.88 million polybags	3,250	4.88 million polybags	3,250	4.88 million polybags	6,500	19.52 million polybags
			2.28 million polybags		2.28 million polybags		2.28 million polybags		2.28 million polybags	6,500	9.12 million polybags

Pl = Plantation

APPENDIX 7
TERMS OF REFERENCE

PROJECT 372001/20
FORESTRY MASTER PLAN
BANGLADESH TA 1355-BAN

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: JANUARY 1993

SILVICULTURE

APPENDIX 7
TERMS OF REFERENCE

a. Review and assess current silvicultural practices in the Country Advise on necessary improvements;

b. Assess the nursery distribution, layouts and techniques in Bangladesh. Recommend improvements. In the review, examine both public and private nurseries. Include an analysis of seedlings produced (both quality and quantity);

c. Review the species and provenances used in reafforestation including exotic and indigenous species. Prepare list of suitable species and provenances by region and end use;

d. Evaluate efforts to promote tree improvement (seed orchards, cloning, etc). Prepare a programme supporting tree improvement;

e. Examine silvicultural prescriptions (e.g. information generated by UNDP/FAO project BGD/85/085) for natural (in particular sal), plantation and private/community forests. Suggest measure to improve these prescriptions;

f. Assess changes occurring in the coastal Sundarbans forest ecosystem. Suggest interventions which may be necessary to keep pace with these changes;

g. Review the coastal afforestation programme and identify any new practices to enhance this programme;

h. Assess the implications of the trend to develop large scale monocultures of exotic species. Recommend practical alternatives;

i. Review available information on tree growth and yield. Identify projects to improve knowledge on these subjects;

j. Review and assess the different agroforestry systems (e.g. taungya, homestead tree cropping, etc) which have been practiced in rural Bangladesh for decades. Determine their contribution to the economy and recommend improvements which could increase their effectiveness;

l. Identify the appropriate multi-purpose tree species for different agroclimatic regions and recommend technical prescriptions for their cultivation. Suggest possible multi-tree species combinations which could be viable alternatives to monoculture plantations;

k. Review the current efforts to promote agroforestry, identify the constraints and propose measures to enhance the efficacy of the programmes;

m. Identify the gaps in information in promoting agroforestry and with the Institutions subteam propose measures to strengthen the research support;

n. Examine the feasibility of adopting agroforestry in degraded government land and identify the technical and socioeconomic constraints limiting a large scale application of agroforestry in such areas; and

o. Prepare a strategy for agroforestry development and identify the priority areas for investment.

APPENDIX 8
VERNACULAR AND BOTANICAL NAMES OF PLANTS

SILVICULTURE

APPENDIX 8
VERNACULAR AND BOTANICAL NAMES OF PLANTS

Vernacular Name	Botanical Name	Vernacular Name	Botanical Name
Hill Forest			
Am	Mangifera indica	JaruL	Lagerstoemia flosreginae
Uriam	Mangifera longispes	Jhau	Casuarina equisetifolia
Amra	Spondias mangifera	Jiul bhadi	Lannea grandis
Civit	Swintonia floribunda	Banderhola	Duabanga sonneratioides
Amloki	Phyllanthus embelica	Kadam	Anthocephalus chinensis
Asok	Saraca indica	Kainjal	Bischofia javanica
Assam lata	Eupatorium odoratum	Kala baen	Avicennia officinalis
Arjun	Terminalia arjuna	Kala koroi	Albizzia lebbek
Arsol, Horina	Vitex Spp.	Kali sorri bamboo	Oxytenan thera nigrociliata
Badam, Jangli badam	Terminalia catappa	Kamdeb	calophyllum Spp.
Bad rang	Zanthoxylum budrunga	Kanak	Schima Wallichii
Bahal	Cordia myxa	Kanchan	Bauhinia Spp.
Bahera	Terminalia belerica	Kumaria lata	Smilax prolifera
Baitta garian	Diplerocarpus pilosus	Khagra	Saccharam spontaneum
Bandarhola	Duabanga sonneratioides	Khoir jam	Syzygium Sp.
Bat	Ficas Spp.	Kanak	Schima wallichii
Batna	Quercus Spp.	Koroi	Albizzia procera
Bariala bamboo	Bambusa vulgaris	Kurchi	Holarrhena antidysenterica
Barta/ Lakooch	Artocarpus lakoocha	Lakoch/ Barta	Artocarpus lakoocha
Barali bamboo	Teinostachyum griffithii	Madder	Erythrina Spp.
Bhadi	Lannea grandis	Mahogany	Swietenia macrophylla
Sil Bhadi	Garuga pinnata	Chundul	Tetrameles nudiflora
Bhui kumra	Ipomea paniculata	Maula, Goalia lata	Spatholobus roxburghii
Bohal	Cordia myxa	Moos	Pterospermum acerifolium
Boilam	Anisoptera glabra	Nageswar	Mesua ferrea
Chakua	Albizzia stipulata	Narikeli	Sterculia alata
Chalta	Dillenia indica	Natiuga	Bruguiera gymnorhiza
Chaul mugra	Taraktogenos kurzii	Orah bamboo	Dendrocalamus longispathus
Champa	Michelia champaca	Padauk	Pterocarpus dalbergiodes
Chatim	Alstonia scholaris	Panisaj	Terminalia myriocarpa
Chikrassi	Chickrassia tabularis	Pati pata	Glinagyna dichoiatama
Muli bamboo	Melocanna baccifera	Pitraj	Amoora Spp
Chundul	Tetrameles nudiflora	Kamdeb	Calaphylum Spp
Civit	Swintonia floribunda	Pynkado	Xylia dolabriformis

Vernacular Name	Botanical Name	Vernacular Name	Botanical Name
Dalu bamboo	Neohouzeaua dullooa	Raktan	Lophopetalum fimbriatum
Dhaki jam	Eugenia grandis	Rankhat/Haldu	Adina cordifolia
Dailla garjan	Dipterocarpus costatus	Rohinia	Kandelia rokburghiana
Dhali jam	Syzygium Sp.	Teak/Shegun	Tectona grandis
Tali	Dichopsis Polyantha	Sheora	Stereblus asper
Dulia baen	Avicennia alba	Shonalu	Cassia fistula
Gab	Diospyros embryopteries	Bhadi	Gargua pinnata
Gamar	Gmelina arborea	Simul/Tula	Salmalia malabaricum
Garjan	Dipterocarpus Spp.	Sundri	Heritiera minor
Gila	Entada purseetha	Sungrass	Imperata arundinacea
Gundroi	Cinnamomum cedidodaphne	Surusbed, Toon	Cedrela toona
Guttva	Ceriops roxburghiana	Tali	Dichopsis polvantha
Hantal	Phoenix paludosa	Telsur	Hopea odorata
Hargaza	Dillenia pentagyna	Telya garjan	Dipterocarpus turbinatus
Haritaki	Terminalia chebula	Tetoiva	Albizzia odoratissima
Hogla	Typha Spp.	Tejbohal	Cinnamomum Spp.
Jalpai	Eleocarpus Spp.	Udal	Sterculia colorata
Jam	Syzygium Spp.	Moluccana	Paraserianthes falcataria
	Sal Forests		
Amloki	Phyllanthus embeliea	Haritaki	Terminalia chebula
Bohera	Terminalia belerica	Kumbi	Careva arborea
Chalta	Dellenia indica	Ravna/Pitraj	Amoora rohituka
Chapalish	Artocarpus chaplasha	Sal	Shorea robusta
Haldu	Adina cordifolia	Sonalu	Cassia fistula
	Littoral Forests		
Amur	Amoora cucullata	Kankra	Bruguiera gymnorhiza
Baen	Avicenia officinalis	Keora	Sonneratia apetala
Ban jam	Syzygium fruticosa	Khalshi	Aegiceras maius
Bhola	Hibiecus tilliaceus	Kirpa	Limnitzera racemosa
Dhundal	Carapa obovata	Kumia	Barringtonia racemosa
Gab	Diospyros embryopteris	Math-goran	Ceriops candellana
Garjan	Rhizophora conjugata	Nal	Orundo karka
Gewa	Excoecaria agallocha	Nona-jhao	Tamarix indica
Gila	Entada scandens	Ora	Sonneratia acida
Golpata	Nipa fruticans	Passur	Carapa meluccensis
Goran	Ceriops roxburghiana	Sada-baen	Avicennia alba
Hantal	Phoenix paludosa	Singra	Cynometra ramiflora
Hargoza	Acanthus ilicifolius	Sundri	Heritiera minor
Hogla	Typha elephantina	Ullu	Saccharum cylindricum
Jir	Ficus retusa	.	.

APPENDIX 9
REFERENCES

SILVICULTURE

APPENDIX 9
REFERENCES

Ahmed, Y.S., Working Plan for the Forests of Dhaka, Mymensingh Forest Division, 1937-38 to 1957-58 Forest Department, Bengal

Ahmed, N., Working Scheme for the Forests of Dhaka, Mymensingh Forest Division, 1959-60 to 1963-64

Aleem, S.A., 1981. Tariff on Village Trees and Bamboos, UNDP/FAO/BGD/78/020. Field Document No. 3

Ali, O., 1992. Report on Forest Research, Forestry Master Plan. Asian Development Bank

Aliff International Ltd., 1981. A study in the Forestry Planning Commission of Bangladesh Ministry of Planning, Govt. of Bangladesh

Aliff International Ltd., 1981. Special Studies of Related Industries in Bangladesh. Prepared for BFIDC

Aliff International Ltd., 1985. Reports on the Inventory Poles, Anchor and Stabilizer logs available in Bangladesh, Prepared for BFIDC

Alim, A., 1976. Water-shed Management with particular reference to CHT

Appraisal Report of Community Forestry. Asian Development Bank

Appraisal Report of Upazilla Project. Asian Development Bank

Appraisal Report of Second Forestry Project. World Bank, 1985

Bangladesh Bureau of Statistics - Preport on Survey of Farm Forestry 1988 April 1990

Bangladesh Bureau of Statistics - Statistical Pocket Book of Bangladesh, 1981.

Brammer H.J., Antoine, A.H., Kassam and H.T. Van Velthuizen 1988a. Land Resources Appraisal of Bangladesh for Agricultural Development: Executive Summary (Report 1-6) UNDP/FAO, Dhaka, Bangladesh

Byron, R.N. 1981. Future Consumption of Wood and Wood Products in Bangladesh. UNDP/FAO/BGD/78/010. Field Document No. 4.

Chaffey, et al 1982. Forest Inventory of the Sundarbans, Bangladesh

Champion, H.G., Seth, S.K., 1968. A Revised Survey of the Forest Types of India

Champior, H.G., Seth, S.K., and Khatak, G.M., 1955. Forest Type of Pakistan

Chowdhury, J.H., 1992. Working plans of Sangu & Matamuhuri

Chowdhury, J.H., 1992. Working plans of Cox's Bazar

Chowdhury, J.H., 1992. Working plans of Chittagong Forest Division

Chowdhury, J.H., 1992. Working plans of Chittagong Hill Tracts (South) Forest Division

Chowdhury, J.H., 1992. Working plans of Sylhet Forest Division

Chowdhury, M.R., 1976. Nursery and Plantation Mannual

Chowdhury, A.M., 1962, Cutis, S.T., 1931. Working plans of Sundarbans (Vol 1 & 2)

Davidson, J., Khan, S.A., Latif, M.A., and Zashimuddin, M. Biomass Production of Tree Crops in Bangladesh, Bangladesh Forest Research Institute, 1985

Davidson, J., Species and Sites, FAO Field Document No. 5, April, 1985

Davidson, J. and Khan, N.M., Computerised Matching of Tree Species to Sites, FAO Working Paper No. 1 August, 1986

Dereje, Asrat, 1981. Household Survey of Rural Consumption of Wood and Bamboo in Bangladesh. A Review of the Survey Methodology. UNDP/FAO/BGD/78/010. Field Document No. 1.

Douglas, J.J., Rahman, K. and Aziz, A., The Industrial Forestry Sector of Bangladesh, FAO Field Document No. 3, June, 1981

Douglas, J.J., Consumption and Supply of Wood and Bamboos in Bangladesh, FAO Field Document No. 2, June, 1981

Douglas, M.V, Hussain, M.Z., 1989. Nursery Techniques for common Industrial and fuelwood species in Bangladesh. Working Paper No. 20. FAO/UNDP

F.D. Planning, 1992, Chani, C.Q., 1950. Project Proforma, Thana Banayan and Nursery Prokalpa (Revised) Working Plans of Chittagong Forest Division

F.D. Planning, 1992. Project Proforma, Thana Banayan & Nursery Prokalpa (Revised)

F.D. Planning, 1992. Project Proforma, 3rd Forestry Project

FAO 1985. Field Document No.5. UNDP/FAO BGD/079/17

FAO 1981a. Village Forest Inventory. UNDP/FAO BGD/078/20. Hammer Master

FAO 1990. Rehabilation and Land Use Planning of Sal Forests. UNDP/FAO BGD/085/085

FAO 1980a. Supply and Demand of Forest Products and Future Development Strategy. UNDP/FAO BGD/070/10. J Dauglas

FAO. 1990. Rehabilitation and Land use planning of Sal Forestry Vol. I to III. FAO/UNDP/BGD/85/085. Ghani, C.Q., Alim, A. and Stevens P.R.

FAO. Village Forest Inventory. Terminal Report. FAO/UNDP

FMP 1992l. Wood Harvesting. Forestry Master Plan. ADB 1355-BAN. UNDP/FAO/BGD/088/025. J W Rithaler

FMP 1992j. Conservation. Forestry Master Plan. ADB 1355-BAN. UNDP/FAO/BGD/088/025. K Moore

FMP 1992k. Non Wood Forest Products. Forestry Master Plan. ADB 1355-BAN. UNDP/FAO/BGD/088/025. A M Polijon

FMP 1992h. System Analysis Report. Forestry Master Plan. ADB 1355-BAN. UNDP/FAO. BGD/088/025. A B M S Mahmud.

FMP 1992o. Environment Planning. Forestry Master Plan. ADB TA 1355-BAN. UNDP/FAO/BGD/088/025. W Treygo

FMP 1992n. Investment Analysis. Forestry Master Plan. ADB 1355-BAN. UNDP/FAO/BGD/088/025. F Q Siddique

FMP 1992m. Land Use. Forestry Master Plan. ADB 1355-BAN. UNDP/FAO/BGD/088/025. G A Shea

FMP 1992i. Participatory Forestry. Forestry Master Plan. ADB 1355-BAN. UNDP/FAO. BGD/088/025. P K Manandhar

FMP 1992f. Forest Products Demand Projection. Forestry Master Plan. ADB TA 1355-BAN. UNDP/FAO/BGD/088/025. R Islam

FMP 1992g. Village Forest Inventory. Forestry Master Plan. ADB TA 1355-BAN. UNDP/FAO/BGD/088/025. R Islam

FMP. 1992b. Bamboo. Forestry Master Plan. ADB TA 1355-BAN. UNDP?FAO BGD/088/025. R L Banik

FMP. 1992a. Silviculture, Forestry Master Plan. ADB TA 1355-BAN. UNDP/FAO. BGD/088/025. A. Alim

FMP. 1992c. Institution Structure, Education and Training. ADB TA 1355-BAN. UNDP/FAO/088/025. M R Chowdhury

FMP. 1992d. Forest Policy. Forestry Master Plan. ADB TA 1355-BAN. UNDP/FAO/088/025. C Chandrashekharan

FMP. 1992p. Wood Processing. Forestry Master Plan. ADB TA 1355-BAN. UNDP/FAO/BGD/088/025. R Henriksen

FMP. 1992e. Forest Management. Forestry Master Plan. ADB TA 1355-BAN. UNDP/FAO/088/025. C Q Ghani

Forestal Forestry and Engineering Ltd., 1959. Inventory Report on Sundarbans

Forestal Forestry and International Ltd., 1963. Inventory Report on Chittagong Hill Tracts

Ghani, C.Q., 1950. Working Plans of Cox's Bazar Forest Division

Ghani, C.Q., 1950. Working Plans of Cox's Bazar Forest Division

Ghani, C.Q., 1950. Working Plans of Chittagong Forest Division

Huq, A.M., 1986, BARC. Plant names of Bangladesh

Huq, F. & Banik, R. L. (1990). Improved Productivity of man made forests of Bangladesh. In Proc. of the Regional Workshop on Tree breeding & Propagation. 10-14 July 1990. Bangkok, Thailand. Page 19-48

Stevens, P.R., Handbook for Site Classification and Site Suitability Assessment, FAO Working Paper No. 25, October, 1986

Stevens, P.R., Hand Use and Site Suitability for Plantation - A Case Study, FAO Working Paper No. 12, September, 1988

Sydneysmith, S., 1986. On the optimum socio economic rotation for strip plantation: Benefit cost sharing and the discussion to harvest. Working Paper No. 27. FAO/UNDP

Sydneysmith, S., 1985. Economic data for the determination of value added. Working Paper No. 21. FAO/UNDP

Sydneysmith, S., 1985. Data Requirements for plantation Project appraisal. Working Paper No. 19. FAO/UNDP

Sydneysmith, S., Contribution of the Forestry Sector to the Bangladesh Gross Domestic Product, FAO Working Paper No. 13, July, 1985

Sydneysmith, S., 1986. Forest Department Investment Planning. Working Paper No. 24. FAO/UNDP