GOVERNMENT OF BANGLADESH
MINISTRY OF ENVIRONMENT AND FORESTS

BAMBOO

FORESTRY MASTER PLAN

ASIAN DEVELOPMENT BANK (TA NO. 1355-BAN)

UNDP/FAO BGD 88/025

1992

GOVERNMENT OF BANGLADESH
MINISTRY OF ENVIRONMENT AND FORESTS

BAMBOO

FORESTRY MASTER PLAN

ASIAN DEVELOPMENT BANK (TA NO. 1355-BAN)

UNDP/FAO BGD 88/025

1992

PROJECT 372001/8
FORESTRY MASTER PLAN,
BANGLADESH (TA NO.1355-BAN)

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 30 JUNE 1992

BAMBOO

SUMMARY

Bangladesh has significant bamboo resources located both in forests and in the villages.

Seven different bamboo species are naturally occurring in the forests, among which muli bamboo (Melocanna baccifera) is the predominant one. The forest species are thin-walled in nature while thick-walled bamboos are extensively cultivated in the villages. Bariala bamboo (Bambusa vulgaris) and bhaluka bamboo (B. balcooa) are the most common village species.

The report fully describes the distribution of naturally growing species and the climate requirements for the growth. Bamboo do not grow naturally in the littoral and sal forests. Distribution of cultivated species in the plain districts appears related to the planters' choice, utility values of the species and availability of planting materials.

The current demand estimate is 706 million bamboo while the need by 2013 is 900 million. Demand projections include the needs of rural housing, agricultural implements, community buildings, urban housing, industrial requirement including both pulp and paper, and cottage and transportation requirements in boats, bullock carts and rickshaw hood construction.

Currently, Bangladesh is slightly deficient in bamboo. This shortfall will alarmingly increase by the Year 2000 due to the large scale death of muli bamboo as a result of gregarious flowering. At present, village forests supply 80 percent of the total national supply. Village forests supply about 528 million pieces and National forests supply 128 million.

Forest bamboo growing area is decreasing on average by two percent annually. Inaccessibility and over exploitation are also important factors for reducing bamboo supply in the Country.

About 10-20 percent of the bamboo area is inaccessible and as a result resources of this area remain untapped. Infrastructural development would render these areas open to harvesting and increase supply.

Excepting harvesting, existing management practices are not carried out properly to maintain the bamboo forests. Meanwhile, management prescription for the village bamboos do not exist.

Plantation techniques are discussed fully and scientific harvesting and other silvicultural practices both for forests and village bamboos are suggested.

A number of development programs including, resource management, production, and research have been proposed to minimise the supply gap. Emphasis is given to training on bamboo plantations, farming and bamboo preservation. The program incorporates participatory approaches to achieve success in future programs.

PROJECT 372001/8
FORESTRY MASTER PLAN,
BANGLADESH (TA NO.1355-BAN)

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 30 JUNE 1992

BAMBOO

INTRODUCTION

General

The Asian Development Bank (ADB)*, the United Nations Development Program (UNDP) and the Government of Bangladesh (GOB) are financing the technical assistance services to prepare a twenty year Forestry Master Plan for Bangladesh. The Plan aims to assist the GOB to decide on priorities and implement programs for the development and protection of the country's forest resources. This report presents the Bamboos Specialist's assessment and is part of the overall planning process for the Forestry Master Plan for Bangladesh.

For consistency, this report uses standard metric units of measurement, definitions and abbreviations. Appendix 2 includes the Terms of Reference for the Bamboo Specialist.

Unlike other members of the grass family, the plant bamboo is unique in both its sexual and vegetative characters. Bamboos are often called giant woody grasses. The plant generally has more than one tall aerial shoot (culm) and each shoot has distinct nodes and hollow internodes. The culms originate from the complex underground rhizome system having a prominent sheathing organ at each node. The culms are the main parts of a bamboo plant utilized for various purposes by man. Both climate and soil of south and southeast Asia are favourable for the growth and development of bamboos. These regions are rich in vegetation of different bamboo species. In the plains and villages people have cultivated this plant from time immemorial for their day to day needs.

Bamboo has many inborn qualities, among which the following are remarkable:

- Fastest growing plant (8.0-35.05 m within two-three months);
- Highly elastic, resists strong winds and springs back when the stress is over;
- Straight and cylindrical stem;
- Light, hollow, but hard and strong;
- Stems are of different diameter (1.0- 5.0 cm) and wall thickness (less than 1.0-1.63 cm at mid culm);
- Possesses long fibre with maximum amount of cellulose (2.3-3.6 mm is average range for bamboos of Bangladesh); and,
- Excellent splitting ability in straight lines.

Unlike trees bamboos lack a distinct bark. The outer layer or epidermis is quite heavily cutinized to prevent loss of water from the culms. In common with the culms of grasses, those of the bamboo have a hard, siliceous exterior which makes them more impervious to moisture and more durable than ordinary wood of the same weight. Cutinization of the outer wall increases the power to resist tearing as much as ten times over ordinary cellulose walls (Glenn 1950). High elastic strength of bamboo is

* See Appendix 1 for this and other terms, abbreviations or conversion factors.

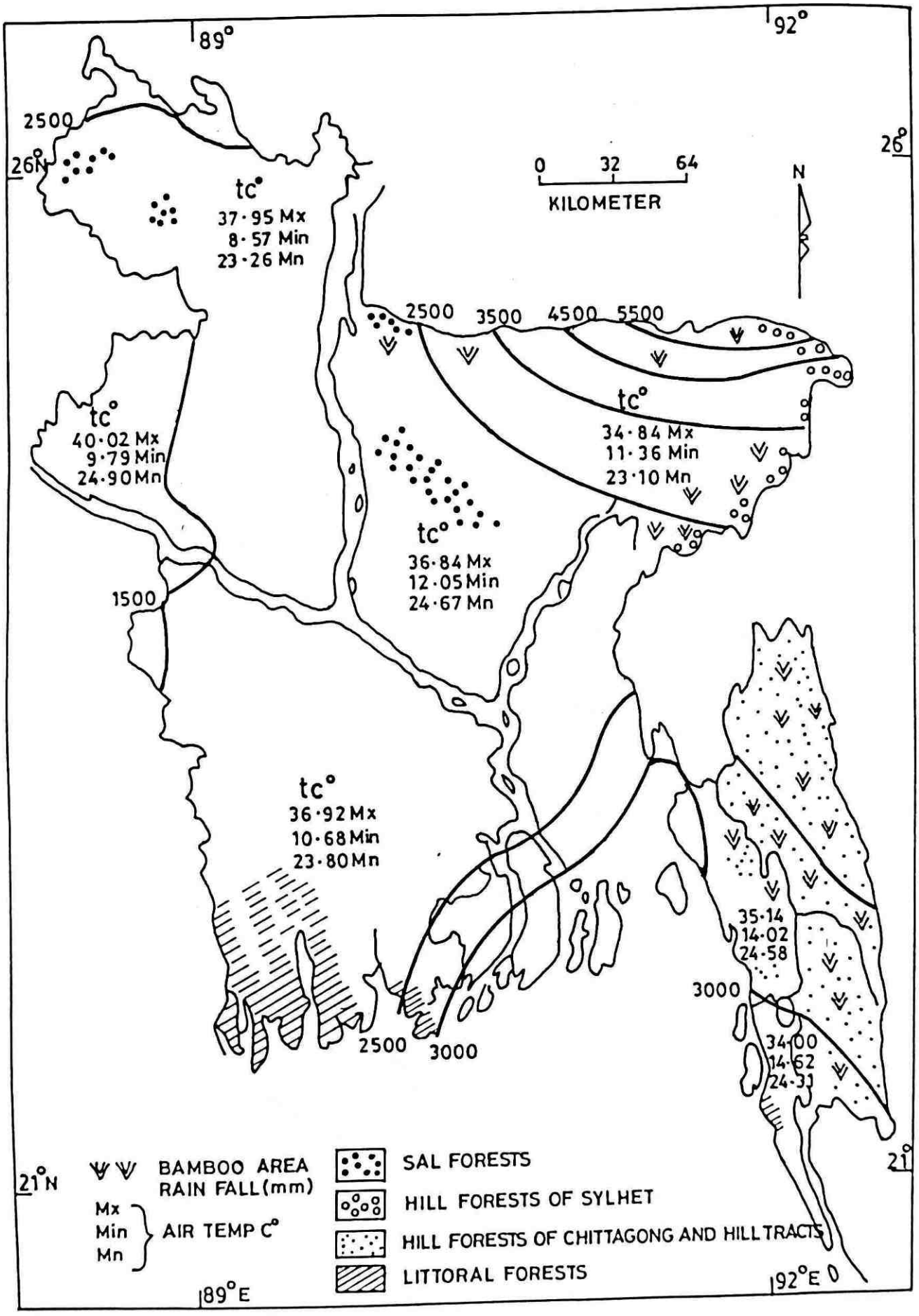


Figure 1 - Natural distribution of bamboos in the different forest types, rainfall and temperature zones of Bangladesh

of prime importance to its use as a reinforcing material in concrete (Glenn 1950). It is one of nature'sstrongest natural materials. Its cylindrical design, segmented by integral partitions, gives bamboo its amazing physical characteristics. Bamboo's strong, rigid structure makes it an ideal material of construction. In many parts of the world it is used as scaffolding, strong enough to withstand typhoons where steel scaffolding has collapsed.

It is the fastest growing plant species so far known and is rich in cellulose content. It is estimated that six or seven times as much cellulosic materials can be obtained per unit area from a bamboo forest compared to that of a pine forest (Sineath and Daugherty 1954).

Uses

Due to its excellent splitting ability bamboo has a wide range of use in construction, making baskets, furniture and novelty items. Bamboo materials knitted by thin split pieces of culm are commonly used for the support of muddy walls of rural houses of Bangladesh. Fencing with bamboo splits on the boundaries of agricultural fields are common picture in the countryside. Bamboo plantation also acts as wind break (Hsiung 1987) and helps in soil conservation and flood control (White and Childers 1945) and therefore in Japan, bamboo cultivation was recommended since sixteenth century for the protection of river banks (Ueda 1960).

Besides all these versatile uses of bamboo, man probably from his ancient nomadic life, used this plant as one of his food items. Young shoots of several species of bamboos are important vegetable ingredients in the daily meals in China, Japan, Thailand, Burma, Korea and Philippines and are considered as gourmet item in the western world where these are available as imported canned products. The listed countries earn significant foreign exchange by exporting the bamboo shoots. During 1977, Taiwan exported nearly US$ 25 million bamboo shoots to the western world (Sharma 1980). In the hilly areas of Bangladesh, the tribal people use bamboo shoots as one of their major food items.

Branches, twigs and leaves of bamboos are very common sources for fuel in Bangladesh. The calorific values of bamboos are within the range of 4,600-5,400 cal/ kg, higher than the 3,000-4,000 cal/ kg of wood (Shigematsu 1937). Thus bamboo, with its fastest growth rate and higher calorific value, is a potential alternative renewable energy to conventional energy source.

Species

Bamboo is a perennial member of the grass family (Gramineae) and belongs to the subfamily Bambusoideae. In this subfamily twelve hundred and fifty species under 47 genera are found in the world. Morphologically bamboos fall into two major groups - one is clump forming (sympodial type), and another is nonclump forming or runner type (monopodial). Clump forming types are usually tropical and the nonclump forming type are temperate zone plants.

Figure 1 shows the distribution of bamboo according to local temperature and rainfall regions. Appendix 3 contains a full description of species characteristics, distribution and habitat requirements.

Bamboos are very unevenly distributed in the tropics, subtropics, and mild temperate regions of the world (47° south to 40° north) from sea level to the snowline. The majority of bamboos are found in the southern and southeastern borders of Asia, from India, Bangladesh through Korea to Japan. In Asia the widespread distribution of some bamboo species parallel man's past migrations. Bamboos may also have travelled along the several ancient maritime spice routes between China, Indonesia, Sri Lanka and India. However, the distribution of bamboo is rich and gregarious in the areas of Tropic of Cancer at the northern side and in the Tropic of Capricorn on the southern side, especially, for clump-forming bamboos.

Similar to other countries of tropics and subtropics, bamboos grow naturally in the forests and are also being cultivated in the villages of Bangladesh. All the village species are clump-forming in nature. Four major types of bamboo plants, on the basis of clump habit and culm type, occur in the Country. The four types are, clump, thornyless culms; clump thorny culms; clump having openly growing single distant culms (diffused) and climbing culms in the clump.

MAJOR ISSUES

The report develops several issues involving the state of the resource, conservation and harvesting measures and utilization improvements. These are all summarized below and detailed more thoroughly in later sections.

1. Supply Shortage

   Bangladesh presently suffers a slight deficit in bamboo supply. The rapidly increasing population and high demand for rural housing is the chief cause. Forecasts are that the shortfall will alarmingly increase by the Year 2000 due to large scale death of bamboo, a result of gregarious flowering of the principal forest species. This will effect seriously pulp and paper industries and housing construction in the Country.

   Plantation of bamboos in the villages and forests along with the maintenance of natural regeneration of wild seedlings need starting immediately.

2. Shrinking Bamboo Areas

   Encroachment, shifting cultivation and other biotic interferences have markedly reduced the bamboo areas in the natural forests of Sylhet, Chittagong Hill Tracts and Sangu Matamuhuri Reserves.

   Proper protection and management of the natural bamboo forests would sustain existing productivity.

3. Production Increasing Methods

   Bamboo plantation has not been practised in the forests of Bangladesh. Farmers have cultivated bamboos mostly in their homestead on a limited scale. With the increasing demand the resource base needs more development. There is ample scope for the former and reasonable opportunities for the latter.

   Effective training and extension programs would raise large scale bamboo plantation in the forests and villages with improved technology.

4. Increased Construction Durability

   At present, untreated bamboo is common in housing and other construction works. Untreated bamboo has a short lifespan and needs replacing within two-five years. Poor durability puts a major pressure on consumption.

   Preservative treatment increases the durability of bamboos upto 15-20 years and thereby reduces consumption by one quarter to one third. These treatments need popularizing.

5. Ineffective Harvesting

The existing forest cutting rules are not followed properly. As a result repeated cuttings in the accessible areas goes on more than once in a three-four year felling rotation. As a result, forest bamboo resources get depleted. In addition, tops and butts of the harvested culms are left in the forests during harvesting operations wasting material.

Thorough supervision, monitoring the complete felling operation would keep these losses to a minimum.

6. Research Strengthening and Knowledge Dissemination

The present state of research knowledge on different aspects of bamboo propagation, cultivation, maintenance and product development is not fully adequate to cater to the needs of bamboo.

A sound research, training and extension program needs developing to determine and disseminate knowledge at the grass root level.

7. Product Quality and Design Improvement

Existing design and quality of the different bamboo products focuses on the traditional knowledge of the craftsman.

Providing up-to-date training and proper facilities to the craftsman would enable improved product design and quality and offer better marketing opportunities.

8. Bamboo Conservation

Among the seven naturally grown forest bamboo the occurrence of three species is reducing due to the destruction of their natural habitat.

Conservation of these species is important for future studies and improvement works.

9. Resource Base Information

It was not possible during two forest inventories, in 1961-63 and 1984, to survey the bamboo resources in the Chittagong Hill Tracts, and Sangu and Matamuhuri forests. As a result, the estimate of growing bamboo stock in the forests of Chittagong Hill Tracts and bamboo area in Chittagong, and Cox's Bazar are not assessed accurately There is a vital need to correct that deficiency once access conditions permit.

NATURAL FOREST BAMBOO AREAS

Major natural bamboo producing areas of Bangladesh are the forests of Sylhet and Chittagong Hill Tracts and the Kassalong, Rankhiang, Sangu and Matamuhuri Reserves. Almost all the bamboo reserves in Sylhet are located in the southern part of the Division. The following section assesses the past and the present conditions of these natural bamboo areas.

Sylhet Forests

The Working Plan for Sylhet Forest Division from 1963-64 to 1982-83 (Choudhury, 1970) reported that bamboo occurs as an undergrowth in the whole of the forest. Some areas were practically

without trees, but densely stocked with bamboos. In these areas bamboos occur homogeneously in pure vegetation or with scattered trees. The pure bamboo areas are only located in the eastern side of the Division in the Reserve Forests (RF) of Rajkandi, Hararganj and Patharia and Prithim Pasha Acquired Forests (AF). According to that Working Plan, the bamboo area of the Division was 39,251.97 ha; much of the area (38,444 ha) is in the south and only 808 ha is in the north.

Drigo et al (1988) inventoried the forest resources of southern Sylhet Forest Division under FAO/UNDP Project BGD/85/085 and reported that bamboos were found to occur in 13,933 ha of forest land. This indicated that (38,444-13,933 ha) 24,511 ha of bamboo area disappeared in the southern part of the Division within the last 25 years. The rate of decrease was 64 percent up to 1988. In the northern part of the bamboo area of Tilagarh, bamboo area decreased from 808 ha to 16 ha as reported by DFO Sylhet in the 29 year period ending 1992. This loss is about 98 percent within this time (Table 1).

Thus the annual loss of major bamboo area in Sylhet Division is 2.6 percent. The reported bamboo area in 1988 was 13,933 ha. So in 1993, the base year of the FMP, the estimated bamboo area in Sylhet forest likely is 12,237 ha adopting the 2.6 percent rate of annual loss. With the same assumption the bamboo area in Sylhet will further squeeze after 20 years from now to the end of FMP period, reducing 7,302 ha unless protected.

Table 1 - Comparative Statement of Sylhet Bamboo

Forest Reserve/ Acquired Forest	Bamboo Area (ha)			
		1988[b]		
	1963[a]	Pure	Mixed	Total
Rajkandi RF	8,185	2,892	1,471	4,363[f]
West Bhanugach RF	2,742	3,724	481	NA
Barshijura AF	359	1,633	408	NA
Satgao Dinarpur (East) RF	1,169	3,339	0	NA
Taraf Hill RF	4,745	-	16	NA
Taraf Hill Rashidpur	1,475			NA
Satgao Dinarpur (West) RF	1,541			NA
Ranghunandan Hill RF	4,046			NA
Hararganj RF	4,362			4,205[f]
Prithimpasha AF	4,386			2,041[e]
Patharia RF	5,443			3,339[f]
Tilagarh RF (North Sylhet)	808			16[d]
Total	39,251			13,964

Note:

a. Working Plan for the Forest of the Sylhet Division, for the period 1963-64 to 1982-83, Vol-I, M U Choudhury, East Pakistan Govt. Press (1970)
b. Inventory of Forest resources of Southern Sylhet Forest Division, Drigo et at, 1988; FAO/UNDP Project BGD/85/085, Field Document No. 3.
c. From field visit estimates there might be about 80 percent pure (1,633 ha), and 20 percent overlapping (408 ha) areas in Prithimpasha A.F.
d. Personal communication with DFO, Sylhet on 27.4.92.
e. Rajkandi Range
f. Juri Range
NA Not available for bamboo, whether the land is reforested or encroached is not mentioned.

Kassalong and Rankhiang Reserves

It is evident from Table 2 that during 20 years from 1963 to 1983 the biggest loss of forest areas has occurred in the predominantly bamboo types (mixed bamboo-timber plus bamboo) both in Kassalong and Rankhiang Reserves. In 1983 the reported land area under bamboo became 22 percent against 44 percent in Kassalong and 28 percent against 59 percent in Rankhiang of 1963. Within this 20 years of time (from 1963 - 1983) non forest and non productive areas increased upto 32 percent from 6 percent in Kassalong, and 49 percent from 3 percent in Rankhiang. The loss of bamboo area was about 50.7 percent in Kassalong and 56.4 percent in the Rankhiang Reserves. So the annual loss of bamboo area has been 2.53 percent at Kassalong and 2.82 percent at Rankhiang reserves. Shifting cultivation and clear felling of the forests are the main causes of the retrogression of bamboo forests in these reserves.

Table 2 - Comparative Kassalong and Rankhiang Bamboo Areas

Forest Cover Type	1963[a] Area		1983[b] Area	
	hectare	Percent	Hectare	Percent
Kassalong				
Timber-types	52,689	32.0	46,395	28.2
Timber-bamboo	23,506	14.3	14,878	9.0
Bamboo-timber	31,972	19.5	23,525	14.3
Bamboo	41,366	25.1	12,653	7.7
Plantation	5,013	3.0	14,330	8.7
Non Forest(d)				
Non Productive and Water Areas	9,981	6.1	52,667	32.0
Total	164,527	100	164,448	100.00
Rankhiang				
Timber types	20,325	26.3	7,116	9.2
Timber-bamboo	6,933	9.0	3,228	4.2
Bamboo-timber	17,519	22.7	6,194	8.0
Bamboo	27,907	36.2	13,606[c]	17.7
Plantation	2,011	2.6	8,873	11.5
Non Forest[d]	2,409	3.2	38,087	49.4
Non Productive and Water Areas				
Total	77,104	100.0	77,104	100.0
Total CHT	241,631		241,552	

Note:

a. Chittagong Hill Tracts Forest Inventory survey 1961-63, Kassalong and Rankhiang Reserved Forests. Vol-I, Forestal, Canada, Project No. F334.
b. FAO/UNDP Project BGD/79/017, Field Document No. 10, R. De Milde et at (1985).
c. All muli bamboo.
d. Nonforest areas included jhum areas, all clearings, and all selectively logged areas.

After the liberation war, jhuming started in such an alarming rate that entire Subalong, Pharua and upper Rankhiang blocks are completely damaged. Figures also indicate that destruction of pure bamboo forest (Bamboo type) has been very much serve in Kassalong reserve. Since 1963 the pure bamboo land has been decreased by 69.4 percent. The destruction is also less severe in

Rankhiang, where the pure bamboo land has been decreased by 51.2 percent. It is to be noted that muli bamboo flowered gregariously and died in the Chittagong Hill Tracts during 1957 - 1961, just prior to the Forestal Inventory and even then the estimated bamboo areas in these two big reserves were higher than the amount reported in 1983.

There is an area difference of about 804 ha in Rankhiang with that recorded by Forestal in 1963, because the forest area was taken to be 77,103 ha but now is taken at 76,300 ha as per original gazette Notification of 6458, date 28.07, 1948. (Choudhury 1990, unpublished).

Sangu and Matamuhuri Reserves

As regards the bamboo forests in Sangu and Matamuhuri Reserve the inventory survey in 1961 estimated bamboo area as 31,260 ha, that is 42 percent of the total forest lands. In 1984, it was reported that the total pure bamboo area came down to 24,606 ha (Choudhury 1984). Loss in bamboo area is 21.3 percent over 23 years (from 1961-83), with an annual rate of 0.93 percent (Table 3).

Table 3 - Comparative Bamboo Areas of Sangu and Matamuhuri Reserves

Forest Types	1961[a] Inventory		1984[b] Inventory	
	Hectare	Percent	Hectare	Percent
High Forest medium -	7,100	10	8,700	11.7
good	18,450	25	-	-
High Forest poor	14,530	23	23,234	31.2
Low immature forest poor	2,380	-	-	-
Low forest medium - good	31,260	42.0	24,606[c]	33.0
Bamboo	30	0.5	17,100	23.0
Shifting cultivation	270	0.4	380	0.5
Grass	480	0.6	480	0.6
land/settlement/Agric				
Water				
Total	74,500	100.0	74,500	100.0

Note:

a. East Pakistan Forest Department, Working Plan Division, 1961
b. Inventory report of FAO/UNDP Project BGD/79/017
c. A study on supply and demand of bamboos and canes in Bangladesh (draft), FAO/UNDP Project BGD/78/010, Choudhury M.R., 1984.

Chittagong and Cox's Bazar Forest

In Chittagong and Cox's Bazar one can rarely find pure bamboo vegetation. However, good bamboo stands, mostly muli, in patches, can be seen on barren or denuded hills with or without scattered trees. According to the working plan of Cox's Bazar Forest Division for the period from 1968-69 to 1977-78 (Choudhury 1967), the area under bamboo working circle is 58,301 ha.

Table 4 shows the most recent forest inventory reported, including overlapping and major bamboo areas estimated for Chittagong and Cox's Bazar Forests (De Milde 1985). So the loss in bamboo area in the Cox's Bazar forest estimated to be 40.8 percent within 18 years from 1967 to 1985

(Table 4). Thus the estimated annual loss in about 2.3 percent. However, the loss of bamboo area in Chittagong forest could not be ascertained due to inadequate data.

Table 4 - Comparative Bamboo Areas, Chittagong and Cox's Bazar Divisions

Forest Division	Hectares	
	1967	1985
Chittagong	-	52471
Cox's Bazar	58301	34499

It is evident from above facts and discussion that the bamboo forest of Bangladesh have been exploited only and never been managed scientifically. The last three decades have witnessed a progressive reduction of bamboo areas from the hill forests of the Country. However the loss of bamboo area was comparatively less in Sangu and Matamuhuri Reserves in comparison to other forests.

At the present rate of annual deforestation, the future bamboo areas in the natural forest will decline from 14,890 in 1993 to 96,000 ha in 2013 unless effective corrective action takes place. Appendix 4 contains the forecast annual bamboo area. Table 5 summarizes the total bamboo area at the start and end of the Plan. Appendix 3 has detailed annual forecasts of productive area.

Table 5 - Forecasted Bamboo Areas, Hectares

Item	1993	2013
Sylhet Division	12,240	7,300
Kassalong RF	28,000	16,770
Rankhiang RF	14,880	8,390
Sangu/ Matamurhi	22,620	18,770
Chittagong Division	42,920	26,980
Cox's Bazar Division	28,220	17,820
Total	148,880	96,030

Issues and Recommendations

Natural regeneration from seeds and seedlings has not been maintained during and after gregarious flowering. Care needs to be taken to protect regeneration from weeds and fire.

1. Intensive Biotic Interference and Absence of Management

Biotic factors, particularly the human influence, is a major limiting factor for the natural distribution and growth of bamboos in the forest of Bangladesh. Fangming (1988) mentions that the main limiting factor of bamboo distribution is deficiency of water due to destruction of forests and soil erosion. In the hill forests of Bangladesh, tribal people practice an ancient form of cultivation, locally known as jhum. Prior to the jhum cultivation, jungle cutting, burning, little soil work on the hilly terrain decrease moisture and organic matter content in the substratum and also increase the rate of soil erosion due to the runoff of torrential rain water.

Generally, the jhum area is cultivated for a year or two and then it is left fallow to allow natural regeneration of a forested cover. In the hilly areas of northeastern part of the subcontinent previously the cycle of jhum was used to be approximately 30 years (Ramakrishnan and Toby 1983), now the cycle has commonly become shortened to four-five years (Biswas 1988) due to

population pressure and scarcity of land. As a result of successive short jhum cycles, bamboos typical to the region are gradually degrading in health and density.

a. Burning prior to afforestation discourages bamboo - The fire set to burn the debris following the clearfelling of high forest prior to starting plantations progressively destroys the rhizome systems of naturally growing bamboos in the areas. Incendiary fires usually cause damage to bamboo groves and trees in the forests. These are mostly in the form of ground fire. This is particularly the case in the sungrass, savanna areas which are burnt annually and the land gradually becomes poorer in organic matter content. As a result land become dry and unproductive. Such incendiary fires are set on the hills for obtaining the pure sungrass or sometimes for fodder grass for grazing cattle. Sungrass (Imperata cylindrica) hinders both bamboo and tree growth by its gregarious nature and strong spreading runner. Fire, grazing, repeated hacking of young culms and trampling of rhizomes by cattle resulted in congested clumps with small sized ill health culms. Troup (1921) reported that in Chittagong Hill Tract weight of a muli bamboo culm was about 2.6 kg. After 63 years in 1984 the weight of some culms of the species were also measured in Kaptai, Bandarban, Rankhiang and the average weight was about 1.3 kg.

b. Protect bamboo areas by making fire lines - Bamboo forest is also decreasing due to public encroachment. In Prithimpasha AF, tribal people, mainly Khasia, use to get some land from the government for their settlement and survival. They make houses and form villages called punjee. The population in the punjee have been gradually increasing and accordingly the number of settlement also increased. Along with the tribal people some plainland people also entered into the forest and managed to collect patta, a permit to use the forest land, from the then zamindar of Prithimpasha. In the name of this patta they enter into the forest and ultimately expand the area under their control. They clear up the forest, settle and usually plant betel leaf, pineapple, etc. The Labanchara and Begunchara bamboo forests of Prithimpasha have become totally depleted. The other area are also becoming poorly stocked.

c. Participatory forestry and equity in resource sharing offer a more positive means of protection - Bamboo sprouts are removed at least for three years of weeding and clearing operation in the young plantations. Such action accelerated damage to the bamboo rhizomes.

d. Ring weeding and only vine cutting is the best practice in the tree plantation - Every year portions of pure bamboo area in the hills of Bangladesh are being converted into tree plantation. In most of the plantation bamboo failed to invade as an undergrowth mainly due to the closed canopy of the existing trees. Bamboo needs some amount of light for its survival and growth. In the last 15-20 years thinning operations are not done in due time and in most of the cases it is not being done at all. This created closed canopies which is an unfavourable condition for bamboo growth. Bamboo appeared as undergrowth only in those plantations which were thinned properly and transformed into mixed vegetation.

Thinning operation in the plantation creates crown opening and provides favourable environment for invasion of bamboos as undergrowth. Profuse regeneration of bamboo under teak plantations in the Alikheong block in Rankhiang reserve may be cited as an example in support of the above inference. A good bamboo undergrowth in Kurma and Putichara Mahal of Sylhet Forest has been observed under well-thinned teak forest. Natural regeneration through seeds and seedlings have not been maintained during and after the period of gregarious flowering.

In summary, the major practices needed are:

- Discourage burning before planting.
- Protect bamboo stands with fire lines.

- Participatory appears to offer a better means of protection compared to traditional measures.
- Ring weeding and vine cutting favours bamboo regeneration.

2. Overexploitation

Overexploitation and repeated felling of bamboo and cutting rule violations are decimating the existing bamboo resources. According to felling rules, bamboos are to be felled at three-four year rotations. In practice bamboo are being cut twice within the four year rotation. This results in deterioration of health and regeneration of bamboos. In the Dholaichara bamboo mahal of Hararganj Reserve in Sylhet Forest the contractor started harvesting bamboos in the year 1987 and could not complete within one year (1987-88). As a result, the harvesting operation was again started in the month of January, 1989 after only a one year gap from 1987-88. Similarly Sylhet Pulp and Paper Mills (SPPM) has been given permission by the BFD in 1985 to harvest bamboo from Kurma Mahal (108 ha), Sonarai Mahal (100 ha) and Champarai Mahal (881 ha) of Sylhet Forest area. The mill has been permitted again in 1989 only after two years (1986-88) of gap to harvest bamboos from these as felling operation was not completed mahals within one year (1985-86) of permission. Therefore, these two incidences are clear examples of repeated harvesting of bamboo in the same area within one-two years of gap.

Cutters do not pay importance to the existing bamboo cutting rules. Lack of adequate supervision by the field foresters, bamboo cutters most of the time cut all the mature culms from the clumps. Some older culms, usually 15-20 percent have to be retained in the clump for mechanical support and protection to the young shoots. In muli bamboo young culms are devoid of leaves excepting a very few at the tip. One year and older culms of muli have branches and leaves and therefore have the ability to photosynthesize food and thus maintain the rhizomes in full vigour. It has been observed in Kurma Mahal just after felling in 1989 that in most of the areas not a single one-two year old culm remained in the clumps. Only immature culms less than one year old were seen in the forests.

Proper field supervision specially during the time of harvesting is critical to maintain the bamboo reserves. Workers can cut the stems easily because of the diffuse and open growing culms.

SILVICULTURAL CHARACTERISTICS

Rhizome, culm and clump growth, flowering characteristics and harvesting prescriptions are discussed in the following sections.

Rhizome Growth

All the bamboo species of the Country are clump forming in nature. A bamboo clump of a species is an individual plant having more than one culm originating from the common rhizome system. Thus a bamboo clump is the smallest unit of a management. New rhizomes are produced from the previous years rhizomes. The buds in rhizome are initially flat in shape usually 10-25 mm in width, and are covered profusely with scales. The buds on the one to two year old rhizomes are alive and die progressively as the rhizome ages. Younger rhizomes are yellow while the older ones are blackish to muddy in colour. Rhizome buds start growing during March - April, just before the monsoon. Lateral buds of a mother rhizome produce new rhizomes, but a culm originates only from the distal end of a rhizome axis. Usually the basal lateral bud growth starts first; if it is destroyed then the next bud starts growing (Banik 1980).

New culm growth is completely dependent upon the nutrition provided by the rhizome of the older culms (McClure 1966). So for offset planting, the offset should not be older than two years of age. Rhizomes should not be disturbed after March/ April until the culm emerges (October).

Culm Emergence

A bamboo clump starts producing culms generally either from May or June and continues up to six or seven months ending either in October or November. Each species of bamboo has a definite period of culm emergence. The emergence period was found to be four-five months in B. nutans, B. polymorpha and D. giganteus where as the period was further long six-eight months in B. balcooa, B. glaucescens, B. longispiculata, B. tulda, B. vulgaris, D. longispathus, D. strictus, M.baccifera, N.dullooa and O.nigrociliata.

Harvesting interferes with the growth of the rhizome system and injures the emerging culms. Therefore, it can not be allowed during the peak time (June-August) of culm emergence.

Culm Elongation and Juvenile Mortality

Unlike trees, bamboo does not acquire more girth as it grows, the new sprouts emerge with full diameter. The observed total culm elongation periods of B. balcooa and B. vulgaris is 75-85 days, and 55-60 days in M. baccifera. The rate of daily culm elongation varies from 40-70 cm depending on the species. All emerging culms do not develop into full grown culms. The natural mortality of emerging culm appears (28-69 percent) in thick-walled and tall species, compared to lower rates (9-37 percent) in thin-walled and small size bamboo species (Banik 1983). Such juvenile mortality was higher in the later part of the growing season when storage food has been exhausted and rainfall lower.

Physiological conditions (clump congestion, soil moisture, and food storage) and genetic make up of each species and clump influence the rate of mortality of emerging culms. Proper thinning of culms along with occasional irrigation and fertilization are important management practices to minimize the juvenile culm mortality.

Culm Clump Growth

Generally three to five year old culms are treated as mature and thus harvested (Huberman 1959). Presence or absence of culm sheaths, culm colour and branching pattern are important morphological characters for determining culm age of different bamboo species. Culms with sheathed nodes are young. One year old culms of muli bamboo do not have branches, have only four to six leaves at the tip directly on the culm nodes, and have sheaths throughout the nodes. Three to four year old culms are usually yellowish green and may have dead black root rings on the basal nodes. Determination of age is the major consideration in harvesting bamboo. In the clumps of B. balcooa, B. longispiculata, B. tulda, and B. vulgaris production and growth (height and diameter) of full grown culms gradually increase upto fifth year of planting, after that it stabilizes or even declines (Banik 1988a).

Therefore, in these latter species, selected felling of older culms should be started after five to seven years of planting. Considering the clump expansion pattern, five m spacing between the planting stock has been suggested for these species. In M.baccifera, both culm production and clump expansion continue even after the age of 15 years.

The life of culms in the clumps is long (10-13 years) in B. balcooa and D. giganteus, while it is short (5-10 years) in thin-walled (M.baccifera, D. longispathus, D. nigrociliata, B. tulda, B. longispiculata) species. The life period of individual culms seems to be an important criterion fixing the upper limit of the felling cycle of a species. Therefore, culms of thin-walled species must

be felled at three to four years of age, whereas felling of thick-walled species sometimes may be delayed up to six to eight years of culm age.

Height and diameter growth of culm of M.baccifera is rapid up to four to five years of planting, and a culm of this species dies within four to five years due to aging effect. With this consideration felling in this species may not be delayed at beyond seven to eight years of planting.

Most bamboo species are light demanders. However, in many cases, bamboo occurring as an understorey exhibits poorer growth. Bamboo can stand fire and grazing to a limited extent due to its well developed underground rhizome system.

Congestion and Coppicing

Congestion in bamboos is one of the most serious management problems. Damage by human agency is probably one of the main causes of bamboo congestion. In localities where heavy and irregular cuttings take place the frequency of congested clumps is high. When the young culms are injured or felled many coppices shoots develop and clump congestion forms. Congested clump shoots are whippy and thinner than the normal culms.

In extreme cases, if mature bamboo culms are not harvested in time they prevent new shoot growth and as a result clumps become congested with degenerated culms. Cleaning/ thinning operations and even spacing relieve congestion in clumps and dense stands, promote regeneration and also facilitate harvesting (Huberman 1959 and Kondas 1981).

Flowering

Bamboo behaves in a peculiar manner as regards flowering and fruiting. Generally, the plant dies after flowering. The flowering and death of bamboo forest results in a marked shortage of raw materials as happened during the nineteen sixties affecting the Karnafuli Paper Mills and rural construction. Gregarious flowering and large scale death of bamboos is an alarming situation facing bamboo resource managers. No information on the dependable symptoms of flowering are known as a basis for forecasting the flowering year in bamboos at least one year ahead (Banik 1986). On the basis of their flowering behaviour bamboos can be classified into following three major groups (Brandis 1906). However, a species may exhibit flowering behaviour in more than one of these group (McClure 1966). The three classes are: annually, periodically (gregariously) and irregularly (sporadically).

Incidence of flowering in bamboo appears genetically controlled rather than an environmental effect (Banik 1980, 1986, Kasahara 1981, Watanabe and Hamada 1981). Therefore, a bamboo species will flower after a definite period of vegetative state as determined by the genetic makeup of the plant. Scientists (Ueda 1960, Uchimura 1980), till now, failed to stop or control large scale death of bamboos in the forest due to flowering. Foresters have to face this natural calamity and simultaneously manage this resource.

The exact period (seed to seed) of the flowering cycle of the species of Bangladesh are not available. Estimates are based on analyzing the past flowering records of each of the major bamboo species of the Country. The duration of flowering cycle (the gap between the two consecutive flowering) in bamboo varies from one species to another. The period between two gregarious flowering over the same area is believed to be constant for a species, thus establishing its life cycle (Troup 1921, Ueda 1960. McClure 1966). Estimated ranges of flowering cycles of different bamboo species of Bangladesh were found to be within 20-80 years but the majority have 30-50 year cycles (Hasan 1973; Banik 1981, 1987b, 1989, Banik and Alam 1987).

Table 6 forecasts the possible next flowering year of the major bamboo species of the Country on the basis of their estimated interseeding (flowering cycle) period. Bariala and barua clumps did not produce any seeds in their recent flowering, so it is not possible to predict their next flowering.

Muli bamboo constitutes 70-98 percent of bamboo vegetation of the hill forests of Chittagong, Chittagong Hill Tract and Sylhet (Choudhury 1984). The natural habitat of this species is restricted to the high rainfall hilly areas (250-600 cm per annum) of the World. This species with a net-like extensive rhizome system might have been selected naturally in the region for protecting the forest soil from erosion. Besides this ecologic importance, muli bamboo is the main raw material for rural housing and also the principal material for making basketing and matting. The species is also utilized as raw materials in the pulp and paper industries (KPM and SPPM), and for making high quality rayon. Thus, from ecologic, social and economic viewpoints, muli bamboo is an important bamboo resource for Bangladesh.

Table 6 - Major Bamboo Flowering Cycle Characteristics

Species/ Local name	Flowering Nature	Last gregarious flowering year (Date)	Estimated Cycle (Year)	Forecasted Flowering Year
Forest Bamboo Muli	Mainly gregarious, rarely sporadic	1957-61 all hill forests	30 ± 5	1987-1991 ± 5, Initially sporadic then gregarious and finally sporadic, 10-15 year flowering wave
Mitinga	Frequently sporadic and irregular, occasionally gregarious	1977-79 Shishak 1978-80 Adumpur, Lawachara	20 ± 5	1997 ± 5, 1999 5, 1998 5, 2000 ± 5 (frequently sporadic through out the forest)
Orah	Often sporadically, occasionally gregarious	1967-72 Shishak 1974 Rankhiang 1972 Rangarh	30 ± 2	1997 ± 2 2004 ± 2 2002 ± 2
Kali	Sporadic and, occasionally gregarious	1978 (Pablakhali)	47 ± 3	2025 ± 3
Dalu	Sporadic and occasionally gregarious	1974 (Kassalong)	45 ± 2	2020 ± 2
Lathi	Gregarious, rarely sporadic	1975(Cox's Bazar)	50 ± 3	2025 ± 3
Village Bamboo Bariala	Rarely in flowering state, no seed production	1979 (a few clumps in Chittagong)	80 ± 8	Any time any where, but likely to confine in a very few clumps
Barua	Rarely in flowering state, no seed production	1983 - 85 Isolated clump in Mymensingh and Rangpur	40 ± 5	Any time any where, but likely to confine in isolated clump
Talla	Sporadic, rarely gregarious	1985-88(Dinajpur)	20 ± 5	2005 ± 5 2008 ± 5
Pharua	Gregarious, sporadic	1982-83(sporadic in Sylhet)	50 ± 5	2032 ± 5 2033 ± 5
Lathi	Gregarious and sporadic	1984-86(gregarious in the cultivation of Chittagong, Sylhet	45 ± 5	2029 ± 5 2031 ± 5

Muli has already started sporadic flowering in the different areas of Chittagong, it seems the gregarious flowering and the large scale death is imminent. In Burma, muli flowering was first reported to occur during 1863-1866 (Troup 1921). After that the species had been reported (Troup 1921) to start flowering again in the area in 1902. Initially the flowering was sporadic for four years (1902-1905) which became gregarious during 1910-1913, and then finally it was again sporadic for the last two years (1915-1916). In total, the flowering wave continued for 14 years

(1902-1916) spreading over the whole forest area. According to Troup (1921), species exhibiting such 3-phase flowering nature (initial sporadic, then gregarious and finally again sporadic) with a long duration of flowering wave can be termed as gregarious flowering species. A similar flowering wave could also be observed in Bangladesh.

The last muli flowering in Chittagong and Chittagong Hill Tracts, was reported to occur in 1952, was sporadic and continued for eight years up to 1958 or 1959. Thereafter, gregarious flowering took place and continued for two years during 1960 and 1961 (Hossain 1962, Hasan 1973). So the duration of flowering wave in M.baccifera, in Bangladesh, though not completely reported, could be estimated as nine-ten years (1952-1961). The present incidence (1986 to 1992) of sporadic flowering in muli seems to be the initial sporadic flowering phase of a 3-phase flowering nature of the species. Therefore, it is assumed that the species is going to flower gregariously in the area within a few years. It is likely to maintain a flowering wave for 10-14 years, that is up to the end of 2000 AD. It also appears that the estimated gap between the last flowering (1952-61) and present flowering (started in 1985-86) of the species is more or less 30-35 years.

All muli culms of different age groups present in a clump flower and die simultaneously. The thin leafy branches produce leafless elongated floral shoots always at the apex. The inflorescence produce one-sided pseudo-spikelets on the branches. Soon after flowering the leaves rapidly turn yellow and wither, and the buds on the nodes of the branches also produce short panicles. The species produce inflorescence in September and florets start blooming within two months in November. Seeds ripen in April-May and seeding continues up to September. The weight of a fruit vary from seven to 150 g. The seed germination is high (70.8 percent) under partial shade while in the sunlight it is low 33 percent.

1. **Gregarious Flowering Problems**

a. Shortage of Raw Materials - It was reported that during last flowering in 1956-61, Karnafuli Paper Mills suffered from raw material shortage due to the large scale death of muli bamboo in Chittagong and Chittagong Hill Tracts (McClure 1966). So, the present flowering in muli bamboo is likely to create similar conditions for bamboo resources in the coming years, as happened earlier. Bangladesh pulp and paper mills have to use pulpwood during this period as an alternative raw material.

b. Problems of Natural Regeneration - Many clumps of Bambusa tulda flowered and ultimately died during 1978-79 at Sagornal Block of Patharia Reserve of Sylhet forest and also in 1983-84 at the bambusetum of BFRI, Chittagong. Similarly Dendrocalamus longispathus flowered in Koila Block of Karerhat, Chittagong forest and at the bambusetum during 1972-73 and 1977-79 respectively. Huge number of seedlings were produced naturally in the forest floor after the dropping of seeds from the flowering clumps of these two species.

Observations show that factors like shade and weed influenced the density and survival rate of the regenerating seedlings (Banik 1988b). As there was no leaves and branches on the dead mother clump the forest floor was partly exposed to the sunlight. This condition accelerated the regeneration of many vines and weeds, such as, Eupatorium odoratum Linn, Imperata cylindrica Beauv, Streblus asper Lour., Desmodium trifolium De, and Mikania scandens Willd. As a result regenerating bamboo seedlings faced competition for their survival.

It was also reported that the burning or clear felling of the dead mother bamboo clumps with in two to three months of seed dropping and germination hindered the natural regeneration process by destroying almost all the bamboo seedlings. In both the bamboo species almost all seedlings died within 7-12 months under complete shade conditions (created due to the complete shade of trees or full weeds). Leafless dead mother clumps provided partial shade to the regenerating seedings favourable for the regeneration process. In Burma, Kurz (1977) observed similar

problems for natural regeneration of bamboo seedlings. He added that it was not certain whether the next generation would be a pure bamboo jungle or whether the bamboo area would be reduced.

Young muli seedlings are comparatively tall (1.7-2.0 m), the stems are soft and tender. As a result they usually break and get damaged if disturbed. So wild seedlings need protection from grazing and disturbance.

c. Localized Famine - Muli bamboo being a member of the grass family is also monocarpic in nature. It has been observed that the whole flowering clump die within one to two years of flowering (Banik 1988b, Hossain 1962). During flowering, ripe seeds droop onto the forest floor from the master clump and germinate profusely. Seeds are eaten by rats, wild boars and other animals. When flowering is completed the seed supply to the predators is stopped and as a result rats and other animals are likely to migrate for food towards nearby agriculture fields partly or fully destroying the crops and creating a localized famine condition for the people. It has been reported (Soderstorm and Calderon 1976) that in the past flowering in muli bamboo created a disastrous condition in Burma, Bangladesh and India.

2. Muli Flowering Management

A specific study on the natural regeneration of muli bamboo has not yet been made possible as the species has just started flowering sporadically in the forests of Bangladesh after 1960. The following management prescriptions have been made based on the information developed from the studies on other bamboo species (Ahmed 1954, Banik 1988b, Seth 1954).

a. Bamboo Plantations - Large scale death of muli clumps as a result of the intensive gregarious flowering in the forests is due at the end or beginning of the century. As a result the harvesting of (dead) bamboos would rapidly increase. After that there would be sharp fall in bamboo outturn due to the final sporadic completion of flowering. The forecast years are 2004-2010 in the Hill Tracts and Chittagong, and 2010-2015 in Sylhet.

Such a shortage in bamboo can not be met within a few months or a year. At present seeds of muli are available from the sporadic flowering and the reforestation of bamboo seedlings can be geared up. Within the next 10 years these seedlings would produce merchantable culms and can compensate the future shortage of bamboo. The details of seedling germination, nursery management and their outplanting in the field have been discussed later in this report. Therefore, raising of muli plantation should be started immediately in the hills of CHT, Chittagong, Cox's bazar and Sylhet.

b. Required Cultural Operation - Natural regeneration of bamboo under complete shade condition is not possible. Like other reforestation works weeding and protection from grazing or predation are important steps to be taken for the optimum natural regeneration and growth of the bamboo seedling. Proper weeding and maintenance of the seedling enhance the growth and within four to five years muli seedlings develop into merchantable clump, whereas it take 10 - 12 years in natural condition. Though the work may involve expenditure, it will protect the bamboo resource and maintain the success of natural regeneration. Bamboo seedlings are not available every year and therefore need protection.

Partial shade condition and occasional weeding promote successful natural regeneration of bamboo seedlings after each gregarious flowering in the forest. To provide partial shade to the regenerating seedlings felling of dead mother clump must be delayed at least for six to nine months.

Light thinning of bamboo seedlings from the densely regenerating areas decreases the seedling competition. These thinned out wild bamboo seedlings can serve other plantation programs.

c. Seed Collection - During flowering period millions of seeds of muli bamboo are available. Therefore huge number of seeds could be collected and germinated for seedling raising. This also minimise the predation and the population of rat and other animals will also be under control. These numerous seedlings can be planted in the hills either as pure or under the well thinned long rotation plantations.

Harvesting Prescriptions

a. Over exploitation by repeated cuttings of bamboos more than once per year from a unit area of the forest must be stopped. In reality it is the field labourers who themselves select, cut and harvest the bamboos from the forest. Therefore, they need training and education by the foresters about the existing bamboo cutting rules (Appendix 3). An audio-visual aid may be utilized to educate the labourers, contractors and permit holders before entering into the bamboo forest for the purpose of harvesting. FDTC may conduct such training program for the natural bamboo forests. Forest Extension Department and NGOs may take the task of training the farmers about the village bamboo groves. NGOs trainers may be trained by FDTC/BFRI/Forest Extension or by all the three agencies.

   The areas of bamboo mahals in Sylhet forest are large ranging from 400-1,000 ha. The field staff of related forest divisions are not sufficient to look after and supervise the whole felling operations inside such big land areas. The big mahals may be divided into a number of small mahals. Strict superior supervision must be ensured.

b. New roads and paths are to be established in the inaccessible areas of the forest to facilitate the bamboo extraction. Construction of overhead ropeway may be useful as KPM did in the Chittagong Hill Tracts.

c. Following the prescribed bamboo cutting rules properly produces negligible wastage. Thorough supervision is needed to advise and guide the labourers. The present cutting rules (Appendix 3) are perfectly adequate, if followed, to preserve and sustain the resource

   During harvesting a bamboo culm must be cut at the soil level and saw/hacksaw must be used to avoid splitting or tearing of the stem. The thin top portion of the bamboo must not be chopped off and left at the forest. To encourage the labours to bring full bamboo by shoulder load they must be paid a higher wages rates than at present. This will lead to a substantial reduction in the wastage of bamboo during harvesting. It may be mentioned that the top and butt portion of the bamboo which are now left at the field contains longer fibres and the higher cellulose content, respectively, are essential ingredients for producing quality pulp.

   Besides this, to discourage the present practice of wastage, contractors engaged in harvesting must be penalized if such wastage are found by the supervising authority. Cutting terms and conditions must be rigidly incorporated in the contract documents.

d. Both poor and big farmers are to be educated about the management and harvesting of bamboo groves. Proper marketing and processing facilities of bamboo have to be developed through activating and establishing new, small scale and cottage industries in the rural areas. As a result, bamboo will be regarded as a cash crop and farmers will know that intensive management of bamboo groves will pay.

Bamboo can be treated with inorganic water soluble preservatives to increase the durability in use. As a result, annual requirements of bamboos in the rural construction work will gradually come down and over exploitation from the bamboo groves will also be discouraged.

BAMBOO HARVESTING

General

The bamboo vegetation in the forests and villages, are not similar. Bamboos in the forests usually cover in large tract of land from valley, slopes and tops of the hills. In villages bamboos are cultivated in the homesteads, usually the clumps are in few in number, rarely covering one-two ha land. Village bamboos are, majority, in the plain land of the Country and clumps are owned by the families whereas the forest bamboos are owned and maintained by the Government. Morphologically, forest bamboos are thin-walled and comparatively smaller in size to village bamboos. Besides these technical aspects, harvesting procedures in these two sectors are not similar and therefore are discussed separately.

The agencies responsible for harvesting forest bamboos are as follows:

a. Karnafuli Paper Mills Limited (KPM) from their licensed areas in the forests of Kassalong and Rankhiang Reserves.
b. Sylhet Pulp and Paper Mills Limited (SPPM) from their allotted areas in the forests of Sylhet Forest Division.
c. Auction purchasers through their own agencies.
d. Permit holders for domestic uses and trade.

1. Karnafuli Paper Mills Limited

The area earmarked for KPM is 17,349 ha in the Kassalong and 3,3351 ha in Rankhiang Reserve Forests. The harvesting of bamboos is done on a three year rotation using selection felling. Normally, felling starts in October and lasts for about 120 days in a season. Harvesting of bamboo crops include a series of operations broadly divided into three phases as follows and charted in Figure 2.

a. The felling of exploitable bamboo stems 0.3 to 0.45 meters above the ground, their trimming and cutting into pieces for bundling then extraction by ropeway - shoulder load and haulage to river side depots.

b. Transporting of bamboo includes bunching and rafting from river side depot to the Kaptai Bamboo Yard.

c. Chipping, handling and supply of bamboo from the Kaptai Bamboo Yard to Chandraghona at KPM's mill site by ropeway, rafting or by agricultural tractors and trailers.

KPM carries out the extraction program by employing contractors using hired labourers. Bamboo cutting is generally carried out in two phases - road side cutting and ropeway cutting. In roadside cutting, cutters cut bamboo along the road extending to an average lead of 90-150 m. In ropeway cutting, cutters cut bamboo extending to an average lead of 90 m on each side of the ropeway. On average, a labourer can cut, trim, carry and stack 100 bamboos/day which is equivalent to about 210 kg (Zahiruddin 1967) to 250 kg (Choudhury 1984).

Bamboo cutting is a piece rate job, irrespective of age, size and quality. Felling is purely manual using a sharp tool (bill hook or dao) for cutting bamboo stems three years old at or above 15-35 cm from the ground level. Labourers are always tempted to harvest bamboos from the easily accessible areas, usually from the banks of perennial streams (chara). Therefore bamboos are over exploited in these accessible areas. The over use causes a gradual degeneration in health and

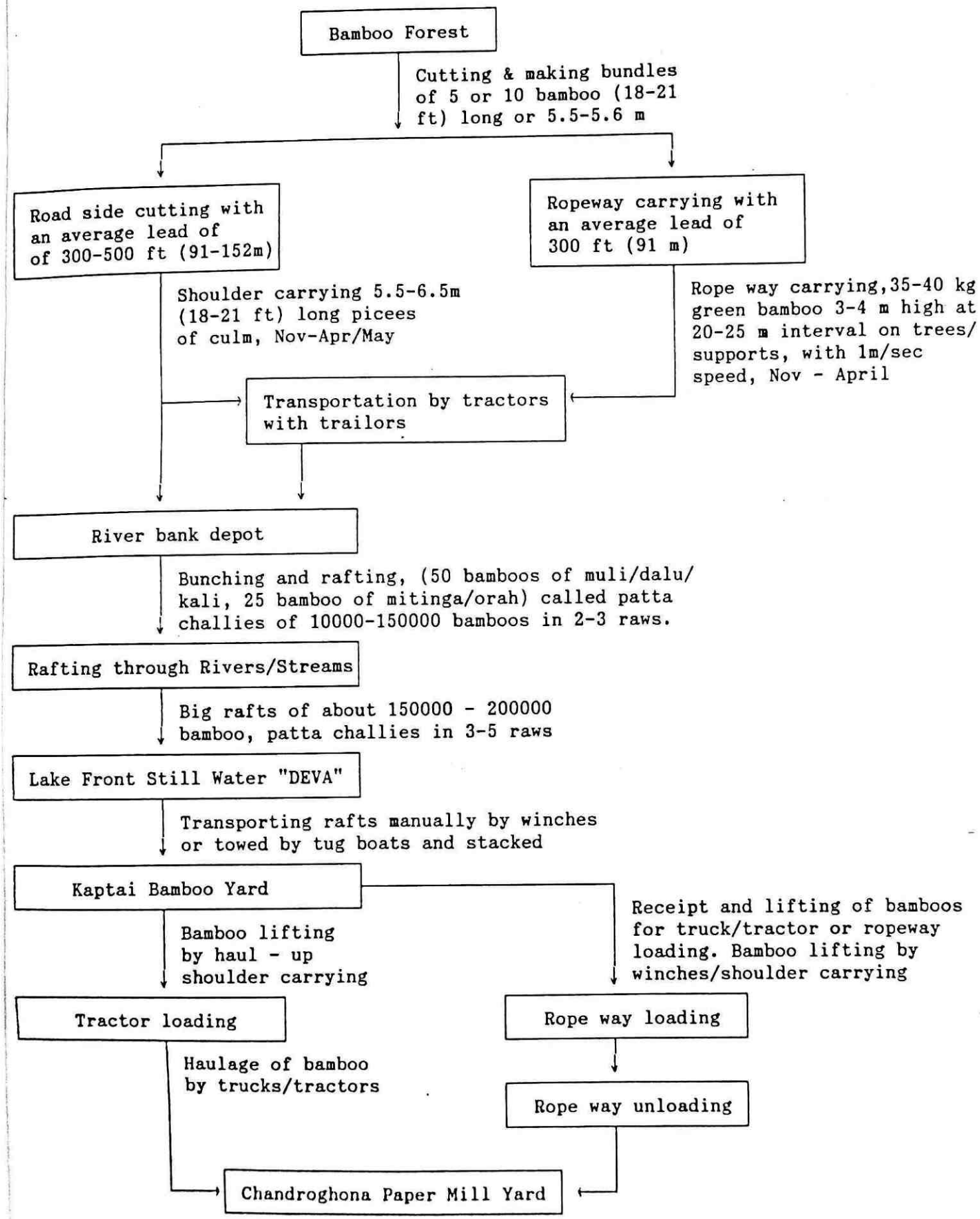


Figure 2 - KPM Bamboo Harvesting and Transportation Flowchart

size. Bamboos are seldom harvested from the steep slopes or inaccessible areas in the forest, and as a result bamboo clumps in these areas remain undercut (under exploited) and congested conditions develop.
Moreover, labourers often cut bamboos 1.0-1.5 m above ground level, chop off the upper narrow portion 1.5-2.0 m, only harvesting the mid portion. The basal 1.0 to 1.5 m is heavier and has more biomass and the upper portion of the culm has longer fibre length much desired for pulp production. In most of the cases these portions are left in the forest and not harvested even by the pulp and papermill authority. Choudhury (1984) estimated that about 50 percent of the total length of the harvested bamboo is left on the forest floor.

After felling, the culms are pulled out of the clump, then limbed and trimmed for handling and cut into pieces of 1.7-3.0 m in length for road or rail transport. Generally, 5.5-6.5 m, sometimes 8 m, pieces are transported through waterways. After felling, bamboos are tied with doga bamboo (very young soft culm), or strings made out of bamboo into bundles of 5-10 pieces each, so that each of the bundle can be carried on the shoulder. In the case of muli/ dalu/ kalichari, 10 bamboos are tied to make a bundle. But orah and mitinga bamboos are comparatively bigger in size and, therefore, usually five stems are used for a bundle (Hossain and Sharwardy 1990).

A ropeway system consists of endless moving cables which are suspended at about 2.5-3.0 m above the ground at an interval of 18-25 m on trees or other supports. The cable is operated at a slow speed of one m/ sec by a 20-25 hp petrol/ diesel engine. Maximum load given is 30-35 kg (green) at an interval of about 12-15 m. The ropeway extraction season is approximately five months duration from November to April. These bamboos are than stacked at the ropeway heads to be carried by tractor trailers to the river site.

Tractors with trailers are used for the transportation of bamboos extracted by ropeways as well as those cut along walking paths. The operations generally starts from November depending on the good weather and conditions and lasts until the monsoon starts.

Alongside streams or charas 30 or 50 bamboos are bundled into pattas and then floated into the water. When water depth is shallow the pattas are floated by constructing temporary earthen dams, locally called godha, to raise the water level. At the beginning, small rafts of 10,000-20,000 numbers of bamboos are prepared and in the bigger streams up to the lakefront large size rafts (100,000-150,000 pieces) are made and transported. These big rafts are propelled either by a manual winch or tug boats. A contingent of 8-12 men can handle such big rafts in fair weather. Rafting starts from November and continues upto March after which it becomes risky due to cyclones and rains.

Bamboos harvested from Kassalong are always not possible to transport to the Kaptai depot in the same year due to long distance. Therefore, KPM stacks bamboos in the riverbank depot inside the forests. Bamboos also get lost during transit when the rafts are torn apart by storms or caught in the narrow streams. It has been reported that on average 11 percent of total harvested bamboos decayed in one year in the forest stacks and 7-19 percent got lost in the flood or rain during the years 1971-1975 (Choudhury 1984). Such loss due to rotting can be minimised by proper stacking and spraying of proper pesticides during storage. Proper care can also minimise the loss in transit. Bamboo is also lost during transit when the rafts get caught in the monsoon floods in narrow streams. In wide water courses the bamboo rafts may be torn apart by storms and high waves. Choudhury (1984) reported about five percent loss in transit.

The average delivery cost of bamboo, 1976-77, from Kassalong and Rankhiang to Chandraghona was Tk 490/ ADT including supervision charges (Choudhury 1984). The cost has gone up in the subsequent years and reportedly was Tk 1,088/ ADT in 1980-81 and Tk 1,343/ ADT in 1983-84. During 1990-91 the cost of harvesting and transportation including royalty up to the mill is Tk 2,525/ ADT, almost double that of 1983-84 (A Hossain, 1992).

2. Sylhet Pulp and Papermill

Bamboo is present throughout the southern part of the Sylhet Forest Division as an undergrowth of the high forest and in some plantations or as a pure vegetation in Rajkandi, Patharia, Hararganj Rfs and Prithimpasha AF. These Reserves and Acquired Forests are divided into bamboo mahals that represent the area units under bamboo extraction every four years. Bamboo mahals identify the catchment areas of the water courses (or charas) that are used for the bamboo extraction and after which they are named such as Surmachara Mahal and Dholaichara Mahal. Sylhet Pulp and Papermill's (SPPM) allotment is 12,150 ha in the Sylhet bamboo forests.

Every year after getting allotment of bamboo mahals from the Forest Department, the Mill authority appoints a harvesting contractor through tender. The permission for harvesting bamboos remain valid from 1st January to 31st December, with a gap of three months from 16th June to 15th August. This gap period is a closed season for harvesting. Cutting procedures are also similar to those practised in the Kassalong and Rankhiang RF's. Labour usually make bundles of 100 bamboos and stack then inside the forest. These are then transported by waterways on a particular day of a week to the base depot on the bank. The size and number of the felled bamboos are then checked and verified by the SPPM and BFD officials.

The cutting operation coupled with transportation upto the base depot on the stream bank is done in dry weather. Transportation through water is done during the rainy season. A long distance of over 300 km is to be covered to the mill site at Chattak. Part of this distance bamboo has to be transported against the river current.

The entire operation is done on contract and the delivery cost including supervision up to the mill site came to Tk 905/ ADT during 1980-81 and Tk 1,204/ ADT in 1983-84 (Choudhury 1984). At present the cost has gone up. It varies between Tk 2,500 to 2,600/ ADT during 1990-91, similar to KNM's costs. (A Baten, 1992, Personal written communication).

3. Auction Purchasers

Bamboos from the nonlicenced area of Sylhet, Chittagong and Cox's Bazar Forest Divisions are sold in auctions. The cutting cycle is three-four years and the yield is regulated by area. Every year bamboo coupes are auctioned and very competitive prices are obtained. The extraction of bamboos by the auction purchasers is a manual process described above. Shoulder load transportation up to the river bank, extends 3.5 km in same cases, are is done by the labourers due to the absence of extraction forest roads. As the cutting and extraction is done on a piece rate basis, the workers have tendency to cut more bamboos in the accessible areas, and also immature (less than one year old) bamboos ignoring the prescribed cutting rules (Appendix 3).

Bamboo extracted by purchasers in the Sylhet Forest Division is often sold to the bamboo traders at the major transportation points, mostly located near the railway stations. The average price in 1984 for muli bamboo at Juri station reportedly was Tk 3,000 to Tk 3,500 depending on the quality (Choudhury 1984). During 1990-91 the price has gone up and according to Juri Ranger, the price of average size muli bamboo is about Tk 5,000 to Tk 5,500/ 1,000. In the case of quality muli bamboo (3 years old, 6.5 m long, 15-17 cm girth at base), the price is Tk 6,000 to Tk 7,500/ 1,000.

Long distance transportation even upto Barisal and Patuakhali is carried out mostly through rivers and taken to these areas in big rafts. Some bamboos are also transported by rail and truck. Sometimes, to reduce bulk, bamboos are converted into tarjas (flats) and transported by bundles in trucks or on railway wagons (Choudhury 1984). Generally the bulk of the bamboo extracted in Sylhet by the auction purchasers is utilized outside the District. However, for local consumption there is a provision that the auction purchaser should allow a certain percentage (25-

30 percent) of total bamboo of the auction coupe to the local permit holders. The local demands are also met by issuing permit of bamboos in the clearfelling reforestation coupe areas. Some of the auction - auctioned bamboos are also sold to SPPM.

4. Permit Holders

In the Chittagong Hill Tracts, bamboos are mostly sold through a permit system issued by the local officers, specifying the quantity, area and the time limit. The royalty for the quantity of bamboos is paid at the time of issuing the permit. After the completion of the harvesting rafts are checked by the Forest office and royalty realized for any extra bamboos taken out. The entire system is a manual operation and is mostly located along the river bank or stream bank for ease of extraction. Under this system bamboo is rarely cut beyond 1.6-3.2 km of the floating stream banks.

Such bamboos are rafted or taken by boat by the permit holder to important selling centres. These bamboos are mostly sold at Kaptai, Dohazari, Chiringa and the local markets near the forests of the Chittagong and Cox's Bazar Forest Divisions. At Kaptai, a substantial quantity of the bamboos extracted by the permit holders get purchased by Karnafuli Paper Mills. This is the cheapest method of bamboo harvesting but, due to the change of hands, the prices go up to accommodate the profit of the different parties. This method only harvest bamboo in the accessible areas along the stream and river banks.

The wholesale price, in 1984, of muli bamboos at different centres like Kaptai, Dohazari, Chiringa (Chittagong) reportedly varied from Tk 2,000-4,150/ 1,000 culms (Choudhury 1984). The 1991-92 price went to Tk 3,500-Tk 5,500/ 1,000.

Village Bamboo

Bamboos in the village homesteads mostly occupy the backyard and the periphery of the holdings. Village species are clump-forming, usually congested in nature with large, tall, branchy culms. Moreover the mature harvestable culms (more than three years old) are in the clump centre. Therefore, harvesting is more difficult and time consuming. This is partly compensated by the higher price for village bamboo (Table 6). In most of the districts the price of a culm of barak bamboo, the most useful and common species, has gone up three to four times within the last ten years.

Due to the price hike, the rate of felling of bamboos is increasing in some villages near urban areas. Compelled by poverty and tempted by higher price, poor farmers also sell immature good looking bamboos to traders. This practice ultimately destroys the clumps by gradually decreasing the rhizome vitality. Thus, the landless and marginal farmers bamboo supply is decreasing and less is available for house and fence construction. Previously, the bamboo traders could collect and purchase local bamboos for the market. Now they have to move further into the rural area to collect bamboos. Abedin and Quddus (1990) reported that bamboo traders at Kushtia Town used to purchase bamboos from a village near Sadar Upazila as recently as four years ago but now collect from Rajbari District. Similarly, traders at Rajshahi Town have to go to Kurigram, Thakurgaon and Saidpur Districts to purchase bamboos. A few years ago they collected from villages within the district or from Natore and Ishurdi.

In contrast, big farmers and absentee landlords in the Greater Districts of Dinajpur, Rangpur, Rajshahi, Pabna, Jessore, Kushtia where bamboos are cultivated in the uplands as patches on small farms, do not usually fully sell or harvest their bamboos. As a result, in this part of the Country the clumps are in a congested condition. If any culms are harvested from these clumps bamboo traders cut and collect immature culms from the peripheral zone as the owners do not supervise the harvesting operation properly. Decreased numbers of immature culms adversely affect the

regenerative capacity of the clumps. In the clumps unharvested, mature culms die due to their over age and start rotting in the rainy season. These unhygienic conditions attracts insects and fungi initiating diseases in the clumps (Boa and Rahman 1987).

Most farmers treat bamboo as an insurance crop not a cash crop like rice or jute. According to the survey report on farm forestry of 1988, the purpose of sale usually included meeting family expenses, payment of loans, marriage, festival, etc. (BBS 1990).

Farmers in the west and north western part of Bangladesh also dig up the old and dead rhizomes to sell to the local brick kilns. Kiln owners purchase the bamboo rhizomes at the rate of Tk 600-800/T, while the cost of fuelwood is double that amount. For the last ten years bamboo rhizomes are being extensively used for brick burning in these areas of Bangladesh. It become serious concern to the Government. Questions are often asked why the farmers of these localities are destroying their own bamboo groves. A personal interview of 50 farmers in the villages of Bogra, Rangpur, and Saidpur showed that farmers only sell the old and dead rhizomes. They know that older rhizomes of a clump do not produce a new culm and eventually die, therefore, such practice is useful to maintain the productivity of bamboo groves.

Considerable force is needed to pull cut bamboo out from the clumps. Once extracted, the culms are trimmed to full length. There is no standard length to which bamboos are cut after felling. The cutting length depends on the types of use. Sometimes the bamboos are cut into suitable lengths for ease of transportation depending on the mode of transportation used. In road and rail transportation, the lengths are cut to accommodate the space. In water raft transportation, full lengths of bamboos are usually transported. If, however, boats are used, culm length is cut accordingly.

Table 7 gives the average wholesale price of barak bamboo in important town centres in selected years.

Table 7 - Annual Average Wholesaler Price of Barak Bamboo

Year	Dhaka	Narayanganj	Chittagong	Rajshahi	Khulna	Sylhet	Rangpur
1982-83	32	32	26	23	24	22	23
1983-84	30	32	31	30	26	27	23
1984-85	40	39	42	31	38	34	36
1985-86	45	41	52	46	36	44	44

Source: 1989 Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics; and monthly Statistical Bulletin of Bangladesh, July 1991.

Issues

Reviewing the existing harvesting and transportation method of bamboos highlights the following issues:

a. Over exploitation in the easily accessible natural forest.

b. Incomplete utilization in the unexploited areas of natural forest.

c. Resource wastage during harvesting and transportation from the forest.

d. Ignorance of appropriate cutting rules for the village bamboos.

e. Both over and under exploitation of village bamboos causes resource degeneration.

BAMBOO SUPPLY AND DEMAND

Domestic Use

The reports of Douglas (1981), Byron (1981), Choudhury (1984), Ohlsson (1984), and FAO (1986) are important documents which have dealt with the consumption of bamboo in Bangladesh. All these reports primarily use the survey report of Douglas (1981), which estimated bamboo per capita use at 35.7 culms. Without preservative treatment bamboo is unlikely to last more then three or four years in external, and perhaps as little as a year when exposed to the atmosphere and the soil (Liese 1985). Under cover it may last four to seven years. In rural Bangladesh construction materials are very rarely treated with preservatives, therefore almost every year a portion of the dwellings are repaired and replaced with new materials.

With the above consideration Douglas (1981) estimated the average durability period of bamboo as 3.5 years. Thus his estimate of bamboo use was 35.7 ÷ 3.5 = 10.2 bamboos/ capita/ annum in rural house construction. By multiplying the figure with the rural population of 1981, the estimated number of bamboo comes to 738.9 million. However, according to FAO (1986), the national consumption of bamboo for construction for the year 1980 was 1.7 to 2.5 million tonnes. This report did not give any conversion from weight to the number of bamboos, the standard measure for bamboo. Therefore, it becomes difficult to accurately ascertain the consumption of bamboos in terms of weight. In fact, with the exception of the paper mills, bamboo use is quantified by numbers, including small scale cottage industries. It is more understandable to most users if the supply and consumption data are given in numbers.

Byron (1981) estimated the consumption of bamboos as per the Douglas (1981) estimation of 10 bamboos/ capita/ annum. Choudhury (1984) also estimated the total quantity of bamboo consumption per year for building construction. His estimation was 0.742 million ADT of bamboos and according to him this is fairly close to Douglas' (1981) figure 0.803 million ADT.

The Forestry Master Plan surveyed different regions of Bangladesh in 1992 to have a direct statistical estimation of bamboo consumption including house construction and agricultural implements. The FMP report presents survey results, contains a detailed description of the methodology of the survey procedures, and an assessment of its suitability and limitations. Based on this 1992 survey the estimated use of bamboo in rural building and fencing is 19.9 per capita. Considering the lifespan of a bamboo as 3.5 years, as Douglas (1981) did, the number of bamboo required for construction of rural building is 5.8 or 6.0 number per capita annually.

This reduction from ten to six culms is attributed to the following reasons:

a. The price of Bamboo poles are high and becoming unaffordable to poor villagers.

b. The standard of living has increased and big farmers are now using other materials like bricks and cement.

c. Absentee landlords are increasingly common and they are reluctant to repair their inherited houses.

Thus the total estimated requirement of bamboo in rural house construction and fencing at the base year 1993 is 564.3 million culms (94.05 million rural population x 6). Regional estimated bamboo demand on the basis of population density is as follows. Appendix 3 defines the regional boundaries exactly.

Region	Million Culms
Northwest	148.8
Northcentre	107.7
West	78.7
South	64.7
Southeast	87.2
Northeast	72.0
Hill Tracts	5.2
Total	654.3

The use of bamboo in constructing agricultural implements has also been assessed in the present survey of the FMP Project. The per capita consumption of bamboo in this sector has been found to be 5.1 m. For fabricating various types of agricultural implements villagers use both thin and thick-walled bamboos. As most of these materials are used inside the house the lifespan of these material is likely to be more than 3.5 years, assumed as 4.5 years. It is also assumed that an average bamboo is 9.4 m long. Thus, total requirement of bamboo in fabricating agricultural implements at the base year 1993 is (94.05 million x 5.1 m = 479.7 million metres), 51.0 million bamboos. Considering the life span as 4.5 years, the total figure comes to 11.4 annually.

For the purpose of obtaining a complete picture of bamboo consumption, bamboo usage in structures excluded from individual households need including. These are religious buildings, schools, shops, tea stalls, small factories and bridges. According to Douglas (1981) about 0.014 bamboo were in use for each person. Thus the present requirement of bamboo in this sector is 0.38 million culms (0.014 x 94.05 = 1.32 million bamboos ÷ 3.5 years).

Besides the rural use of bamboos as construction material, many urban houses are also constructed with bamboos. The Population Census 1981 reports that 6.9 million urban households use bamboo both as roofing and walling material. The average population size of a household during 1981 was 5.79 (BBS 1989) persons. Thus the estimated population in these household comes to 40 million. Per capita annual bamboo use for house construction is 19.9 bamboos and the durability factor is 3.5 years. Estimated annual bamboo consumption in this sector is 22.7 million pieces (3,992,014 x 19.9 ÷ 3.5). The 1991 census shows that the number of household increased by 32.7 percent over 1981. Therefore, the estimated consumption of bamboo in this sector at the current year becomes 30.1 million culms.

FAO (1986) reported the use of bamboo as fuel was 2.3 million tons for the year 1980. The report also mentioned that though the fuel usage of bamboo is heavy, it consists mainly of old, rotted structural material or tops, roots and leaves from the bamboo stands. Therefore according to Ohlsson (1984) the bamboo as a fuel should not enter into any estimate. In summary, the estimated total domestic consumption of bamboo in base year 1993 is as follows: (Appendix 4 has regional details).

Domestic Consumption	Culms Million
Rural Housing	564.3
Agriculture Implements	11.4
Community Buildings	0.4
Total Rural	576.1
Urban Housing	30.1
Total	606.2

Pulp and Paper Industry

Karnafuli Paper Mills Limited (KPM) was established at Chandraghona in 1953 for producing 30,000 ADT/A to meet the requirements of the Country. The mill was designed to use 100 percent muli bamboo as its fibrous raw material (FRM). The Government granted KPM exclusive licence of 959 km reserved bamboo forests in the Chittagong Hill Tracts on 99 year lease. Later in 1968, the original base area was revised to 510 km plus a temporary allotment of 114 km , in total 624 km of bamboo forests in the Kassalong and Rankhiang RFs.

It is evident from the Table 8 that up to 1982 KPM used to receive more bamboos from the leased forest than from the private source. After 1982-83 and specifically since 1985 the industry depended more on private source for its bamboo requirement mainly due to the deteriorating law and order situation in Chittagong Hill Tracts which minimised the extraction of bamboos from the leased area of forests. Out of total bamboo receipts during 1989-90 and 1990-91, private sources contributed 93 and 85 percent respectively. Presently, the mill uses muli bamboo and wood more or less in a 50:50 ratio (Table 10). It is also important to note that village grown baria bamboo contributes about 20 percent of KPM's raw material needs. Muli bamboos are also purchased by KPM from the auction purchasers and local permit holders as a private source.

The law and order situation in the Hill Tracts, specifically after 1985, has made KPM more dependant on private source for muli. Figures show that during last five years (1986-87 to 1990-91) on average 80 percent of the mill's muli bamboo derived from private sources while only 20 percent comes from the forest (Table 10).

Table 8 - 10-Year Industrial Bamboo Use for Pulp and Paper

	Karnafuli Pulpmill			Sylhet Pulp and Papermill			
Year	Lease	Private	Total	Lease	Private	Total	All
1980-81	22.3	15.9	38.2	11.9	16.5	28.4	66.6
1981-82	22.0	14.7	36.8	7.0	15.5	22.5	59.3
1982-83	21.0	21.5	42.5	12.7	14.3	27.0	69.6
1983-84	13.9	16.9	30.9	15.2	15.1	30.3	61.2
1984-85	15.9	12.8	28.6	7.1	14.3	21.4	50.1
1985-86	10.0	27.5	37.5	2.8	22.4	25.1	62.6
1986-87	4.4	50.2	54.6	7.0	26.0	33.0	87.6
1987-88	12.0	39.8	51.7	5.7	23.2	28.9	80.7
1988-89	10.8	32.4	43.2	9.4	16.9	26.3	69.5
1989-90	3.2	42.7	45.8	7.2	22.7	29.8	75.5
1990-91	7.0	39.3	46.3	9.4	17.7	27.1	78.7
Total	14.3	313.6	456.1	95.4	204.7	300.1	761.4
Aver ADT/A	13.0	28.5	41.5	8.7	18.6	27.3	68.8
Percent	31.2%	68.8%	100%	31.8%	68.2%	100%	100%
Aver/A[c]	8,098	17,818	25,917	5,422	11,631	17,053	42,969

Source:
[a] Hossain, A. and Sharwardy, M.(1990).
[b] Baten, A. Forest Manager, SPPM, 1992.

From 1980-81 to 1990-91 the consumption of bamboo by KPM totals 241,665 ADT and averages 41,470 ADT/A. This conversion is based on 625 bamboo/ADT (Hussain, 1992). An annual requirement of 48,000 ADT, is equivalent to 45,000 ADT x 625 = 25.92 million culms. KPM's production target for paper and rayon pulp is in two phases. Phase I (from 1990-94) has a production target of 42,300 ADT/A before completion of the papermill BMRE, while Phase II (after the 1994 BMRE) indicates production target of 55,000 ADT/A.

Table 9 summarizes KPM's future requirement of bamboo to fulfil the production target as follows:

Table 9 - KPM Planned Bamboo Needs, 1990-94 and 1995 Onward

Item	Phase I, 1990/91-1993/94		Phase II, After 1994/95	
	Paper	Rayon	Paper	Rayon
Target	34,000	1,800	40,000	3,000
Raw Material				
Wood/Bamboo	72,000	6,300	84,800	10,000
Bamboo only	36,000	6,300	42,500	10,000
Buffer Stock	-	-	2,000	-
Total Bamboo	42,300		54,000	

(a) 2.65 MT raw material/paper tonne
(b) 3.5 MT raw material/rayon tonne

KPM has capacity to produce 80 percent pulp. The rest, 20 percent pulp, comes from SPPM and imports. The annual requirement of bamboo upto 1993-94 as per planned target is 42,300 ADT. However the present requirement of bamboo, as calculated on the basis of the last five years consumption, is 45,000 ADT/A (Table 10). This is taken as the annual requirement instead of 42,300 ADT/A considering two weeks buffer stock of raw material.

KPM, therefore, annually uses (45,000 ADT x 625) = 28.3 million culms before mill BMRE. Thereafter, balancing modernization and expansion will increase production to about 55,000 ADT/A. Therefore, in total, 55,000 ADT x 625 = 34.4 million culms is the use from 1994/95 onwards.

Table 10 - KPM's Raw Material Use 1986 to 1991, (000 ADT)

Year	Muli Bamboo			Baria	Wood	Total
	Lease	Private	Total			
1986-87	4.4	29.4	33.9	20.8	13.2	67.9
1987-88	12.0	24.9	36.8	14.9	13.8	65.5
1988-89	10.8	23.0	33.8	9.4	29.0	22.2
1989-90	3.2	30.5	33.7	12.0	36.5	87.2
1990-91	7.0	38.7	45.7	.6	21.4	67.7
Total	37.4	146.5	183.9	57.7	113.9	310.5
Percent	20.3%	79.7%		16.0%	32.0%	
Ratio			50	50		100

Source: Hossain, A. and Sharwardy, M (1990).

During 1961 the Government began planting to establish the Sylhet Pulp and Papermill (SPPM) at Sylhet for the production of 15,000 ADT/A of pulp based on the utilization of naturally occurring reeds. In 1967, the production target was changed and the capacity increased to 30,000 ADT/A. Meanwhile, the availability of reed did not materialize. The little reed available has

gradually degenerated due to intensive biotic interference and ecological changes in the reed lands. Therefore, the current raw material supply plan is:

Item	ADT/A	Percent Pulp ADT/A
Bamboo	45,000	60 =18,000
Reed	15,000	20 = 6,000
Jute Cutting	15,000	20 = 6,000
Total		30,000

The mill began production in 1975. In accordance with the above target of production 45,000 ADT of bamboo is the annual need. SPPM's allotment, designed to work the area quickly, is set as follows:

Item	Hectare
Rajkandi RF	8,094
Prithimpasha AF	4,047
Total	12,151

Since 1975, SPPM collection used a three-four year rotation. In addition to the Government source, SPPM also procures bamboo from tea estates and local villages as private source (Table 15). Both the sources have contributed at 50:50 up to 1983-84. After that period the supply from the forest gradually declined. At present it is down to 32 percent only. The total amount of bamboo collected annually by the mill is around 27,000 ADT, well below the target of 45,000 ADT. This indicates that the annual supply of bamboo requires improvement.
Maintaining the bamboo requirement of SPPM needs only 50 percent of the total raw material. This means only 35,000 ADT gets used compared to 45,000 ADT. At the moment 27,000 ADT bamboo is harvested by the mill so only an additional 8,000 ADT will be required to procure 35,000 ADT/A.

Cottage Industries

The Bangladesh Small and Cottage Industries Corporation (BSCIC) reports that the present total number of village bamboo and cane products industries is 46,400. Mymensingh (4,470), Dhaka (4,442), Rangpur (3,932), Sylhet (3,875), and Chittagong (3,332) have the maximum number of industrial units out of total 20 districts surveyed (BSCIC Unpublished Report, 1993).

The amount of raw material consumed annually by these industries are not available from the survey report. Only the value of the raw materials are given from which it is difficult to assess the amount of material used per annum. However, it has been assumed that about 95 percent (44,241) of the total number of industrial units are mainly dependant on bamboos as raw materials. These industrial units have been grouped under the following seven different regions of the Country from the main survey data report (Table 11).

Based on an analysis of the BSCIC report of 1981-82 and 1991-92 the bamboo based cottage industries of Bangladesh is stagnant during the last ten years (Table 12). Only a quality product is likely to improve the condition of the industries combined with better marketing.

Table 11 - Small Scale Cottage Industry Bamboo Needs, 1991-92

Region	No. Industries	Annual Culms (Million)
Northwest	11,017	11.5
Northcentre	8,842	9.2
West	7,523	7.8
South	2,520	2.6
Southeast	6,872	7.1
Northeast	7,045	7.3
C H Tracts	422	0.5
Total	44,211	46.0

(a) Basic assumption, 20 bamboos are consumed in a week by a unit of industry, cottage industries operate fully during the lean season of agricultural activity, so requirement is averaged.

Transportation Industry

Boat and Bullock Carts - Both boats and bullock carts are the major means of transport in the villages of Bangladesh. In the localities intersected by the rivers, canals and streams, boats are the only cheap transports for people and movement of goods. This become more important during the rainy season and flood. In the comparatively raised and drier localities of the Countryside bullock carts are also important both for men and movement of goods. According to the last available district statistics there are about 0.72 and 0.53 million boats and bullock carts in Bangladesh (BBS 1983). Based on these statistics, the distribution of both boats and bullock carts in different regions of Bangladesh is shown in Table 12.

Table 12 - Performance of Bamboo Based Cottage Industries

Item	1981-82[a]	1991-92[b]
Number Units	42,169	46,386
Labour Employed	125,960	138,556
Value of Raw Material Consumed, Million	Tk 224.0	Tk 246.4
Production Cost, Million	Tk 237.2	Tk 260.9
Sale Value, Million	Tk 500.2	Tk 550.2
Fixed Investment, Million	Tk 98.8	Tk 122.8

Source: [a] Cottage Industries of Bangladesh - A survey BSCIC, Dhaka, Oct. 1983.
[b] Unpublished report of BSCIC of 1990-91.

In boat and bullock cart construction bamboo plays a vital role. Boat roofs, plying rods and platforms are made of both thick and thin-walled bamboos. Similarly, cart shed roofs, cart platforms, and cart yokes are also made of bamboos. On average 10-12 bamboo are required in boat and a bullock cart construction. Durability of bamboo in boats is comparatively low, estimated at four years. In bullock carts the durability is considered at five years.

Based on these assumptions, the annual requirement of bamboos for boat and cart construction the estimate is in Table 13. As the estimation relies on 1983 statistics, a five percent increase in the total requirement has been considered for 1992-93. Presently, the annual requirement of bamboo for constructing the boat and bullock cart is 3.2 million culms. Generally, boat and cart roofing uses thin-walled bamboos like muli, mitinga and makla. Thick-walled bamboos like barak, jai, baro and farua occur in bullock carts.

Table 13 - Bamboo Use in Construction of Boats and Bullock Carts

Item	Year	Regions							Total
		NW	NC	West	South	SE	NE	CHT	
Boat Nos.	1983	43,320 (6%)	124,206 (17.2%)	324,933 (45%)	144,390 (20%)	64,977 (9%)	18,038 (2.5%)	2,464 (0.3%)	722,300 (100%)
Bamboo/A (million)	1983[a]	0.11	0.31	0.81	0.36	0.16	0.05	0.005	1.8
	1993[c]	0.12	0.33	0.85	0.38	0.17	0.05	0.005	1.9
Bullock Cart Nos.	1983	246,025 (46.4%)	79,535 (15.0%)	139,984 (26.4%)	45,867 (8.6%)	18,027 (3.4%)	265 (0.05%)	497 (0.1%)	530,200 (100%)
Bamboo/A (million)	1983[b]	0.59	0.19	0.34	0.11	0.04	0.0006	0.001	1.27
	1993[c]	0.62	0.20	0.36	0.12	0.04	0.0006	0.001	1.33

Source: District Statistics, BBS 1983.
Notes:

[a] An average of 10 culms per boat and durability four years.
[b] An average of 12 culms per cart and durability five years.
[c] Five percent increase by 1993 estimated.

Rickshaw - This is one of the most economic transports in both urban and rural Bangladesh. BBS (1991) reports that during 1989-90 about 0.19 million rickshaws registered in 20 selected municipal areas. About 0.08 million rickshaws are present in rural areas. The number of rickshaws both in municipal and rural areas comes to 0.19 + 0.08 = 0.27 million.

However, it is generally believed that about 0.4-0.5 million rickshaws (both registered and unregistered) are available in Dhaka, and about 2.5 million are in other parts of Bangladesh. Considering this figure, the estimated requirement of bamboo for constructing rickshaw hoods is:

3,000,000 rickshaws x 1.5, = 4.5 million bamboo

The average life of a frame is about five years, so annually 4.5 ÷ 5 = 0.9 million bamboos are required for this purpose. Thick-walled bamboos such as, bariala and barak, barua make hoods and these are purely village grown species.

The total national consumption in Bangladesh under different regions projected for the plan period on the basis of 1991 population census and population growth trends, are shown below. Appendix 4 contains regional estimates.

Year	Million Culms
1993	709.3
1998	761.1
2003	815.5
2008	868.1
2103	901.5

Natural Forest Supply

Bamboos only naturally grow in the hill forests of Bangladesh. These hill forests occurring three of the zones recognized in the FMP village forest survey. The following section discusses the annual outturn of bamboos from these Zones.

1. **Chittagong and Cox's Bazar Forests**

This southeast region includes the Chittagong and Cox's Bazar Forest Divisions. It is evident from Table 8 that the quantity of bamboos produced from the forests of Chittagong is three times more than those of Cox's Bazar. According to the inventory report of De Milde (1985) the total number of bamboo culms/hectare is much higher in Chittagong's Forests than those of Cox's Bazar. It may reach up to 22,000 culms/ha of which 9,610 are mature and 12,390 are immature. In Cox's Bazar Forest the maximum number of culms reportedly is 10,380/ha of which 2,670 were mature and 7,710 were immature culms.

On average, the number of mature and immature culm per hectare in Chittagong forest is 4,915 and 9,573 respectively. In Cox's Bazar forests the average number of mature and immature culm per hectare are 1,540 and 4,723 respectively. This indicates that the high forest types are more open in Chittagong than in Cox's Bazar regions. Bamboo quantity progressively deteriorated after 1988-89. This is mainly due to the excessive cutting of bamboos from areas close to human habitation. Deterioration also occurs in the quality of bamboos seen when one visits the forests.

According to De Milde (1985), the amount of bamboo area is about 52,471 and 34,499 ha in Chittagong and Cox's Bazar respectively. The annual rate of area loss in these areas is about 3 percent (see Appendix 3). Therefore, the expected land area of these two bamboo forest during the year 1993 is 42,900 ha and 28,220 ha in Chittagong and Cox's Bazar, respectively. Like Sylhet forest, the bamboos in these forests are being felled at a four year cycle. One fourth of the land gets harvested every year. The eighty percent of mature culm in Chittagong and Cox's Bazar are 3,932 and 1,230/ha respectively. Assuming 5-15 percent decrease in culm productively, the number of harvestable culms in these areas during 1993 comes down to 3,260 and 1,020 per hectare of land in Chittagong and Cox's Bazar, respectively. Thus by adding the production of these two forests (42,920 ha ÷ 4 years = 10,730 ha x 3,264 ha and 28,220 ÷ 4 years = 7,050 ha x 1,032), 42.3 million bamboo is the estimated annual potential supply. This compares with the production records shown in Table 15, which show an average production of 28 million culms.

The inaccessible areas in Chittagong and Cox's Bazar amount to 10 percent. Thus the available supply is reduced by 10 percent due to inaccessibility. The recorded supply has been estimated from the average of annual bamboo outturn from the Forest Divisions of Chittagong and Cox's Bazar (Table 14). By subtracting the recorded supply from the available forest supply unrecorded supply of the Southeast region has also been estimated (see Appendix 4).

The unrecorded supply is maximum from forests of Chittagong and Cox's Bazar mainly because of easy accessibility to the forest lands. People residing very near the forest bring out unrecorded bamboos and thus cause over-exploitation.

Supply projections for these areas take into account the following:

a. Sporadic flowering in muli bamboo has started since 1988 and is likely to continue for six-ten years resulting in a three-five percent increase in outturn due to the sporadic clump death (1988/89-1998/99).

b. About 10 to 30 percent increase in outturn number is likely due to the large scale death of the clump as a result of expected gregarious flowering at the end of the century (1989/99-2003/04).

c. Fall in outturn by 45-30 percent due to the final sporadic and completion of flowering in the remaining flowering clumps (say from 2003/04-2009/10).

d. About 10-30 percent gradual increase in outturn number as regenerating muli seedlings take 10-12 years to attain merchantable size in natural forest condition (2009/10-2019/20).

Table 14 - Chittagong and Cox's Bazar Production, (Million Culms)

Year	Chittagong	Cox's Bazar	Number (million)
1980-81	16.4	15.9	32.36
1981-82	9.8	15.8	25.61
1982-83	10.5	15.4	25.93
1983-84	12.0	8.9	20.95
1984-85	14.2	12.1	26.34
1985-86	15.6	-	-
1986-87	9.5	16.4	25.97
1987-88	20.3	126.3	32.97
1988-89	30.1	141.4	44.24
1989-90	15.1	124.8	27.61
1990-91	11. 8	5.8	17.68
Total[a]	199.4	129.7	279.66
Average	14.99	12.97	27.97

Note : Source: Divisional Forest Officers of Relevant Forest Divisions, Written Personal Commission, 1992

2. Sylhet Forest

Sylhet natural forest bamboo production averages 28.5 million culms. This part of Northeast Region contains all the natural sources of bamboos in the area. This includes the Patharia, Rajkandi and Hararganj Reserve Forests of the southern part of the District. Besides these, about 13 percent of the total outturn of the natural source comes from the unplanted fallow lands of the existing tea gardens in Sylhet, Table 15.

In a few bamboo mahals (like Madabchara and Surma mahals) the quantity of bamboo outturn, interestingly has increased gradually during the last felling years. Madabchara Mahal in Patharia Reserve shows such a trend (Table 17). This increase is due to the availability of degenerated muli bamboo known as Tengra muli formed as a result of intensive biotic interference. Earlier Tengra muli was not available in the mahal as the human interference was less at least in the last 10 years. It also indicated that previously Pecha bamboo were not harvested for trading purpose. Presently this species is also being sold in the market due to the shortage and deterioration of the major commercial species, muli bamboo.

Table 15 - Sylhet Forest Bamboo Production, (Million Culms)

Year	Sylhet Forest Division	SPPM	Tea Garden	Total
1980-81	10.7	7.4	0.4	18.5
1981-82	16.9	4.4	3.1	24.4
1982-83	16.0	7.9	0.9	24.8
1983-84	15.0	9.5	1.5	26.0
1984-85	13.0	4.4	1.9	19.3
1985-86	15.1	1.7	3.1	19.9
1986-87	20.5	4.4	5.6	30.5
1987-88	23.5	3.6	10.1	37.2
1988-89	14.5	5.9	4.2	24.6
1989-90	24.9	4.5	1.1	30.5
1990-91	16.6	5.9	4.8	27.3
Total	186.7	59.6	36.7	282.3
Total, Forest	246.2		36.7	283.0
Percent	83.6%		16.4%	100.0%

Source: Divisional Forest Officer of Forest Sylhet Division, Forest Manager of SPPM; Personal written communication 1992.

Repeated cutting with little or no gap created a coppicing effect on the culm base and also activated the culm buds on the underground rhizome. Thus, more shoots originated in the clumps. These are thin and smaller in size and transformed into Tengra muli. Within the last 10 years the total annual outturn from the forest shows a gradual increase in numbers harvested up to 1987-1988. After that the outturn gradually started decreasing. Continuous cutting of culms for a longer period has weakened the vitality of underground rhizomes (Table 16).

Drigo et al (1988) while inventorying the forest reserve of Sylhet reported that the average number of culms per hectare was 20,049 and 26,685 in high forest and low forest, respectively. Based on a very limited survey during field visit in 1992, the FMP estimates that the average diameter at the base of an existing healthy culms are of 1.2-2.7 cm. Drigo found the weight of 1,000 air dry culms in the Sylhet forest ranged from 1.6 to 1.66 ADT. Presently, SPPM authorities consider the weight of 1,000 bamboos as 1.6 ADT or slightly less. Such deterioration in health and number of culms per unit area of bamboo mahal is definitely a matter of concern. According to Drigo, the potential number of mature culms per ha were 18,100, 8,540 and 18,100 at Juri, Rajkandi and Kulaura Ranges respectively. The average was 14,910 per ha in 1988.

In most of the mahals the felled bamboos are transported along waterways and streams as described earlier. However in some mahals the extraction and transportation of all harvested bamboos are always uncertain since the waterways flow through Indian territory.

Table 16 - Tengra Muli Bamboo Harvesting in Selected Years, (Millions)

Species	1979	1983	1987	1991
Madabchara Mahal				4.3
Muli	3.4	4.8	4,4300	0.4
Tengra	-	-	-	0.2
Dalu	0.08	0.1	0.09	.06
Pecha	-	-	-	5.0
Total	3.5	4.9	4.5	

Species	1981	1985	1989
Surma Chara			
Muli	6.0	6.8	6.7
Tengra	0.4	0.45	0.6
Dalu	0.05	0.07	0.08
Total	6.4	7.4	7.31

Source: Bamboo mahal register of Juri Range, Sylhet Forest Division. Personal communication Juri Ranger, April 1992.

Eighty percent of 14,910 is 11,930 and during the year this amount could be harvested from a hectare of land. On average, with two percent annual deforestation (Appendix 3) and at four year rotation the total bamboo land comes down to 3,059 ha during 1993 and the expected potential supply would be 3,059 ha x 11,930 culms = 36.50 million culms. The annual culm yield from fallow tea garden land is likely to be about 3.3 million number (Table 15). Thus the total expected potential bamboo supply during 1993 from the Northeast Sylhet forest is about 39.8 million pieces (Appendix 4). The recorded supply from the forest for the year 1993 has been estimated on the basis of last 11 years (1980-81 to 1990-91) historical bamboo outturn data. Subtracting the recorded supply from the available supply provides a basis for estimating the unrecorded supply for each of the projected years.

Projecting the supply for future years 19898, 2003, 2008 and 2013, considers the following assumptions:

- Yields decrease gradually 5-10 percent mainly due to over exploitation and repeated cutting in different bamboo mahals.

- An initial decrease of 2-3 percent in outturn due to the sporadic flowering in muli bamboo (say in 1994/95). Then the outturn of dead flowering clumps increases markedly and continues up to the end of the century 1995/96-2002/03).

- Large scale death of clumps due to expected gregarious flowering and as a result the outturn likely to increase by 5-35 percent (2003/4-2008/09).

- Sharp fall in outturn by 50-35 percent due to the final sporadic and completion of flowering (2008/09 - 2012/13).

3. Chittagong Hill Tracts

Yearwise, bamboo outturn from the different Forest Divisions in the Chittagong Hill Tract provide the historical supply data of that area. Among all forest divisions the annual outturn is highest in Hill Tract South and Hill Tract North Division (Table 17).

Table 17 - Chittagong Hill Tracts Production, (Million Culms)

Year	Hill Tract (North)	Hill Tract (South)	Khagra-chari	USF (Ranga-mati)	Kaptai PWP	Bandar-ban PWP	Bandar-ban (USF)	KPM (Leased Forest)	Lama	Total (Nos)
1980-81	22.7	4.0	-	1.2	1.3	-	-	13.9	-	43.1
1981-82	25.5	4.2	-	0.2	1.7	.003	0.8	13.8	-	46.2
1982-83	12.3	7.8	-	0.9	1.7	-	2.7	13.1	-	38.5
1983-84	12.8	9.4	-	3.3	1.5	-	3.8	8.7	-	39.5
1984-85	24.7	5.8	0.8	4.5	2.1	.03 -	2.6	9.9	-	50.6
1985-86	13.3	7.5	4.8	3.1	2.2	.07	2.1	6.2	7.6	39.4
1986-87	4.2	9.7	4.9	4.8	3.5	-	3.9	2.8	12.3	41.3
1987-88	16.0	8.9	4.8	5.0	4.4	1.0	4.4	7.5	18.9	64.4
1988-89	13.7	11.7	2.4	15.9	5.0	2.4	4.5	6.8	14.4	68.8
1989-90	1.6	11.5	4.5	7.6	7.0	3.2	5.5	2.0	9.6	57.3
1990-91	2.6	16.3	7.1	9.5	5.2	3.9	5.7	4.4		64.4
Average (of 1986-87 to 1990-91)										59.2

Source:Relevant DFO's personal written communication, 1992.

The Kassalong and Rankhiang Reserves are under the control of these two Forest Divisions and therefore the annual bamboo outturn is also high. During the last two years, ending 1990-91, the amount of harvested bamboos in the Hill Tract North Division declined mainly due to the disturbing law and order situation. The Unclassed State Forest (USF) Divisions of Rangamati and Lama have the next higher annual outturn of bamboos. All the Forest Divisions of CHT have been controlling the vast USF and also harvesting bamboos every year.

Today the health of the bamboos has declined. Previously 400 culms were equivalent to one ADT, but at present 625 bamboos are needed. That means that bamboos are smaller in size and lighter in weight due to overcutting today.

The bamboo areas of Kassalong, Rankhiang, Sangu and portions of Matamuhuri have been considered as the major CHT bamboo forests. Assuming that about 2.0 percent is the annual area loss, the total bamboo area of CHT in the base year 1993 comes to about 65,500 ha of land available for potential bamboo supply from the Hill Tract forests. No inventory reports have given any estimate of bamboo production from unit areas in the Chittagong Hill Tracts. However, assuming that the number is about 30 percent higher than that of Chittagong forests, the estimated harvestable culm yield is about (3932 + 30 percent of 3,932) 5,110 culms/ha. The estimated potential supply in 1993 is about 21,830 ha x 5110 = 111.6 million culms. A 20 percent supply reduction is due to inaccessibility and about 16-17 percent loss is due to wastage and over exploitation is also estimated. Thus the remaining amount estimated as available supply (Appendix 4) is 128.7 million culms.

However, the recorded supply during the last five years (1986-87 to 1990-91) from the different forest divisions of CHT and KPM, is the basis for the recorded supply data for the year 1993. This totals 62.0 million in number (Appendix 4). The unrecorded supply has also been estimated from the available and recorded supply from this forest as was done in the Sylhet estimate.

Besides the above, other assumptions helped quantify the project's estimated bamboo supply during the plan. These were:

- Sporadic flowering in muli bamboo started in 1986 and likely to continue for six-ten years and the law and order situation in the Hill Tracts is expected to improve gradually. The cumulative increase, say 5-7 percent in bamboo outturn occurs in 1986/87 to 1996-97.

- Expect about 15 to 35 percent increase in outturn number largely due to massive death of clumps as a result of expected gregarious flowering at the end of this century (1996/97-2001/02).

- Sharp fall in outturn by 50-35 percent due to the final sporadic and completion of flowering (2001/02-2007/08).

- Forecast a 10 to 30 percent gradual increase in outturn number as regenerating seedlings mature. This usually takes 10-12 years to produce merchantable sizes of culm in natural forest conditions (2007/08-2017/18).

Village Forest Supply ✓

Almost all households of Bangladesh excepting the coastal and lowlying areas cultivate bamboos. On most parts of the deltaic plains of Bangladesh, the villages consists of houses built on earth mounds as protection against seasonal flooding. The mounds also usually contain a multi-storied canopy of bamboos, climbers, palms and trees.

FAO (1982) summarized the 1980 inventory of the village forest resources of Bangladesh. The report estimated that village bamboos totalled 198.8 million mature culms and 558.1 million immature culms, equivalent to 2.5 and 7.5 standing bamboos per capita, respectively (Table 18). The Forestry Master Plan Project made a village resource inventory. Fieldwork occurred from mid January to mid April 1992. The survey estimated the total number of standing mature and immature culm at about 443.8 and 611.2 million respectively. The per capita standing mature and immature bamboo from the new survey are 4.3 and 7.0 culms respectively. The present survey shows that both total and per capita number of mature culm increased significantly, more or less double those observed in 1981.

The FAO enumeration fieldwork occurred from May 1980 to March 1981. This means the survey period covered both the growing (emergence of new culms) and rest period of the clump. The present survey took place just prior to the appearance of new culms, i.e. during the period of the year when the total number of bamboo culms is at its lower side, when harvesting is almost completed.

The increase in the number of mature culms also indicates that culms are not fully harvested in due time from the clump. In other words, harvestable culms are left in the clumps. Increase of mature culms are high mostly in the northwest, west, and northeast regions of the Country (Table 19).

Per capita number of mature culms is highest in the bigger land holding of these areas. This indicates that big farmers do not harvest bamboos properly from their groves (Table 19). Big farmers of these areas are mainly absentee landlords and in most cases only the old parents or grand parents reside in the village. As a result, harvesting of mature culms is not done properly in due time and the overall maintenance of the bamboo groves is neglected. On the other hand, small farmers usually stay in their homesteads and they harvest mature bamboos in due time and their clumps are more productive. As a result in their bamboo groves the ratio of per capita production of mature and immature culm is in between 1:2 to 1:3, where it is less than 1:2 in the bamboo groves of big farmers. Moreover, bamboo is treated as an insurance crop never as a cash crop like rice or jute, and therefore, is not harvested adequately. The above facts explain the increase in the number of mature bamboos during the last decade. Development of steady

marketing facilities through ensured regular consumption of bamboos in the rural-based small scale cottage industries would be important step to make bamboo as a cash crop.

Table 18 - Regional Comparison of Rural Bamboo Resources, in 1981 and 1991

Region	Mature Culms				Immature Culms			
	1981[a]		1991[b]		1981[a]		1991[b]	
	Million	Per capita	Million	Per Capita	Million	Per Capita	Million	Per Capita
Northwest	63.7	3.3	152.7	6.3	171.8	9.0	249.5	10.3
Northcentre	39.5	2.4	61.0	3.5	117.0	7.2	115.2	6.6
West	35.2	2.8	93.2	7.3	113.7	9.0	80.0	6.3
South	9.6	1.4	37.2	3.5	34.1	5.0	59.2	5.6
Southeast	17.8	1.5	32.0	2.3	45.2	3.9	30.9	2.2
Northeast	24.0	2.9	67.6	5.8		9.2	76.4	6.5
Total, exclude CHT	189.8	2.5	443.8	4.3	558.3	7.5	611.2	7.0

Note:

Mill No. = Million number

No/Cap = Number per capita, based on 1980 and 1991 population

[a] = Hammermaster (1981)

[b] = Statistician Report, Forestry Master Plan Project (ADB TA 1355-BAN), 1992. The indicated deficit in 1993 is 50.0 million culms, rising to 325 million by the Year 2013.

The north and southeast region of Bangladesh exhibits the least amount of bamboo (both mature and immature). This appears related to occasional adverse cyclonic wind and saline soil.

The FMP survey started in mid-January and finished by April. Farmers usually start harvesting bamboos from October and may continue upto June. Therefore, one can assume that a substantial amount of mature bamboos have already been harvested before the counting of bamboos in the 1992 surveyed areas. It is very likely that the number of mature culms counted during the survey was less than the real number. Based on discussion with the farmers October-January and March-April are the two peak periods for bamboo harvesting. Thus, it is assumed that 50 percent and 30 percent of harvesting are carried out in these two periods respectively, and the rest 20 percent is being done in other months. So it is likely that 50 percent of harvestable culms had already been felled before the later survey. As a thumb rule, one third of the total culms present in a clump get harvested in a year. The total number of culm counted in 1992, including both mature and immature, is 1,054.9 million. With the above assumption, one third of the total bamboo (1054.9 ÷ 3) is 351.6 million which can be harvested annually, 50 percent of which is not counted in the survey. Therefore, after adding 50 percent of 351.6 million (175.8 million) the existing annual harvestable bamboos comes to 527.5 million culms.

The FMP assumes that the present condition of village grove yield continues if no development work to further improve the plantation and managment activities are taken up.

Table 19 -Per Capita Village Bamboo Resources (1991) By Land Ownership

Regions	Property Size (ha)									
	<0.20		>0.20-<1.0		>1.01-<3.0		>3.03		Weighted	
	Mat	Imm	Mat	Imm	Mat	Imm	Mat	Imm	Mat	Imm
Northwest	3.6	6.9	7.8	13.4	11.0	17.8	18.4	24.2	6.3	10.3
Northcentre	1.7	3.8	5.4	9.6	6.6	12.2	10.1	14.3	3.5	6.6
West	2.5	6.3	3.5	9.2	6.1	13.6	10.9	22.2	7.3	6.3
South	4.0	5.9	3.8	6.6	3.2	5.8	4.6	6.7	3.5	5.6
Southeast	1.4	1.5	3.3	3.0	4.7	4.1	6.4	5.4	2.3	2.2
Northeast	4.1	4.3	6.4	7.1	11.2	13.1	8.9	12.7	5.8	6.5
Weighted, All	2.7	4.8	5.3	8.6	7.6	12.0	11.0	15.6	4.3	7.0

Note: Mat = Mature culm, Imm = Immature culm
Source: Forestry Master Plan Project village inventory survey

Supply-Demand Balance

The estimated total national bamboo supply in the year 1993 is 656.2 million culms. The available forest supply is 128.7 million (20 percent) and the rest 527.5 million (80 percent) is coming from the village source (Table 20). This only confirms that the bulk of the bamboo are being produced by farmers not foresters.

In Table 20 the potential supply gets reduced by two percent annually to reflect deforestation area losses. Inaccessible areas in Chittagong and Cox's Bazar account for 10 percent supply reduction; the percentage in Sylhet is 20 percent. After large scale bamboo death resulting from gregarious muli flowering, this reduction for inaccessibility declines. The reduction for over exploitation and poor management varies from five to 15 percent depending on region. Appendix 4 has full details by region.

Table 20 - Bamboo Supply Demand Balance (Million culms)

Source	1993	1998	2003	2008	2013
Natural Forest Supply					
Potential Supply[a]	193.7	222.1	293.6	138.8	65.7
Less: -Inaccessible[b]	-33.8	-38.0	-48.7	-21.9	-8.3
-Overexploitation[c]	-31.2	-31.4	-16.6	-6.6	-12.3
Available Supply	128.7	152.3	228.3	110.3	49.4
Recorded	112.3	132.9	198.9	91.8	42.6
Unrecorded	16.5	39.4	29.4	18.5	6.8
Village Forest Supply	527.5	527.5	527.5	527.5	527.5
Total Supply	656.2	679.8	755.8	637.8	576.9
Demand	709.3	761.1	815.5	868.1	901.5
Surplus/(Deficit)	-53.1	-81.3	-59.7	-230.3	-324.6

[a] Includes in average 2 percent area loss annually
[b] 10-20 percent less due to inaccessibility, about 10 percent in Chittagong and Cox's Bazar forest, and 20 percent in Sylhet and CHT. After large scale death of bamboo due to gregarious flowering from the year 2003 the less in supply due to inaccessibility become comparatively low.
[c] Similarly about 5-15 percent decrease in the outturn due to the over exploitation and absence of management.

PLANTATION METHODS

General

Bamboos are planted regularly in the villages compared to all forest bamboos which occur naturally. In the past bamboos were considered a perpetual resource because of their vigorous vegetative regeneration. However, uncontrolled exploitation resulted in reduced yield and deterioration in quality. Considering both the ecologic and economic importance the Government recently emphasized the need of raising bamboo plantations both in the forest and private lands.

The major impediments in raising large scale plantations are:

a. Unavailability of bamboo seedlings every year because of its long flowering interval.

b. Little is known about bamboo seeds, their germination and seedling behaviour.

c. Easy and mass macropropagation techniques are unknown.

Beginning in 1975, BFRI conducted research on the development of simple propagation techniques for the major bamboo species of Bangladesh. This research generated some important silvicultural information (Hasan 1977, Banik 1980, 1984, 1986, 1987a, 1987b, 1991). These studies developed seed germination, viability, seedling raising, and different vegetative propagation techniques for the different bamboo species of the Country.

BFRI raised a four ha plantation of B. tulda and D. longispathus during 1978. At the same time, the Institute raised plantations of these species in the Chittagong Forest Division (2.5 ha) and the Pulpwood Plantation Division (2.0 ha). These three patches of bamboo plantations were the first bamboo reforestation programs in the Country. During 1982-1991, several patches of plantation of different bamboo species were also raised successfully from seedlings and branch cuttings in the forests of Chittagong, Ramgarh (Datmara), Bandarban, and Sylhet. Plantations began also in the villages of Patiya, Satkania and Chunati and on the canal banks of Nandigram of Keochia, Sitakundu, Chittagong Cantonment area, and Kamalganj village of Srimangal. The success of such small scale plantation firmly indicates the possibility of raising bamboo plantation in the forests and villages of Bangladesh with the presently available technology.

In this regard, two Bangla bulletins, one on cultivation and management methods (BFRI 1990) and another on prerooted and prerhizomed branch cutting techniques (BARC 1991) established the proper technique. The following sections summarize the existing knowledge on the plantation techniques.

Seed Propagules

1. Seed Characters and Collection

Seeds of bamboos are very different, both in size and weight depending on the species (Table 21). The seed of muli (M.baccifera) bamboo is large (tennis ball size) while in other species seeds are small, grain like and wheat coloured.

Table 21 - Seed Characters of Some Bamboo Species

Local Name	Seed Shape and Weight
Forest Species	
Muli	Large and obliquely ovoid, thick fleshy onion-shaped and the apex terminating in a curved beak, green with smooth surface. The weight of a seed varies from 7.0-150 g, length from 35-110 mm and diameter from 22-60 mm, 45-70 seeds (aver/kg).
Orah	Small like coriander seed, 1,350 seeds (aver) per 10 g.
Mitinga	Small like wheat grain, 150 seeds (aver) per 10 g.
Kali	Small like wheat grain, 265 seeds (aver) per 10 g.
Lata	Like chest nut or betal nut. The weight of a seed varies from 2-20 g.
Village Species	
Bariala, Barak	Do not produce seed
Barua, Bhaluka	Do not produce seed
Talla, Tarala	Small like wheat grain, 145 seeds (aver) per 10 g
Pharua, Bethua	Small like wheat grain, 1,250 seeds (aver) per 10 g
Lathi	Small like wheat grain, 515 seeds (aver) per 10 g
Kanta	Small like wheat grain, 1,325 seeds (aver) per 10 g
Tetua	Small like wheat grain, 151 seeds (aver) per 10 g

Seed production per clump varies from 30-80 g in Kanta, 15-17 g in Tetua, and 40-90 g in Orah. One full grown clump of muli bamboo produces 5-7 kg seeds during flowering time.

Seed Collection is a vital component since bamboo flowers irregularly. In all the species, mature seeds drop on the ground becoming exposed to predators such as birds, especially chickens and pigeons in the homestead, and rats, porcupines and wild boars in the natural forests. Birds and squirrels also eat seeds on the plants. Seeds require careful protection and collection both from plants and the ground. Generally, seeds produced in the early part (mid-February - May) of the season are healthy and more viable.

2. Seed Germination, Longevity and Storage

Bamboo seeds germinate a higher percentage under shade than in direct sunlight (Table 22). Seed should be sown in the polythene bags just after collection. The germination media (soil and cowdung 3:1) should be wet but not waterlogged. Seeds start germinating within 3-7 days of sowing and continue up to 15-25 days.

Table 22 - Seed Germination and Longevity Period

Species	Gemination Percent Under		Longevity
Name	Sunlight	Shade	Period (days)
Mitinga	30.7	58.2	35
Orah	33.4	61.2	55
Muli	33.0	79.8	35
Kanta	23.6	49.5	40
Kali	39.0	-	50
Tetua	26.0	40.2	35

Observation of muli shows that seed weight has a significant effect on seedling survival. Seedling survive up to 70-75 percent when raised from the seeds heavier than 50 g, while it drops to 56 percent when raised from light weight seeds (7-16 g).

Bamboo seeds are short lived, losing their viability within one-two months. Mitinga seeds can be stored upto 18 months by storing over silica gel in a desiccator. At normal room condition the lifespan of muli seed is about 35 days. It can be increased up to 45 days when stored in an air conditioned room. The seed longevity can further be prolonged upto 60 days when stored with dry sand in jute bags.

3. Seedling Nursing and Management

Initially, seedlings do best in partial shade compared to direct sunlight. Complete shading over the seedling should be discouraged. The emergence of shoots is successive. The new shoots are bigger and taller than older ones. The germinating plumules are very thin (1-2 mm) in mitinga and thick (4-6 mm) in muli. Within 1-4 weeks plumule elongate rapidly into a stem bearing single leaves arising alternately.

The stems of mitinga, orah and pharua culms are more or less woody in nature, but muli has soft stems with vigorous growth. Muli seedling become much elongated (175 cm) and thick (0.8 cm diameter) at three months of age.

A rhizome system starts to develop in the seedling after one-two months of germination, and at a young stage the rhizome movement is strongly geotropic. Therefore, at the nurseries roots and rhizomes of a seedling penetrate the neighbouring polythene bags of other seedlings. This creates a mass of twisted and intertwined roots and rhizomes of seedlings. As a result, the roots and rhizomes are damaged at the time of transportation. Frequent shifting of seedlings from one bed to another helps in minimizing the root rhizome intermingling at nursery stage. Seedlings need regular weeding and daily watering at nursery stage.

4. Wild Seedlings

Wild seedlings of bamboo, look like rice or wheat seedlings. They are easily seen on the ground just below the flowering mother clumps. Appearance of seedlings is very profuse and most of the time forms a thick mat on the ground. These densely populated seedlings compete strongly in the wilderness for survival.

These seedlings should be thinned out to minimise the competition. The wild seedlings so collected should be brought to the nursery and transplanted in the soil mixed with cowdung and stored in polythene bags. At the beginning, keep seedlings under shade for three-five days for hardening. Then place them under partial shade. Two to four leaves stage of wild seedlings of mitinga and orah are best for collection, while in muli germinating seedlings are best.

Both artificially and naturally raised seedlings can be multiplied by rhizome separation known as macroproliferation of seedlings. One five month old mitinga/orah seedling may yield three-five multiplied seedlings. Thus, every year bamboo seedlings can be multiplied to increase the number. However, muli seedlings can not be multiplied because the species usually possess one stem up to nine months of age.

For better survival (about 80-90 percent) in the field, less than one-year old seedlings should not be transplanted. Plant the seedlings out during the rainy season.

Vegetative Propagules

1. Prerooted and Prerhizomed Branch Cuttings

These are branch cuttings having spontaneous in situ rooting and rhizome at the swollen base (Banik 1980, 1987b). This type of cutting is common in the case of most of the thick-walled cultivated bamboo species in Bangladesh. Artificial induction of roots and rhizomes at the branch base is possible by chopping the culm tops and removing all newly emerging culms. Aerial roots and rhizomes of such cuttings are not always fully active. Therefore these cuttings have to be collected from the nodes of the standing culms during April to June and be placed in the sand media of propagation beds (Figure 3). A propagation bed is a 3-layered sand rooting media. Each layer is 7-10 cm deep and made up of:

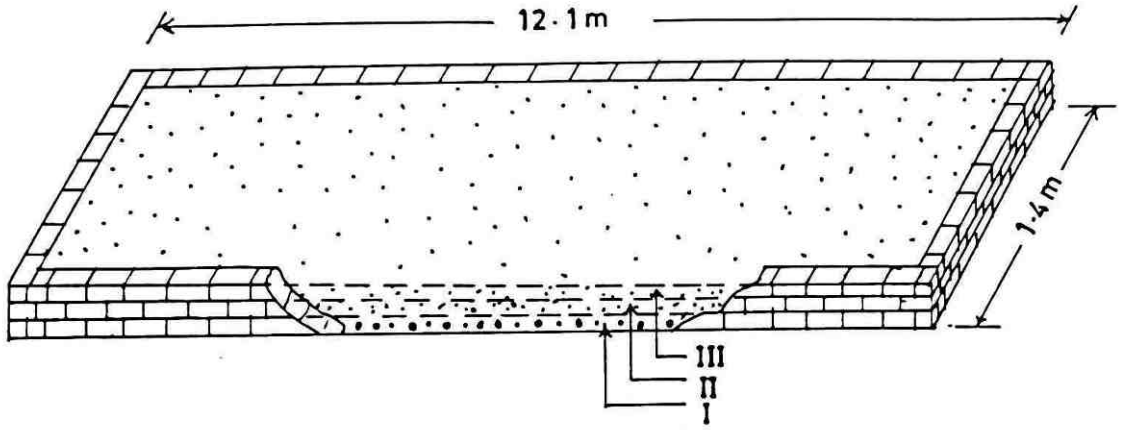
- Gravel and large size sand at the bottom.
- Medium size sand in the middle.
- Fine sand at the top.

In each layer clean sands are placed so that bed remains well-drained. A propagation bed is 1.2 m wide and 12 m long in size, situated on level ground in the nursery. Such beds are also constructed on cemented platforms with low brick walls at the sides and edges.

Place the collected branch cuttings from the culms on the sand media and maintain overhead misting for one month. Within 30 days, each of the prerooted and prerhizomed branch cuttings produce profuse active roots in the propagation bed.

Once rooted, the cuttings are transferred to polythene bags and kept in the nursery. Practice regular weeding and watering of the cuttings int the nursery. Like seedlings, maintain cuttings in the nursery at least up to the next monsoon. Survival of these types of cuttings in the field is high, almost 85-90 percent.

Planting offsets is the most common method of propagating village bamboos in Bangladesh. An offset propagule is composed of basal parts of a culm along with an underground rhizome portion (Figure 4). This method applies when cultivating a few clumps in the accessible area. Large scale plantation offset method is not practicable. This method is costly and seedling availability in large



LEGEND:

I GRAVEL AND BIG SIZE SAND AT THE BOTTOM,

II MEDIUM SIZE SAND AT THE MIDDLE, AND

III FINE SAND AT THE TOP.

Figure 3 - A propagation bed: (i) gravel and big size sand at the bottom, (ii) medium size sand at the middle, and (iii) fine sand at the top.

numbers is very limited. Moreover, offsets are heavy and therefore transportation is difficult and expensive. Offset planting success in thin-walled bamboo species is relatively poor and varies greatly from species to species. Success is normally 5 percent in muli and 9 percent in mitinga.

Offsets from one-two year old culms give better results as the rhizome are young, vigorous and possess active culm beds. Culm buds on the rhizome of older offsets (four-seven years of age) are mostly dead and therefore they fail to produce new culms. March and April are the most favourable time for offset planting as culm buds in the rhizome become active during that time due to an increase in temperature and humidity. The desired length of the culm part of an offset is one to 1.5 m with three to four nodes bearing viable branch buds.

Field Planting

Villagers commonly cultivate bamboos on their homesteads, canal banks and marginal lands for their everyday use and needs. In the wild, the underground rhizome systems with roots binds the soil and thus help in preventing the soil erosion. The following factors need considering for site selection:

- Bamboo do not survive under deep shade.
- Bamboo do not survive in saline habitats or water logged conditions.
- Planting site should be well-drained, moist and preferably rich in organic matter.
- Northwest part of the homestead is the most desirable site for bamboo because the planted clumps act as wind break.
- New canal banks are also good sites.
- Lower slopes of the hills are good planting sites, upper slopes have to be avoided.
- Under planting may be done in the well-thinned or widely spaced forest plantation.

Usually June to August are the best months for planting bamboo seedlings and cuttings. However, offsets need planting just after collection, therefore April-May is the best time for offset planting.

Pits of 30 cm cube are dug at 5m x 5m spacing. Therefore in a hectare, 400 propagules are necessary. In the hills, planting pits are dug by spot weeding. No clearfelling is necessary. Fill pits with cowdung (four-five kg), urea (10 g), triple superphosphate (10 g), muriate of potash (5 g) and soil one week before planting. If there is no rain, watering is preferable just after planting especially in the homestead and marginal land. In the hilly forest lands watering is not possible, therefore planting should be done in the rainy days.

After care in the field is important. After planting in June - August, three weedings and vine cuttings are done in the first year, and two in the second year. Afterwards one thorough weeding has to be done every year around the planted clump. Weeding may be avoided by cultivating the legume crops (arhar, bogamedula etc) in between the planting rows. Mulching around the planted seedling has to be done after soil work, before the annual drought period. On the homestead and in marginal lands, simple irrigation of planted cuttings/seedlings by a bucket of water once a fortnight during the drier months of the year is adequate.

Thin dead and weak culms out to make room for the emerging culms. Apply insecticide, especially to cuttings as and when necessary. Spray heptachlore, dieldrin, chlordan when the clump is affected by white ants. Seedling of forest species (muli, mitinga, orah etc) are generally resistant to the insect/fungi attack.

Yields

Expect a bamboo propagule to produce merchantable size culms at the fifth year of planting. On an average, at the beginning three culms may be harvested from a clump of a thick-walled species.

As mentioned earlier, harvest culms at three year rotations. Out of a total of 400 bamboo clumps/ha effective harvesting occurs from 133 clumps. The first year of harvest yields about 400 culms (133 clump x 3 culms) from one hectare of plantation of a thick-walled species. After that one more culm per clump is produced annually up to 10 years of age, then the production rate become more or less steady (Table 23).

In the case of thin-walled muli species, about 10 culms are produced per clump in the first year of harvest (five years after plantation). Based on felling at three year rotation, 1,333 culms can be harvested from one hectare at the first year of harvesting (Table 23). After seven years of plantation muli clumps start producing two more culms per year, and thus in the eighth year about 1,870-2,130 culms/ha can be harvested. After 13-15 years of age clump productivity becomes more or less steady.

Table 23 - Plantation Yield thick-walled and Thin-walled Bamboo (Culms/ha/A)

	Year After Plantation					
Species	5	6	7	8	9	10
Thick-walled	400 (3)	533 (4)	667 (5)	800 (6)	933 (7)	1,067 (8)
Thin-walled	1,333 (10)	1,600 (12)	1,867 (14)	2,133 (16)	2,400 (18)	2,800 (21)

Note: Bracketed numbers indicate the average culm yield per clump.

PLANTATION COSTS

The cost of raising a bamboo plantation depends on the following factors:

- Types of propagules - offset, prerooted and prerhizomed branch cuttings, seed and or seedling.
- Nursery maintenance and transportation distances.
- Site preparation and field planting conditions.
- Aftercare, fertilizer application and protection techniques.

Conventional method of offset/rhizome planting, modern technology using branch cutting and seed or seedling planting have different plantation costs. The cost difference due to the nature of propagule (offset, branch cutting and seedlings) is an important consideration when raising bamboo plantations.

The following sections present the costs of raising bamboo plantations. Appendix 5 includes summary of program and cost details.

Nursery Beds

Thick-walled village grown species can be cultivated by prerooted and prerhizomed branch cuttings. For producing prerooted and prerhizomed branch cuttings of bamboos, as discussed earlier, propagation beds are necessary.

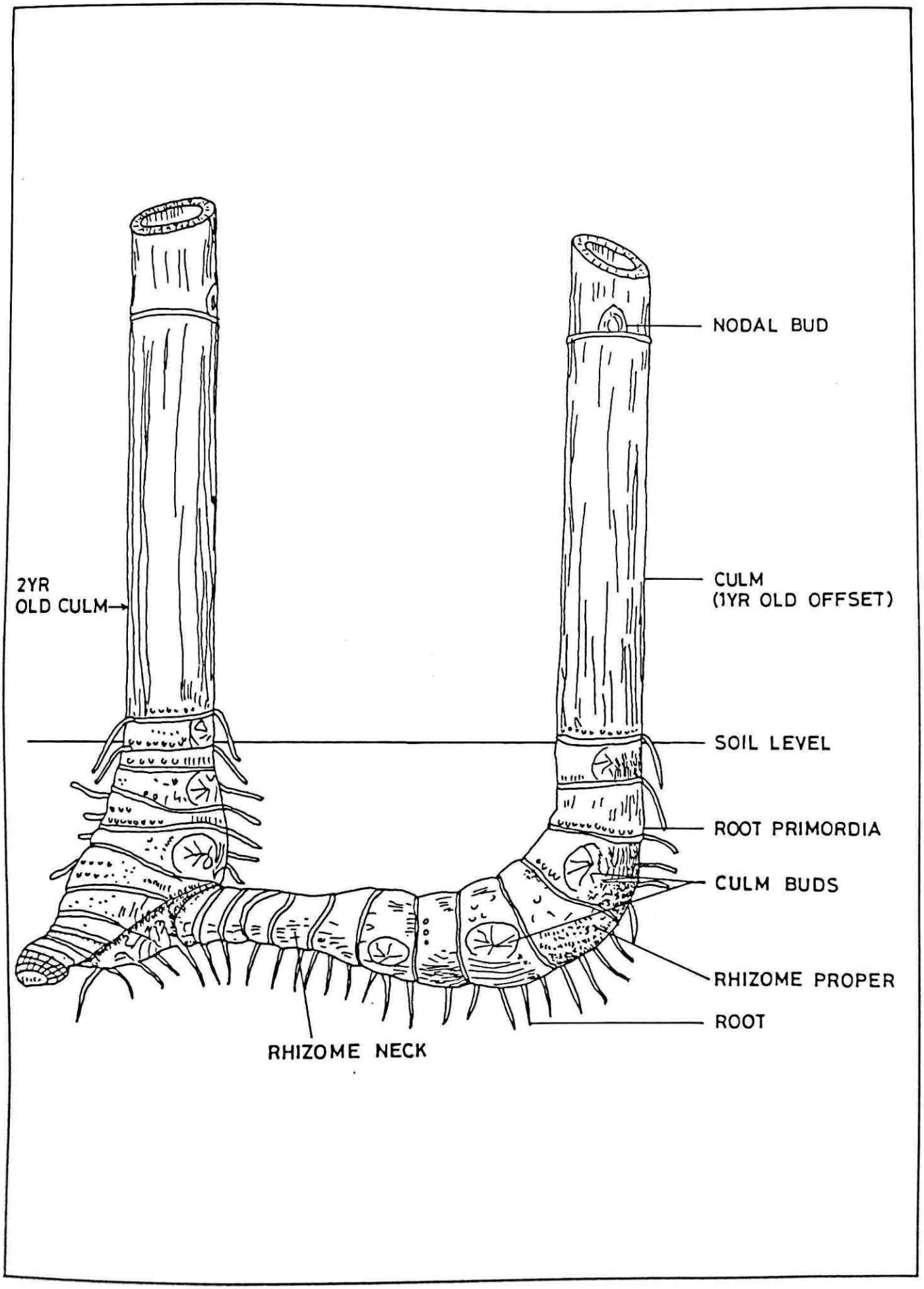


Figure 4 - A Typical Offset of Bariala Bamboo (B. vulgaris)

About Tk.6,000/ is the cost of constructing a propagation bed on a concrete floor with different types of sands as rooting media and bricks for walls. However, the cost reduces to Tk 2,000/ if the propagation beds are made directly in the ground. Once propagation beds are constructed these are used every year just after cleaning and reusing the sand rooting media. Nursery bed construction is a one time expenditure.

Watering the rooting cutting by electrically driven sprinkler is preferred. Six sprinklers are needed for watering evenly on a 1.2 m x 12 m propagation bed. Construction of overhead water reservoir, lay out of water distributing lines and upright pipes with sprinklers provides intermittent mist on the cuttings. Sprinklers provide mist to the cuttings through distribution of water under pressure from a small ¼ hp pump. About Tk 175,000 to 200,000 are required to install and develop these facilities in a nursery, again, a onetime expense. The cost of misting may be reduced by spraying water manually over the cuttings. Manual watering does not require the installation of pipelines, sprinklers and electric pumps.

Propagule Production, Transportation and Planting

The primary cost is mainly dependent on the production cost for raising the different types of propagules (Table 24). The cost of production and planting of a seedling and a branch cutting is Tk 9 and 13 respectively. The cost for offsets is much higher, amounting to Tk 83 each because of the higher production costs.

Table 24 - Unit Raising and Planting Costs

Item	Type of Propagules		
	Offset	Cuttings	Seedling
Cost of purchase	60.00	-	-
Collection cost	10.00	2.00	1.50
Nursery watering and care	-	2.00	-
Soil mixing, bagging, potting	-	3.00	1.50
Care in nursery	-	1.00	1.00
Transportation cost	5.00	1.00	1.00
Pitting and transplanting	8.00	4.00	4.00
Total	83.00	13.00	9.00

Raising one hectare bamboo plantation with 5.0 meter spacing requires 400 propagules. Expected mortality is about 10-15 percent propagules. This loss happens during transportation, planting and after care. Therefore, 15 percent excess expenditure for mortality has been taken into consideration for raising one hectare plantation. The total expenditure for raising one hectare plantation of bamboo comes to Tk 38,180 by offset, Tk 5,980 by branch cutting and Tk 4,140 by seedling (Table 25).

Cultivation and Maintenance

Bamboo cultivation is different from agricultural crops because the crop is not annual. Bamboo cultivation can be compared to that of horticultural fruit crops as both the crops start producing culms/fruits five-ten years after planting. Plantation maintenance occurs during first five-year

period as the first harvesting begins in the fifth year. Therefore, this period is basically for establishing the planted clumps.

Table 25 - Per Hectare Bamboo Plantation Costs

Item	Tk/ Propagule	Cost, Tk/Ha		
		Propagules	Mortality	Total
Offset	83	33,200	4,980	38,180
Cuttings	13	5,200	780	5,980
Seedling	9	3,600	540	4,140

Expenditure increases slightly after the fifth year as both harvesting and maintenance of the clumps have to be done simultaneously. At the same time income generation takes place from the harvesting. However, with seedling plantations, addition of soil and fertilizer will not be necessary after the fifth. When branch cuttings are planted in the hill forests only occasional weeding may be done and other cultural practices are not so necessary.

Bamboo requires intensive cultivation annually. Fortunately, clumps begin producing in the sixth to seventh year. The level of cultivation depends on the type of plantation. A branch cutting plantation needs more cultivation than a plantation begun with seedlings. The chief maintenance cost is for adding organic and chemical fertilizer.

Organic fertilizer costs are Tk 2/ clump in Year 1, progressively reaching Tk 10/ clump in Year 5 and Tk 15/ clump by Year 10. Fertilizer costs show a similar but slightly smaller range - Year 1, Tk 1.70, Year 5, Tk 5 and Year 10, Tk 8.50/ clump. Manual weeding costs range from Tk 3-4 up to Year 7, thereafter stabilizing at Tk 5/ clump. The cost of insecticides and fungicides varies from Tk 5 to 7 by the tenth year.

Financial analysis of two bamboo plantations considers thick-walled bariala bamboo, through branch cutting and thin-walled muli seedlings. Analysis is based on the above establishment cost and extraction costs. Estimated harvesting and transportation labour costs are Tk 8 and Tk 1.60 for thick-walled and thin-walled species, respectively.

The analysis reveals that the financial rate of return on investment is attractive for both cases. The thick-walled bariala bamboo yields a financial rate of return (FIRR) of 37 percent and that of thin-walled muli bamboo is 19 percent. Appendix 5 contains the calculation details.

Irrigation is needed at least in the early stage of life especially in the drier months. In the homestead the full grown clumps benefit from irrigation during the dry season. However in the forest plantations irrigation may not be possible. In that case mulching should be done around the base of the seedling after ring weeding at the end of rainy season.

Weeding and vine cutting is necessary to protect the young seedling. Bamboo seedling cannot thrive under the areas densely covered with weeds. For adult clumps weeding is not so essential. A bamboo seedling thrives better under partial shade condition up to age two. Raw leguminous plants (arhar, bogumedula) are suitable and they have good fertilizer value as well. In general bamboo do not prefer sites directly exposed to the sun. A mature clump should not be congested. Thinning is essential for future culm emergence. Harvesting is essential for continuous culm production.

Calendar of Management Operation

Details of management activities vary since bamboo requires regular attention throughout the year. Monthly activities are as follows:

January-February	During this time of the year most of the leaves of bamboo clumps turn yellow and start shedding due to the dry and comparatively cold climate. Thin branch tips may dry up and fall from the culms. Such effect is more severe in the northwestern regions of the Country. Irrigate the bamboo clump with a bucket of water at least once a week especially on the drier part of the homestead.
February-March	Harvesting of culms from the clumps is generally done in the drier months and continues up to the end of March. Dig out the stumps of the harvested culms and add new earth immediately to the blank. Diseased, cut branches and old rotten leaves have to be cleaned from the clump bases and mild firing may be done in order to kill insects and fungi.
April - May	This is the best time for offset collection. Collect offsets from the 12-18 months old culms in the month of April. Add soil and fertilizers (cowdung/urea) to the soil, especially in the homestead bamboo brakes. Collect and sow seeds if clumps flower and raise seedlings. Storms may damage clumps. Remove broken stems and replant uprooted clumps adding new soil to the base.
May - August	Initiate production of prerooted and prerhizomed branch cuttings, culm-cuttings and ground-layering of culms in May after one or two rain showers. Begin preparation of the propagation beds in the nursery using the different types of cleaned and washed sand media. After collecting the prerooted branches from clumps place them in the sandy rooting media of the propagation beds. Well rooted branch cuttings, culm- cutting have to be transplanted into the large size polythene bags and maintained in the nursery. Plant healthy cuttings of current year and normal cuttings of the last year in the field. Dig planting pits during the month of May at least 15 days before planting. Follow the details of planting technique of bamboo, published in Bangla by BFRI (1990) and of BARC (1991).
August-September	Due to heavy rain in July to August villages are usually flooded. When flood water stagnates at the clump bases for 45-60 days the bamboo plants often die. Drain the water out as quick as possible. Add new soil if the soil from the clump bases is washed off due to heavy showers.
Sept - November	Usually during these months cyclonic storms in the Bay of Bengal hit southern districts of Bangladesh. As a result, many clumps are damaged or uprooted. Clean out broken twigs and culms from the bamboo brakes. Refix the uprooted clumps into the ground properly.
November - January	Both temperature and relative humidity in the air start getting low and as a result climate become cool and dry. This is an unfavourable environmental situation for bamboo. Mulching the ground with water hyacinth/paddy straw/leaves, conserves moisture. Irrigation at the clump bases once a fort-night by a bucket of water also helps.

DEVELOPMENT PROGRAMS

Rationale and Objectives

Bamboos constitute one of the most important renewable biomass resources in Bangladesh. From time immemorial, due to its various characteristics, properties and easy availability, it has been used for various articles of day to day use. It has always been in great demand as a raw materials for housing, agricultural implements, and for handicraft industries in the rural areas. Besides these its socioeconomic role in the countryside has also increased its importance. With the present rate of consumption and supply bamboo has become a scarce commodity in Bangladesh. This situation affects the poor, who depend on it for their shelter and in some cases for livelihood.

The program on bamboo development is designed to achieve the following objectives:

- Achieve self sufficiency in raw material production to fulfil the gap between the supply and demand.
- Make bamboo available to the people at a cheaper rate.
- stop soil erosion and scouring of canal bank, embankment, roads and highways, etc. by bamboo plantation.
- Foster the bamboo related small industries at the village level through steady supply of raw material.
- Provide increased supply of industrial bamboo.
- Improve the quality and design of the bamboo products to increase their demand in local and outside market.
- Provide employment and increasing income at all phases from plantation, harvesting, transportation, processing and product development.
- Update and develop the research activities on genetical improvement, propagation, silviculture, management and product development.

Program Components

Program components focus activities in three major areas - resource management and development, product development and improvement and research needs. The needs in the three areas are summarized below and detailed in subsequent sections.

a. Resource management and development includes:

- Assessment of the total national bamboo resource of the forests through a suitable inventory technique and adoption of scientific management.
- Increase production through plantations.
- Extension and training on bamboo for rural farming.

b. Product development and improvement means:

- Popularizing preservation treatment to increase the durability of housing and other construction material.
- Establishing a training centre to teach the craftsman on designing, and quality improvement of the product.

c. Research needs and importance incorporates:

- Improving the status of research.
- Focusing future research areas.
- Establishing a Bamboo Research Division under BFRI.
- Beginning a bamboo germplasm centre for both indigenous and exotic species.
- Starting a tissue culture laboratory.
- Manpower training.

Resource Management and Development

1. **Assessment**

During the Forestal Inventory in 1961-63, bamboo resource in the Chittagong Hill Tracts could not be assessed as muli bamboo, the major forest species, was in gregariously flowering at that time. Similar conditions existed in the Sangu and Matamurhi reserves, inventoried about the same time, while muli flowered. Therefore, estimates of the growing stock of this species could not be made. The FAO/UNDP Project BGD/79/017 surveyed the CHT to re-evaluate the growing stock of bamboo. Areas were aerially photographed in 1984 under this project but ground truthing was impossible because of travel restrictions. As a result the estimate of growing bamboo stock in the forests of Chittagong, Chittagong Hill Tracts and Cox's bazar are not accurately assessed.

About 20-30 percent bamboo areas in the Kassalong, Rankhiang, Sangu-Matamuhuri reserves are inaccessible and as a result resources of these areas remain untapped. More construction of roads and ropeways in these hilly forests are necessary to harvest and bring out all bamboo. This needs a substantial amount of investment. Cable or ropeway is preferred to roads since the latter represents an open invitation to illicit cutting and encroachment. Roads also magnify the fire hazard. Therefore, to assess the economic viability of harvesting bamboos from these hilly areas, one has to know the present situation of the resource.

In 1990 the bamboo resource in the Erawan National Park, Kanchanaburi Province, Western Thailand were inventoried through application of remote sensing methods. Satellite imagery interpretation was carried out using LANDSAT TM, Bands 4 5 3 (B G R) with 30 m resolution. Images were produced on a 1:125,000 scale. Visual interpretation was employed based on texture, association, shape, and location. Crews also collected data from ground plots. This pilot study established guidelines for a larger scale bamboo resource survey in Thailand. Similar techniques Bangladesh conditions providing detailed mapping required for proper harvesting, utilization and stocking estimates.

The northern part of Kurmachara Mahal of Sylhet Forest belongs to the catchment area draining into India. Drigo el al (1988) estimated that most of the area could be harvested by building a

temporary dam near the border and transporting culms over the ridge to a suitable site along Lawachara or Daluachara. From this point, normal rafting becomes possible. Similar problems are also observed in some portion of Madabchara Mahal.

Bamboo harvesting and transportation mainly relies on water streams. Most bamboo mahals in Sylhet lie on the border of India. In a few cases portions of the streams flow through India. As a result, transportation of bamboo rafts through these water ways gets held up at the Indian Border. Bypass canals or waterways would avoid these problems. This will also help in reducing the sizes of bamboo mahals.

This construction calls for detailed mapping of the mahal areas showing the topographical configuration along with the path of water courses and streams. The investment requirement estimate is Tk 7.5 million.

2. **Management**

At present, bamboo management practices are elementary in Bangladesh. The chief practice is controlling harvesting to three-four year rotation in Sylhet and Chittagong Hill Tracts forests.

The bamboo mahals of Sylhet forests are very large. The area of each of the mahals varies from 500 to 2,000 ha. It is not possible with the existing small number forestry staff to look after, manage, protect and supervise the felling operations of bamboos in such a large area without adequate access. Similar problems also lie with different bamboo areas in the Chittagong Hill Tracts reserves.

The village bamboo resources are privately owned and farmers have been maintaining their groves depending only on their experiences, as there is no teaching or training program on bamboo management. Accepted practice does not relate to a scientific base.

Therefore, creation of a new cell under the BFD is proposed to gear up the management, harvesting, processing and marketing of this important resource of Bangladesh. Logically, this cell would also become responsible for non wood forest products another area with good economic development potential. The cell will be responsible for overall management of bamboo resources both of the forests and villages through providing training in bamboo farming to the farmers. Raising of propagules, their distribution to the farmer/planters, making plantations, supervision and control over the harvesting from the forests and development of marketing facilities through close liaison with bamboo based industries lies within the responsibilities of the proposed cell.

There is a strong need for establishing permanent sample plots to monitor bamboo stands. This program would involve locating a linear sample plot 50 x 200 m in each bamboo mahal to determine the overall health of the crop, annual culm production, flower status, seed formation, natural regeneration, propagation and exploitation. These plots are to be laid out in such a way that maximum number of species and topographic variations are included. Felling operations in the plots will also be carried out as per prescribed rules. The plots need protection from fire and any illicit felling. This program will likely cost Tk 1.0 million annually distributed among the various Forest Divisions.

The sporadic flowering in muli bamboo has already started in different forest areas of Chittagong and the Chittagong Hill Tracts. Estimations are that gregarious flowering and large scale death of the bamboo stands will occur at the end of this century. This will create a tremendous shortfall of bamboos early in the next century. Through natural regeneration the muli forest will again appear by the end of the Master Plan period. Weed suppression, forest fire and grazing are major factors impeding the successful establishment of regenerating muli seedlings. Proper protection and management of the wild seedlings are essential to achieve the successful regeneration and

ultimate restocking of muli forest. Funds to facilitate this natural regeneration need providing at the Range level. The annual cost of the required maintenance work is TK 1,00/ha. The total amount needed from 1985 to 1988 starts at Tk 0.25/A, increasing in later years (1999-2005) to about Tk 0.5/A on average in each Division.

Item	Tk/ha
Weeding/vine cutting	700
Fireline (per unit of 6 x 6m)	200
Miscellaneous	100
Total	1,000

The estimated bamboo shortfall is about 50 to 80 million pieces of bamboos annually from the year 1993 to 1998 (Table 19). Beyond 2003, the shortfall due to flowering is much higher reaching 230 to 325 million annually. Reducing the effect of this shortfall requires immediate steps to improve the national bamboo production. It is not possible to improve the supply situation within one or two years. Starting the plantation programs immediately will definitely ease the situation.

Farmer Training

Planting seedlings and branch cuttings is a completely new technology to the planters, farmers and foresters of Bangladesh. Therefore, regular training programs and extension activities have to be started by BFRI. Training is best conducted in two tiers, one for the trainers and the other for field level workers. At least a five days programs repeated initially over a six month period. About 25-30 trainees is the best size for each batch. Besides this, audiovisual programs narrating the steps of propagules production, plantation raising, silvicultural activities and techniques of bamboo preservation treatments would acquaint the farmers with the needed programs. The estimated fund requirements are:

Capital Expenditure (1993-94)	Taka Million
Audiovisual equipment	0.50
Vehicles	2.00
Dormitory	2.20
Office Equipment	0.80
Total	5.50
Annual Operation Expenditure	
Pamphlets, bulletins, booklets	0.5
Training kits	0.2
Daily allowances	0.6
Trainer Remuneration	0.2
Fuel oil for field visit	0.2
Repair and Maintenance	0.7
Miscellaneous	0.3
	2.5

Private Bamboo Plantation

The FMP surveyed some farmers on the question of planting bamboo. Alarmingly 88 percent have the opinion that number of bamboos decreased during the last five years, 79 percent wanted to plant more bamboos. Women favoured bamboo slightly more that men (83 percent). About 79 percent of farmers (83 percent of poor farmers with small holdings) think that vacant land is the

best planting location. Thirteen percent showed interest in planting on the non farm area, while only 6 percent chose pondsides.

It is important that pilot operations start using innovation methods and approaches to reach the former. During 1986-87 BFRI raised a four mile long canal bank (Satkania Naya Khal, Chittagong) plantation of bamboo seedlings and branch cuttings. At the beginning, the plantation was protected and maintained by monthly paid and locally engaged watchers. After three years, when the planted propagules developed into reasonably tall clumps, when BFRI discontinued the watchers, the clumps were cut. Before withdrawing the watchers several public meetings were arranged with the local farmers to advise them how to look after the plantation. Many asked for written documentation to support their rights on the plantations. No official agreement existed and they lost faith and took their share before others did.

Tenurial rights on public bamboo plantations for selected farmers is an important step in maintaining the planted area. Probably lease arrangements associating landless on canal banks or encroached land under agroforestry plots are the most satisfactory tenurial arrangement.

Bamboo plantations need started both in the forests and villages. The programs are well suited to local participation involving nearby villagers through community forestry activities.

Plantation Targets and Sites

The three recommended sites of forest bamboo plantation are:

		Hectares
a.	Long rotation sawlog plantations where at least two thinnings have been completed. These areas are mostly in the old teak plantations.	6,000
b.	Lower slopes on the banks of streams and canals in Unclassed State Forest (USF).	10,200
c.	Enrichment planting of muli seedling in the depleted areas.	4,000
	Total	20,200

As regards village bamboo plantation (mostly thick-walled species) priority lies with vacant land in homesteads. The FMP village forestry survey reports that farmers prefer planting bamboo on their own vacant homestead areas. The next priority is on the canal banks, roadsides and other marginal land. A canal without a stabilized bank can do more harm than good as irregular scouring of the bank eats up the adjacent cultivable land. A bamboo clump has well developed rhizome system and roots which helps bind the soil, thus controlling soil erosion.

The recommended planting sites and anticipated yield in the countryside for branch cuttings of different thick-walled bamboo species is 6,600 ha and 2.6 million culms, derived below. In the case of roads and railway sides curves and turnings and corners are exempted to allow for unrestricted visibility.

Suggested Sites	Area, ha	Cuttings, millions
Homestead vacant land	4,000	1.60
Canal banks/embankments	1,300	0.52
Highway/Roadsides, Railway (excepting curves)	1,275	0.51
Total	6,575	2.63

One hectare of bamboo plantation of thick-walled species produces about 400 culms (five years after planting). In the case of thin-walled species, muli bamboo yields about 1,330 culms in the first harvesting year from one hectare. Table 26 summarizes average planting areas, plantation establishment and maintenance costs and expected yields by five year periods of the Plan. Appendix 6 presents the yearwise data.

Preservative Treatment

Bamboos buried in the ground as posts are destroyed by termites and fungi in about one or two years; by fungi and borers in stacks placed above the ground in six months to one year; and by marine borers in about six months. Reportedly, bamboo under cover, and not in contact with the ground and in structures, lasts from two to five years. Bamboos successfully treated with inorganic water soluble preservatives has increased service life.

BFRI developed a combination ratio for the well known preservatives CCB (copper sulphate, sodium dichromate and boric acid). The above compounds are mixed 2:2:1 ratio in water. Usually two kg mixture of CCB is dissolved in 10 litres to prepare the preservative solution. Bamboo treatment with this preservative solutions is in two different methods - sap displacement and soaking.

Table 26 - 5-Year Periodic Plantation Areas, Costs and Expected Yields

Item	Units	1993/97	1998/02	2003/08	2008/13	Total
Planted Area						
Cuttings	ha	575	4,000	2,000	-	6,575
Seedlings	ha	5,700	14,500	-	-	20,200
Total		6,275	18,500	2,000		-26,775
Total Establishment and Maintenance Costs (million)						
Cuttings	Tk	9.09	100.44	379.39	428.14	917.06
Seedlings	Tk	68.13	306.26	155.66	-	530.05
Total		77.22	406.70	535.05	428.14	1,447.11
Expected Culm Yield (million)						
Cuttings	No	.02	1.23	11.19	30.83	43.27
Seedlings	No	.67	35.02	188.00	348.82	572.51
Total		.69	36.25	199.19	379.65	615.78

The sap displacement or Boucherie method successfully treats the whole culm, while the soaking method does bamboo strips and mats. A treated bamboo lasts for 15 years compared to untreated ones good for only two to five years. Thus the durability of a treated bamboo increases up to three to four times over untreated one. As a result pressure on the consumption of bamboo in construction works can be reduced. The treatment is simple, inexpensive and well suited to NGO or small operators or demonstrated at the extension centres. The most suitable area in the Country to begin this program of bamboo treatment depots is the wood deficit northwestern and north central regions.

The first program year is used for organization and planning and obtaining the necessary instrument, installations, and chemicals. BFRI can provide training to trainers and relevant BFD workers and interested NGOs. Initially, 50 treatment depot centre under NGOs and five under BFD at different part of the bamboo deficit areas are indicated. In each of these centre some demonstration houses like school, community buildings, mosques have to be constructed with the treated bamboo material to show their durable effect to the rural people. People of these areas

will see the performance of treated and untreated bamboo house. This will demonstrate the preservative treatment effectiveness. Select five upazila extension nurseries in the bamboo deficit areas to start with. The details of the locations of these nurseries are in Appendix 7.

Whole culm treatment at Tk 22/culm produces 30 bamboo x 250 days/A = 7,500 treated culms annually per centre. About 138 m^2 x 250 days/A = 34,500 m^2 (equivalent to 150,000 culms/A) is the annual fencing production at Tk 30/culm. Demonstration houses or community buildings (9.5 x 5.5 m construction) is a one time cost involving 55 x Tk 40,000 = Tk 2.2 million. Annual treatment costs are Tk 13.2 million which preserves 8.7 million culms. Expenditure required for preservative treatment program costs are as follows. Appendix 7 has details.

Item	Annual Amount	Tk Million
Demonstration houses	55	2.20
Annual Costs		
Whole bamboo treatment 7,500 x 55 culms	412,500	9.08
Bamboo fencing 10 x 250 x 60 = 150,000 culms 55 x 150,000	8,250,000	4.13
Total Annual	8,662,500	13.21

Table 27 summarizes a reasonable bamboo preservation program during the Plan. The assumption is that the number of culms treated annually increases by 5 percent/A up to the year 2003, and thereafter by 10 percent. The expansion represents introduction to other parts of the Country and penetration in the areas surrounding the extension centres. Total program cost is Tk 417.14 million and total net production of treated culms is 344 million.

Table 27 - Preservation Treatment Program, (Million Culms)

Year	Annual[a] Production	Taka Million
1993-97	47.83	72.82
1998-02	61.05	92.90
2003-07	90.17	137.34
2008-12	145.17	168.08
Total	344.22	471.14

[a] - On average the lifespan of treated bamboo is about 15 years, so the bamboo treated in 1994 rots in 2009, and so on.

Non Wood Products-Based Industry Training Centre

The working quality and skill of the craftsman are, at present, mainly dependant on their personal experience and family tradition to improve the design and quality of the bamboo and other now wood forest products (NWFP) handicrafts and furniture. Technology and trained manpower both are essential.

Establishment of a training centres for product improvement and diversification is proposed under the umbrella of BSCIC. Many small cottage industries have grouped together forming a number of cooperatives. Training programs will cater to cooperatives and NGOs already working in the field. The centre will have training hall room, laboratory and workshop, library, trainees hostel and trainers residential accommodations.

At the beginning expatriate trainers brought from the different regional countries provide training. Indigenous trainers will be trained by these foreign trainers. Simultaneously, indigenous trainers will be sent abroad to obtain experience from the bamboo based industries in other countries. Training costs envisaged are Tk 20 million to construct a training centre and Tk 29 million to support a three-year training program and Tk 10 million annually for annual operating costs. Total program costs are Tk 59 million for a 3-year program, as summarized in Table 28.

Table 28 - 3-Year Training Program Cost Estimates

Capital Expenditure	No	Months	Year	Tk.(million)
Land	-	-	1994-5	5.0
Civil Works	-	-	1995-96	7.0
Furniture and others	-	-	1996-97	0.5
Equipment/Facilities	-	-	1996-97	6.0
Vehicles	2	-	1996-98	1.5
Total				20.0
Expatriate Trainers				
Product Designer	1	24	1997-98	3.0
Product Engineer	1	36	1969-97	4.0
Tools Designer	1	24	1997-98	3.0
Production Manager	1	40	1996-97	4.5
Marketing Expert	1	12	1998-99	1.5
Course Designer	1	9	1998-99	1.0
Total	6	145		17.0
Study Tours				
Marketing Expert	3	18	2002-04	2.0
Production Manager	4	24	1998-02	3.0
Product Designer	6	36	2000-03	4.0
Product Engineer	6	36	2000-03	4.0
Total				13.0
Total Capital				50.0
Annual Operational Budget				10.0

Research Needs

Bamboo grows fast, conserves the soil, regreens the eroded slopes, provides short term income and has impressive socioeconomic importance. To sustain production the Country needs plans and action programs for the development of bamboo resources and bamboo-based handicrafts and industries. This stresses the need for formulating a resource management policy to generate research-based technologies for improved productivity and optimum utilization.

Previously, bamboo formed a perpetual resource because of vigorous vegetative regeneration. Now, uncontrolled exploitation reduces yield and causes deterioration in quality. Considering both its ecological and economic importance bamboo deserves intensive study and research. In 1974 BFRI started exploratory research on the collection, identification and centralisation of different bamboo species in the Country for future research. So far, BFRI's efforts collected 30 species from different parts of Bangladesh and centralised in their bamboo garden (Bambusetum).

Studies on different aspects of biological behaviour have been conducted and some preliminary data generated on growth, flowering behaviour and seed production. The information assembled on seed biology, natural regeneration, seedling growth, vegetative propagation and possibility of tissue culture on different bamboo species is limited. International Development Research Centre (IDRC) funded a systematic study on the macro and micropropagation of bamboos started 1980. This produced an improved and cheap technique of bamboo propagation using prerooted and prerhizomed branch cuttings developed by BFRI scientists.

This new method of propagation is economic and applicable for large scale plantation. It ensures 80-90 percent success in outplanting. Other methods of propagation such as seed gemination, seedling management and seedling multiplication (macroproliferation) attained success and also attracted attention of planters. However, little or no information exists on the current resource status, management problems and diversified utilization of bamboos. Investigations to date ignore socioeconomic importance of bamboos from harvesting and processing to utilization. These latter need require proper research attention.

The important research issues needing addressing are as follows.

- Suitable bamboo inventory methods.
- Data base development.
- Better understanding of the phenomenon of gregarious flowering.
- Determining suitable silvicultural and management prescriptions.
- Improved crop productivity.
- Development of proper method of training and extension for foresters and farmers.
- Design multiple use management systems for bamboo intercropping and understorey planting.

X. Proposed Projects

Analysis of the above issues is the basis for identifying the following research projects.

a. Growth and yield of bamboos in natural forests and homesteads.

b. Determination of optimum felling cycle and felling intensities of forest and homestead species.

c. Conservation of germplasm of indigenous and exotic species.

d. Tissue culture of bamboos for clonal propagation and genetic improvement.

e. Flowering and natural regeneration of bamboos.

f. Seed production, germination, viability and storage techniques.

g. Growth periodicity of bamboos.

h. Management of bamboo nurseries.

i. Effects of fertilizers and manuring on the growth and yield.

j. Demonstration plantation establishment plots.

k. Field growth trials of different bamboo species.

l. Development of management system suitable for intercropping and underplanting of bamboo for multiple land use at the initial stage of clump formation. Suitable and economically harvesting methods for harvesting bamboo, especially from inaccessible areas.

n. Effect of edible shoot harvesting on the growth and yield.

o. Inter and intra-specific genetic variability in natural bamboos.

2. Training Needs

At present there is no organised research division in BFRI to conduct research on bamboos. Therefore, the report recommends a new research division under BFRI, Chittagong to facilitate bamboo research activities in Bangladesh. To develop, improve and train manpower, the following program describes needs 140 months for six fellowships.

Subject	Countries	Man Months	Number	Degree/ Diploma	Tk, million
Silviculture	China/Japan	48	1	PhD	0.80
Tissue culture centre	India/ Thailand	48	1	PhD	0.80
Product development/ design	Korea/Japan	30	2	M Sc/Phill	0.60
Taxonomy	UK/India	6	1	Study tour	0.15
Tissue culture	India/Thailand/ China	9	1	Study tour	0.20
Total		141			2.35

3. Infrastructure

BFRI lacks a bamboo germplasm ex-situ conservation centre. A suitable site exists at the Keochia field station. The area of the centre is about two hectares. The propagules of different bamboo species of the Country along with their genetic variability will be collected and planted at the centre. Some high yielding exotic bamboo species suitable to the edaphic and climatic condition of Bangladesh will also, if possible, be collected and planted in the centre. Estimated costs for establishing this centre are capital Tk 1.75 million plus annual operating expenses of Tk 0.15 million, detailed as follows:

Item	Tk million
Land development, fencing,paths	0.25
Civil works	0.80
One pick up	0.70
Fuel oil	0.15
Total	1.90

Plans call for a tissue culture laboratory in 1993-98 to conduct research on micropropagation and genetical improvement on different species. Tk 1.75 million is required to establish and equip the laboratory. About $1.2 million in foreign exchange is required to import essential equipment, chemicals and glassware to conduct cultural research. The expected expenditure on the different items is as follows:

Item	Tk,million	$ million
Laboratory room arrangement (inoculation room, chemical room, washing/ sterilization room, water line, basin, tap, electric line, air cooler and instrument installation)	1.0	-
Equipment (Balance, autoclave, Ph meter, hot plate stirrer, growth, computer chamber, refrigerator, deep freeze, shaker, distillation plant, air cooler, oven, camera	0.35	1.15
Chemicals (macro and micro nutrients, organic compound, hormones, sterilents, detergents	0.25	0.04
Glass wares	0.10	0.01
Miscellaneous	0.05	-
Total	1.75	1.20

Impact on Bamboo Supply

Presently there are substantial regional deficits in bamboos in Bangladesh. Conditions are unlikely to improve in the future. For the development programs recommended the expectation is to increase the supply of bamboos in the Country. Table 29 is a balance sheet summarizing the impact of the programs on the bamboo supply. Harvesting improvements (20 percent) come from improved accessability. Management/ research programs aim chiefly at reducing the annual deforestation rates, now estimated by the FMP at 2 percent annually.

Table 29 - Forecast Development Program Effect on Bamboo Shortfall, (Million Culms)

Item	1993	1998	2003	2008	2013
Shortfall	-50.1	-81.3	-59.7	-203.3	-324.6
Development Programs					
Preservation	-	10.5	13.4	21.6	34.8
Plantations	-	1.8	21.6	69.7	94.5
Harvesting Improvements	-	38.0	48.7	21.9	8.3
Management/Research	-	19.3	38.7	58.1	77.4
Natural regeneration	-	-	-	55.0	128.0
Total Improvement	-	69.6	122.4	226.3	343
Balance	-	11.7	62.7	23.0	18.4

The above balance sheet summarizes the effect of the investment requirements outlined previously in reducing the shortfall. It constitutes a technical program and funding estimate to address the imbalance in the supply of bamboo in the Country. Reducing the shortfall is contingent upon the necessary strategies, policies, and programs implementation, and the appropriate level of technical, managerial and research inputs. These programs call for significant changes within the existing institutional set up and require strong support by a motivated staff.

APPENDIX 1
ABBREVIATIONS, TERMS AND CONVERSION FACTORS

APPENDIX 1
ABBREVIATIONS, TERMS AND CONVERSION FACTORS

ABBREVIATIONS

ACCF	- Assistant Chief Conservator
ADAB	- Association of Development Agencies Bangladesh
ADB	- Asian Development Bank
ADT	- Airdry Metric Tonne
AWB	- Asian Wetland Bureau
BARC	- Bangladesh Agricultural Research Council
BCIC	- Bangladesh Chemical Industries Corporation
BFD	- Bangladesh Forest Department
BFIDC	- Bangladesh Forest Industries Development Corporation
BFRI	- Bangladesh Forest Research Institute
BMRE	- Balancing Modernisation Rehabilitation and Expansion
BSCIC	- Bangladesh Small Scale Cottage Industries Corporation
CAI	- Current annual increment
CCB	- Copper sulphate, Sodium dichromate and Boric acid
CCF	- Chief Conservator Forests
CF	- Conservator Forests
cft (H)	- Cubic feet hoppus (.785 x true cubic foot)
cft (T)	- Cubic foot true volume (1.27 x Hoppus cubic foot)
CHT	- Chittagong Hill Tracts
cm	- Centimetre
crore	- Ten million
DCCF	- Deputy Chief Conservator
DCF	- Deputy Conservator Forests
DFO	- Divisional Forest Officer
ESCAP	- Economic and Social Commission Asia Pacific
FAO	- Food and Agriculture Organization of the United Nations
FAO	- Food and Agriculture Organization of the United Nations
FDTC	- Forest Development and Training Centre
FIRR	- Financial Rate of Return
FMP	- Forestry Master Plan Project
FRM	- Fibrous Raw Materials
gm	- Gram
GR	- Game Reserve
GS	- Game Sanctuary
ha	- Hectare
hp	- Flywheel horse power
hr	- Hour
IDRC	- International Development Research Centre, Canada
kg	- Kilogram
KHM	- Khulna Hardboard Mill
km	- Kilometre
km^2	- Square kilometre
KNM	- Khulna Newsprint Mill
KPM	- Karnafuli Paper Mill
KRC	- Karnafuli Rayon Complex
kw	- Kilowatt
lakh	- One hundred thousand
LPC	- Lumber Production Complex (Kaptai)
m	- Metre
m^3/ha/A	- Cubic metre per hectare per annum
m^3/ha	- Cubic metre per hectare
m^3	- Cubic metre
MAI	- Mean annual increment
max	- Maximum
md	- Man day
MEOF	- Ministry of Environment and Forest
min	- Minimum
mm	- Millimetre
MM	- Million
MT	- Metric Ton
NACOM	- Nature Conservation Movement
NEMAP	- National Environmental Management Action Plan
NGO	- Nongovernment organization
No.	- Number
NRS	- Natural Regeneration Strip

ODA	- Overseas Development Agency
POTHIKRIT	- Nongovernment Organization
POUSH	- Nongovernment Organization
RF	- Reserve Forest
SIDA	- Swedish International Development Agency
SPPM	- Sylhet Pulp and Paper Mill
St	- Saint
TEX	- Timber Extraction (Kaptai)
Tk	- Taka
UNCED	- UN Conference on Environment and Development

TERMS

agroforestry	- A set of landuse systems that combine trees with pasture, arable crops, and/or animal production on the same land unit, either simultaneously or in short sequence. This agroforestry is a set of technologies or practices, as distinct from a program or policy. Certain agroforestry technologies find valuable application in programs of social forestry or community forestry.
amenity forestry	- Forestry for the purpose of recreation, pleasure, or general beautification of an area or a settlement.
beel	- deep water , central portion of an haor.
dao	- Large hand-held work knife
dumb barge	- Barge requiring towing or pushing, a high-sided vessel used for water transportation and without propulsion means on board
hoar	- dish-shaped freshwater swamp.
mahal	- Contract block, wood or bamboo
mahaldar	- Wood Contractor
yarding	- Moving logs from stump site to roadside
water bar	- Earthen berm installed across road ways to control water flow to prevent road erosion.
social forestry	- The use of trees, and/or tree planting, to pursue social objectives (usually betterment of the poor). Social forestry is a program that may include many elements of agroforestry. It often includes, but is not interchangeable with, community forestry, which has a narrower meaning. A broader discussion of the term follows in the chapter section on case studies.
wasteland	- Land that is currently producing useful biomass grossly below its potential. The reasons for underproduction may be many and varied, from technical (salinity, acidity or alkalinity, waterlogging) to social (disputed ownership or rights) or political (forest department or community ownership).

CONVERSION FACTORS

US $ 1	- Tk 38.8
Tk	- US 0.0258
1 m^3	- 27.7 cft Hoppus
1 cft(H)	- 1.2732 cubic feet true - cft(t)
1 cft(t)	- one cubic foot true solid volume
maund	- 37.33 kg
1 km	- 0.621 miles
1 ha	- 2.471 acres
1 litre	- 0.220 imperial gallons
ton	- 2,000 lbs
tonne	- 1,000 kilograms
teak	- 1,080 kg/m^3, green weight
gamar	- 650 kg/m^3, green weight
melocanna	- 450 kg/m^3, green weight
1000 culms muli bamboo	- 1.8 ADT
1000 culms other bamboo	- 1.6 ADT
Raw ton	- 0.67 ADT

APPENDIX 2
TERMS OF REFERENCE

PROJECT 372001/8
FORESTRY MASTER PLAN
BANGLADESH TA 1355-BAN

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 30 JUNE 1992

BAMBOO

APPENDIX 2
TERMS OF REFERENCE

a. Review and assess existing data on bamboo.

b. Evaluate present public and private bamboo management practices and cultivation techniques. Recommend needed improvements.

c. Assist the Institutions subteam to evaluate bamboo research and to devise measures to increase research on bamboo silviculture.

d. Review and assess bamboo industries in the Country, including their development potential.

e. Examine the use and cultivation of bamboo by rural communities (homestead forests). Recommend measures (such as extension) to support such practices.

f. Estimate the quantity of existing resources and consumption. Distinguish between bamboo on private and public lands.

g. Project supply and demand estimates for both domestic consumption and industrial use to the year 2000.

APPENDIX 3
SILVICULTURE FACTORS

PROJECT 372001/8
FORESTRY MASTER PLAN
BANGLADESH TA 1355-BAN

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 30 JUNE 1992

BAMBOO

APPENDIX 3
SILVICULTURE FACTORS

TABLE OF CONTENTS

1. IDENTIFICATION CHARACTERISTICS

So far 30 different bamboo species have been seen, collected from different parts of the country and planted in the exsitu conservation plot (Bambusetum) of Bangladesh Forest Research Institute (BFRI), Chittagong. Table 1 lists the identification characters of the clumps of the major bamboo species of Bangladesh. These useful characters permit easy species identification at the field level.

Figure 1 shows the distribution of bamboo according to local temperature and rainfall regimes. Appendix 3 fully describes species characteristics, site, distribution and habitat requirements.

Table 1 - Clump Character and Bamboo Species of Bangladesh

	Clump Character	Species: Scientific Name	Species: Local Name
1.0	**Clumps not thorny**		
1.1	Shrubby, closely growing 2-4 long, culm culm diameter 1-3 cm and much branched from base. Cultivated as hedges	Bambusa glaucescens (Willd.) Sieb. ex Munro	Tetua
1.2	Culms in the clump are straight, 3-4m long, 2-4 cm in diameters, bright green with whitish silky cover when young, dull green and yellowish when old. Branches are only on the upper 1/3rd portion of culm. Leaves are smaller, cultivated as hedges	Thyrsostachys sp.	Rangoon bans, Bilati bans
1.3.	Medium sized 9-12m long closely growing clump. Culm diameter 1-5 cm, dark green, black cilia on the young stem, less branching at the base. Naturally growing in the forests	Oxytenanthera nigrociliata Munro	Kali, Kalichari
1.4	Medium to large size clump 10-15 m long, branching mainly on the upper part of the culm. Culm glaucous-green when young and covered with long persistent papery sheaths often longer than internode growing naturally in the forests	Dendrocalamus longispathus Kurz	Ora, khag orali, rupai
1.5	Medium to large size clump 10-25 m long, 3-8 cm in diameter, dark green, branching excepting basal 3-8 nodes. Growing naturally in the forests and also cultivated	Bambusa tulda Roxb.	Mitinga, mita, mirtinga, nitai
1.6	Clump has more or less similar look to that of B. tulda, culms are slightly bluish green in colour not shining, white ringed below the	Bambusa nutans wall. ex Munro	Peechle, makal, makla, keyitta, nitai

	nodes; cultivated in the villages		
1.7	Clump has similar look to those of B. tulda and B. nutans. Yellowish white vertical striations are present on the basal 2-4 nodes. Cultivated	Bambusa longispiculata Gamble ex Brandis	Talla, tarala, baillo, makla, mal, mahal, bon, sakua
1.8	Medium to large clump 10-35 m long. Culm diameter 5-10 cm, glossy green when young, yellowish when old or exposed to the sun, thick-walled usually branching throughout excepting 3-6 basal nodes. Basal nodes have brown to whitish root rings. Nodes raised, widely cultivated	Bambusa vulgaris Schrad. ex Wendl	Bariala, bahini, barak, bashni, baria jai, jawa, ora
1.9	Clumps are comparatively smaller than B. vulgaris 8-12 m long, stout, thick walled. Culm golden yellow, stripes along the length of internode alternating at each node, diameter 3-7 cm.	Bambusa vulgaris var. striata (Lodd) Gamble	Haldabans, Sharna bans
1.10.	Stout and 15-23 m tall clump, apical part of the culms somewhat curved or hanged centrifugally. Culm nodes prominently raised, thick walled, diameter 8-15 cm, deep green colour with shiny brown pubescence on the internode Branching throughout, long and has prominent nodes. Some auxillary leafless branches recurved like pointed spines especially at the lower culm nodes. Widely cultivated	Bambusa balcooa Roxb.	Pharua, bethua bans
1.11	Clump large 15-25 m. culms grey to greyish-green when young, at maturity covered with the whitish brown pubescence. Branching always at upper half of the culm. Leaves smaller and narrower then other Bambusa species of the country. Cultivated.	Bambusa polymorpha Munro	Pharna, bethua burma bans
1.12	Clump very large and gigantic 20-35 m tall. Culm diameter 12-18 cm, grey-green and basal nodes marked with root scar. Branching usually slender and limited to the upper part of the culm. Cultivated in the Buddist Temple.	Dendrocalamus giganteus Munro	Bhudum bans

1.13	Clump densely tufted, medium to large 6-15 m. Culm glaucous green when young, dull green when old, short and somewhat solid internode at lower portion, diameter 3-9 cm, thickest wall. Branching usually throughout the culm. Cultivated in the drier part of Bangladesh	Dendrocalamus strictus Nees	Lathibans
1.14	Clump large 10-30 m, closely tufted. Culm greyish white when young and dull green when old with brown pubescence, sending out apical part as flagellum, sometimes intermingled with each other. Stout and elongated (4-10 m) branches mostly in upper part of culm. Culm and branch nodes have distinct semicircular creamy colour bud. Naturally growing only in Sylhet forest.	Dendrocalamus hamiltonii Munro	Pecha bans
1.15	Clump medium sized 5-12 m. Culm dark green covered with silvery white pubescence, very much elongated (0.4-1.2m) internode, thinnest (3-5 mm) wall compare to other species of the country, diameter 3-7 cm. Branching from mid-culm to top. Growing naturally in the forests	Neohouzeaua dullooa (Gamble) Camus	Dalu, chunga bans
1.16	Clump medium sized 4-10 m. Culm yellowish green to rusty green. Culm diameter 4-7 cm. branching mostly in the upper portion. Cultivated mainly in Comilla.	Bambusa sp	Kanak kaich Mugal
2.0	**Clump thorny**		
2.1	Large clump 10-32 m. Culm dull to deep green, diameter 3-9 cm, root rings on young culm nodes, nodes prominent. Branching throughout, spreading, thorny. Thorns strong, curved, 2.5-5 cm long. Cultivated	Bambusa arundinaca (Retz.) Wild	Kanta bans
2.2	Clump medium sized, 6-15 m dense. Culm bright green, diameter 2-5 cm, much branched, densely thorny. Thorn smaller 0.5-1.2cm long, usually in 3s, curved. Leaves smaller. Cultivated in drier part of the country.	Bambusa arundinacea var. spinosa Roxb.	Bish kanta bans
3.0	**Diffused clump**		

3.1	Culms in the clump emerge isolatedly at long distance (1-2.5m) from each other. Younger culm (less than 12 months age) has persistent culm sheaths on the node, completely unbranched, apical thin part drooping with 4-6 leaves clearly visible from a distance. Culm diameter 2-6 cm, thin-walled, 6-9 meter tall growing naturally in the forests.	Melocanna baccifera (Roxb.) Kurz	Muli, nali,
4.0	**Climbing**		
4.1	Culms climbing, woody, spreading, clump forming 3-8 m long, diameter 1-4 cm. Growing naturally in the Cox's Bazar forest.	Melocalamus compactiflorus (Kurz) Benth	Lata bans

2. REQUIRED ENVIRONMENTAL CHARACTERS FOR NATURAL BAMBOO

Temperature

The majority of clump forming bamboos grow at temperature ranges from 7°c (sometimes 2-3°c) to 40°c. In general, high temperature accelerates the growth of bamboo and low temperature inhibits it. The luxuriant growth of clump forming types has been observed in the humid tropics mainly in places of low and medium altitude (within 100 m above the sea level) with an average temperature higher than 20°c.

Rainfall

Gamble (1896) reported that distribution of bamboo in India was mainly related to the rainfall, the most common range being 1,270 mm to 4,050 mm. The upper limit is not known but the species are found to grow in zones with over 6,350 mm (Huberman 1959). The most common range is 1,200 to 4,000 mm per year. According to Numata (1987) 1,000 mm seems to mark the minimum annual precipitation required.

The average annual rainfall in Bangladesh varies from 1,500 mm to 5,500 mm which falls mostly between last part of May to August and period of dry months is from October to March. The relative humidity is also correspondingly high ranges from 60 percent upwards. The atmospheric temperature ranges from 5 - 41 °c. Bangladesh fulfils all the above climatic requirements and thus a home of many different species of bamboo (Figure 1). In most of the years country experience strong cyclonic winds but these do not seem to act as limiting factors to the occurrence or growth.

Topography

Top soils that are suitable for bamboo growth vary in colour from yellow to brown-yellow, and heart soil colour are clear red, yellow-brown to blue-grey (Uchimura 1987). Soil pH about 5.0 - 6.5 is the most suitable for bamboo, some species may grow even at pH 3.5. Bamboo do not survive on saline soil. It has been reported that the geographically younger soils are more suitable for bamboo than the older soils. In Bangladesh, healthy bamboo clumps are found in well-drained, sandy loam to clay loam soil with good amount of organic matter on flat or gentle slopes of the hills. In the hilly areas of Chittagong Hill Tracts, Sylhet, Cox's bazar and Northern Mymensingh where bamboo grow naturally the common soil colours are yellow, brownish yellow, or light reddish yellow. A wide range of textural variation and soil depth, however, do not interfere in normal growth of bamboo provided the drainage, rainfall and temperature conditions are favourable. Treatment with N - fertilizers had been recommended for stands of low productivity.

DISTRIBUTION AND HABITAT

General

Semi-evergreen and semi-deciduous forests in the hills of Chittagong Hill Tracts, Cox's Bazar, Sylhet and Northern Mymensingh of Bangladesh have different naturally grown bamboo species either as understorey in association or pure stand. There are usually, but by no means always, scattered trees typical of the semi-evergreen to semi-deciduous climax standing singly or in groups over the bamboo especially in depressions. The shade cast by the bamboos is such that there is normally no undergrowth, but in the more open parts it is developed to a varying extent. Schimper (1895) said that most of the bamboo forests are secondary vegetation on abandoned fields. Bamboos generally invade abandoned fields after slash and burn agriculture (Jhuming), as can be observed in forest areas of Chittagong, Chittagong Hill Tracts and Sylhet. The rhizomes of bamboo in a natural forest are left after jhuming and they rapidly regenerate into pure bamboo forests covering a wide areas as a fire climax (Numata 1987). But repeated firing and jhuming destroy the under ground rhizome and thus destroy bamboo forest. No natural growth or regeneration of any bamboo species can be seen in the sal forests of Madhupur, Tangail, Mymensingh, Gazni and Dinajpur. This was very remarkably distinct that bamboo species such as, M baccifera, O.nigrociliata, B. tulda were found to grow inside the semi-deciduous forest by the side of pure sal forest of Gazni, north-west of Mymensingh, near the border of

Meghalaya province of India. The major tree species of that semi-deciduous forest were Arotcarpus chaplasha, Mimosa sp., Caesalpinia digyna, Dalbergia rimosa, Ziziphus mauritiana, Mallotus sp., Glochidion sp., Acacia catechoids, Moringa sp., Syzygiumsp., Leea sp., and Phyllanthus emblica, Toona ciliata, Bauhinia sp., and Albizia procera. Similarly Waheed Khan (1960) reported that in Bilashpur forest of Madhya Pradesh where sal (Shorea robusta) is almost pure, bamboo is conspicuously absent. A proper scientific investigation is needed to identify the causes of such antagonistic relationship between pure sal forests and bamboo. Bamboos are also not naturally growing in the mangrove forests of Sundarbans (Figure 1).

So far observed seven species of bamboos have been growing naturally in the forests of Bangladesh. Among them muli bans Melocanna baccifera is most common. Other species - mitinga Bambusa tulda, orah Dendrocalamus longispathus, dalu Neohouzeaua dullooa and kali Oxytenanthera nigrociliata occur sporadically either in association with muli or in isolation forming small patches of pure vegetation. The other two species lata Melocalamus compactiflorus and pecha Dendrocalamus hamiltonii are localized only in limited areas of Cox's Bazar and Sylhet forests respectively (Table 2).

Table 2 - Distribution of Seven Bamboo Species by Forest Regions

Forest Area	B. tul	D. ham	D.lon	M. bac	M. com	N. dul	O. nig
Ramgarh	2	0	2	2.3	0	1	2
Sitakund	1	0	1	2.3	0	1	1
Bandarban	1	0	1	2.3	0	1	2
Khagrachari	2	0	1	2.3	0	1	1
Kassalong	2.3	0	1	3.2	0	1	1
Kaptai-Sitapahar	2	0	2	3.2	0	1	1
Jaldi-Harbang	1	0	1	1	0	0	1
Cox's Bazar	1	0	1	1	1	0	1
Panerchara-Teaknaf	1	0	1	1	2	0	1
South Sylhet	2	1	2	3.2	0	2	1
North Sylhet	2	1	1	2.1	0	2	1
Sundarban	0	0	0	0	0	0	0
Dk-Mym Sal Forest	0	0	0	0	0	0	0
Dinajpur Sal Forest	0	0	0	0	0	0	0

Note: 1. 0=Absent, 1=Restricted to a very few localities but found in few numbers, 2=Found in small numbers but occurring in several areas, 3=Occurring gregariously in pure form.
2. B. tul=Bambusa tulda, D. ham=Dendrocalamus hamiltonii, D. lon=Dendrocalamus longispathus, M. Bac=Melocanna baccifiera, M. com=Melocalamus compactiflorus, N. dul, Neohouzeaua dullooa, O. nig=Oxytenanthera nigrociliata.

Forest Species

1. Muli

(Melocanna baccifera (Roxb, Kurz) is the predominant and major species naturally growing in the different forests of Bangladesh (Table 2). Muli is more or less an evergreen with single culms arising at a distance of one to two meters apart from a ramifying underground rhizome system. The branchless young (less than 1-year old) culms with drooping tips having a few leaves and nodes covered with persistent sheaths are the common views of the muli forests during October to April. It is typically a gregarious and handsome bamboo in the forest of Bangladesh. The natural distribution of this species, as described by Gamble (1896), is throughout eastern Bengal and Burma from the Garo and Khasia Hills to Chittagong and Arakan, and certainly in Chittagong this is the most common species. Scientists (Prasad 1948, McClure 1966) believe that the natural home of muli bamboo is in the Chittagong Hill Tracts, where it grows gregariously covering large tracts of land. The above mentioned regions of the world are subjected to torrential monsoon climate having highest rainfall (3,000 to 6,350 mm), and it can be interestingly noted that occurrence of muli bamboo is confined to only these regions of the earth, probably, for protecting the soil from erosion by its long elongated ramifying intermingled rhizome system (Banik 1989).

Muli occurs as undergrowth in many of the tree crops and also forms pure stand in the disturbed areas due to shifting cultivation, burning or extensive clear-cutting. Thus it seems that muli can grow under the crown cover as well as in open hills. The long rhizome necks have the power of spreading and quickly cover the vacant space of the hills by producing culms within a short time provided the plant is not disturbed. Occasional forest fire kills the tree seedlings and other non-rhizomatous plants while the underground rhizomes of muli remain alive. Many new culms emerge from the living underground rhizomes and face a little or no competition from any other plants and thus form a pure muli vegetation. In the forest it is impossible to demarcate the boundary of a clump as the rhizomes of many different clumps intermingled with each other form underground network and make impossible for the other plant species to invade the area. The plant have been thriving satisfactorily equally on the moist sandy clay loam alluvial soils and on the well drained residual soils consisting of almost pure stands, even to the summits of low

sand hills. As regards the topography muli is found to grow on the sandy rough slopes and the top of the hills indicating the hardy nature of the plant.

2. Mitinga

Bambusa tulda (Roxb) is another common bamboo growing naturally in the forest of Bangladesh. Mitinga is an evergreen or semi-deciduous clump-forming bamboo, branching freely from nearly all the nodes. The branches from the lower nodes being thin, early leafless and more or less horizontal. According to Prasad (1948) this species is native of Assam, Bengal, Northern Cachar, Chittagong and Burma. Mitinga is generally found to grow as undergrowth sporadically or in patches. Sometime it forms patches of pure to semi-pure vegetation as observed near Matamuhuri stream of Alikadam Range. In Adampur forest of Sylhet sometimes the species can be seen growing as pure stand. This bamboo frequently grows on the flat alluvial deposits along streams in the mixed deciduous forest and also along the banks of the dry water courses. The species is also being cultivated in the homesteads of Bangladesh.

3. Orah

Dendrocalamus longispathus (Kurz) is a large tufted bamboo with leaves born only on the upper branches and easily recognizable by its long fragile papery sheaths covering the internodes of younger culms. The species has been naturally distributed in the eastern part of Bangladesh (Sylhet, Chittagong) and Burma (Arakan), chiefly along the streams and in the moist parts of the upper mixed forests, on moist fertile loam (Gamble 1896, Prasad 1948). The species is rarely seen on the hill tops and drier slopes. Under the close canopy cover the species are rarely seen, mostly grows in the moist and partially shaded fringes of the forest cover. Sometimes it forms pure patches as observed in koila block of Ramgarh, Rangkhiang Reserves of Chittagong and Rajkandi Reserves of Sylhet.

4. Kali

Oxytenanthera nigrociliata (Munro) is an evergreen semideciduous medium sized with comparatively smaller diameter tufted bamboo, usually dark green, nodes prominent, internodes and culm sheaths of younger culms mostly covered with blackish to brownish hairs. According to Gamble Chittagong, Burma, Andaman Islands, Malaya Peninsula, extending to Sumatra and Java. Parker (1931) reported that the species could be seen gregariously on the flat ground and low elevations along the streams in the evergreen forests of Burma. Characteristically the species is plentiful and found as a congested clump in the fringes of moist semideciduous forests of Chittagong as observed in Kassalong valley and Sitapahar of Kaptai. One can also see the occurrence of this species on both the sides of Chittagong-Cox's Bazar Road near the fringes of Chunati and Harbang forests, and also in the Bhomariaghona forest. Kali is also distributed in isolated clumps on the disturbed scrubby and drier hills of Keochia, Bundarbans, Ramgarh, Kaptai and Rangamati. The species has capability to tolerate the repeated cutting while most of the other bamboo species fail to survive.

5. Dalu

Neohouzeaua dullooa (A. Camus) is dark medium-sized clump with culms growing in large tufts; culms are dark green covered with a few shiny whitish hairs, whitish below the nodes, glossy when dry. Nodes are not prominent. The species is easily distinguishable by its very long (0.3 to 1.2 m) thin walled internodes covered with scattered shiny white appressed hairs. The species is much used for making mats. Leafy branches are switchy, in dense half-whorls at the nodes and less branching at the lower nodes. The natural distribution of dalu is throughout northern and eastern Bengal and Burma, from Bhutan through the Assam and Sylhet valleys and the hills between them to Chittagong and upper Burma (Gamble 1896). The species generally occurs on the moist, well drained and fertile valleys as understorey in the deciduous forests of Sylhet, Chittagong and Hill Tracts of Chittagong (CHT).

Dalu prefers shade and is not available on drier, open and scrubby hills. Rao and Ramakrishnan (1988) have also reported that 'the species is more relatively shade tolerant and belong to the periodic growth - evergreen type'. Gamble (1896) reported that Hooker's collection from Sitakunda, near Chittagong were preserved in Kew herbarium. In 1992, one can seldom find a clump of dalu in Sitakunda Hills. Repeated cutting and fire have destroyed the forest and exposed the ground to direct sunshine. As a result land has become gradually drier and overhead shade due to trees has also been destroyed. Thus the habitat has become unfavourable for dalu bamboo. Similar situations were also observed in the different forests of Bangladesh. It appears dalu has become a threatened species in the Bangladesh forests.

6. Pecha

Dendrocalamus hamiltonii (Munro) a large clump forming bamboo, more often sending out stems at an angle or curved downwards, as a result sometimes culm tips intermingle with each other. The natural distribution of the species is in North East-Himalaya, Assam valley, Khasia Hills, Sylhet, extending eastward to upper Burma, and westwards to the Sutlej (Gamble 1996). The species is now most probably confined only to Patharia Reserve of Sylhet especially in the tea gardens. Tea gardens begin a protected area might be a better site for regeneration of the species. The species occurred in moist places along streams and in valleys, often bending over and forming dense thickets. The species seems to be light demander, because clumps always occurred in the exposed condition rarely under the tree canopy.

According to Rao and Ramakrishnan (1988) dalu and pecha are light demanding early successional species, the former being more relatively shade tolerant. The present destruction of forests have decreased the crown cover and the lands have become mostly exposed creating unfavourable conditions for these species. Based on the leaf characteristics they described dalu as periodic growth - evergreen type whereas pecha is periodic growth - deciduous types.

7. Lata

Melocalamus compactiflorus (Benth.) is an evergreen tufted bamboo with greyish-green, scandent spreading and arching culms climbing on the supporting trees. The stem has remarkable large buds at some of the nodes. The species is naturally distributed in Eastern Bengal and Burma, from Sylhet through Chittagong down to Martaban (Gamble 1896). At present, the distribution of lata is mostly confined to area of Teknaf forest of Cox's Bazar. The species thrives well near the banks of streams and moist valleys in the hills. Large scale monocarpic death of the species due to the flowering in 1975 in the area of Teknaf and Cox's

Bazar has limited its availability in the forests. Even 20 years before (late sixties), lata was a common bamboo species to be found in the forests of Teknaf and Cox's Bazar, but during 1978-80 large areas of these forests were clear felled and slash burned for making plantation of oil palm and fast growing exotic tree species. As a result this species has been eliminated from most of these natural belts. Repeated exploitation and forest fire are the factors also influencing the presence and distribution of bamboos in the forests. The clumps of pecha were rarely found inside the reserve forests and in the areas where human interference was not controlled. It appears that lata, dalu and pecha which were common even two decade ago are now threatened with extinction in Bangladesh.

Village Bamboos

Among the bamboo species cultivated in the different parts of Bangladesh, B. balcooa, B. vulgaris, B. nutans, B. tulda and B. longispiculata seem more common (Table 3). In ranking village grown species barua or bhalku bans (B. balcooa) and bariala (B. vulgaris) bans are in the top of the list. The former being more common in the northern and western districts whereas the later one was frequently cultivated in the south and eastern part (Table 3). According to Gamble (1896) B. balcooa has been naturally distributed in Assam, lower Bengal (western) and Bihar and extending to Goruckpur. It is likely that this species has been commonly introduced in the long past by man nearing the border districts of Bangladesh from the place of naturally occurring areas of India. It was also seen that some of the cultivated species (B. nutans) have been cultivated in small scale in the hills of Bandarbans, Sitakunda, Chittagong, Cox's Bazar and Sylhet. These were mainly on the homestead. Thus it appears that these species can be cultivated in the plain land having pH 6-8, and in the hill soils of pH 4.5-5.5.

The bamboos grown in the flood plains can tolerate short seasonal floods. Flooding for a longer period are probably not favourable condition for any bamboo species of the country. This is evident from the fact that neither the cultivated nor the natural species occurs in the seasonally or tidal flooded areas. Underground rhizomes system in the water-logged condition might suffer from oxygen deficiency and thereby face problem in respiration. Distribution of cultivated bamboo species in the plain districts seems to be related to the choice and liking of planters, utility values of the species and availability of planting materials.

3. CULTIVATION STATUS OF BAMBOO IN DIFFERENT RURAL DISTRICTS

District	B. ar	B. as	B. bl	B. gl	B. ln	B. nt	B. pl	B. tl	B. vl	B. spp
Dhaka	0	1	3	0	1	2	0	2	2	1
Tangail	0	1	3	0	1	2	0	2	2	0
Mymensingh	1	1	3	0	1	2	0	2	2	0
Faridpur	0	1	3	0	1	1	0	2	2	0
Pabna	0	1	3	0	1	1	0	2	2	0
Bogora	0	1	3	0	1	1	0	2	2	0
Jessore	0	1	3	0	2	1	0	2	2	0
Rajshahi	0	0	3	0	1	1	0	2	2	0
Kushtia	0	0	3	0	1	1	0	2	2	0
Barisal	0	0	2	0	2	1	0	2	2	0
Patuakhali	0	0	2	0	2	1	0	2	2	0
Khulna	0	0	2	0	2	1	0	2	2	0
Dinajpur	1	0	3	0	3	2	0	2	2	0
Rangpur	1	0	3	0	3	2	0	2	2	0
Comilla	0	0	3	1	1	2	0	2	2	2
Noakhali	0	0	2	0	1	1	0	2	3	0
Chittagong	0	0	2	1	1	2	1	2	3	0
Hill Tracts	0	0	1	0	0	0	1	0	1	0
Cox's Bazar	0	0	1	0	1	1	2	2	3	0
Sylhet	0	2	3	2	2	2	2	2	2	1

1. 0=not found, 1=rarely cultivated, or cultivated in selected place, 2=rarely cultivated, 3=profusely cultivated.
2. B. ar=B. arundinacea, B. as=B. arundinacea var. spinosa, B. pl=B. polymorpha, B. tl=B. tulda, B. vl=B. vulgaris, B. sp=Rumbusa species (Karaikati), D. gi=Dendrocalamus giganteus, D. ln=D. longispathus, D. st=D. strictus, T. si=Thyrsostachys siamensis.

4. ESTIMATION OF FUTURE NATURAL BAMBOO AREAS (HA)

Year	Sylhet[a] 2.55% annual loss	Kassalong[b] 2.53% annual loss	Rankhiang[c] 2.82% annual loss	Sangu-[d] Mathamuhuri 0.93% annual loss	Chittagong[e] 2.27% annual loss	Cox's Bazar[b] 2.27% annual loss
1983	-	36178	19800	-	-	-
1984	-	35263	19242	24606	-	-
1985	-	34371	18699	24377	-	-
1986	-	33501	18172	24150	-	-
1987	-	32653	17660	23925	-	-
1988	13933	31827	17162	23702	-	-
1989	13578	31022	16678	23482	-	-
1990	13232	30237	16208	23264	-	-
1991	12895	29472	15751	23048	-	-
1992	12566	28726	15307	22834	-	-
1993	12237	27999	14875	22622	42921	28220
1994	11925	27291	14456	22412	41947	27579
1995	11621	26601	14048	22204	40995	26953
1996	11325	25928	13652	21998	40064	26341
1997	11036	25272	13267	21793	39155	25743
1998	10755	24633	12893	21590	38266	25158
1999	10481	24010	12529	21389	37397	24585
2000	10214	23403	12176	21190	36548	24027
2001	9954	22811	11833	20993	35718	23481
2002	9700	22234	11499	20798	34728	22948
2003	9453	21671	11175	20605	33939	22427
2004	9212	21123	10860	20413	33168	21918
2005	8977	20589	10554	20223	32415	21420
2006	8748	20068	10256	20035	31679	20934
2007	8525	19560	9967	19849	30960	20459
2008	8308	19065	9686	19664	30257	19994
2009	8096	18583	9413	19481	29570	19540
2010	7890	18113	9148	19300	28899	19096
2011	7689	17655	8890	19121	28243	18662
2012	7493	17208	8639	18943	27602	18238
2013	7302	16773	8395	18767	26975	17824

Annual deforestation loss:
a. 2.6% b. 2.5% c. 2.8%
d. 0.9% e. 2.3% f. 2.3%

5. EXISTING CUTTING RULES

The following felling rules are prescribed for bamboo cutting and these are to be strictly followed.

a. No new culms of the previous rains will be out.

b. In addition to the new culms some of the older culms have to be retained for mechanical support and protection to the young shoots and to maintain the rhizomes in full vigour. With every one year old culm, another older culm must be retained. Of the older culms thus retained preference should be given to the comparatively immature bamboos for retention. This rule will apply to the single stem muli bamboo as well as other species usually growing in clumps.

c. The older culms to be left as evenly distributed over the area as possible in case of single stem bamboos.

d. Of the culms retained under (a) & (b) at least half should be left on the periphery of the clums. On the steeper slopes more mature bamboos should be retained on the lower side to give mechanical support to young shoots.

e. Culms may not be out less than six inches and more than one foot about the ground except in very congested clumps where cutting should be done at the lowest possible point.

f. Tearing or splitting the base of the culms while cutting should not be permitted.

g. While removing the felled bamboos care should be taken to avoid damages to other standing bamboos.

h. No portion of the cut bamboo may be left in the clump.

i. Doga bamboo or clums of the previous rains may only be cut in a selective way when required for bamboo bundles. Malformed doga should be preferred for this purpose.

j. Digging or extraction of rhizomes will bot be permitted, except for the purpose of artificial regeneration.

k. From any young clump no culms should be cut until they have attained full size.

l. Except for the purpose of rafting timbers no extraction of bamboos will be allowed during the period between 1st June and 1st September when the growth of new shoots takes place.

m. When gregarious flowering takes place in case of any particular species of bamboos over considerable areas the Divisional Forest Officer may with permission of the Conservator of Forests keep the entire are open for extraction of all bamboos of that species, after they have seeded, if that area happens to be in a closed coupe.

6. REGION, STRATA DEFINITIONS

Different Survey Regions of Bangladesh

Region	Area (Greater district)
Northwest (Stratum-I)	Dinajpur, Rangpur, Bogra, Rajshahi and Pabna
Northcentre (Stratum-II)	Dhaka, Tangail, Jamalpur, Mymensingh (Part- Mymensingh Sadar)
West (Stratum-III)	Kushtia, Jessore, Faridpur, Barisal (Part-Barisal, Bhola, Jhalakathi) and Khulna (Sadar)
South (Stratum-IV)	Patuakhali, Khulna (Part- Bagerhat, Satkhira) and Barisal (Part- Pirojpur)
Southeast (Stratum-V)	Comilla, Noakhali and Chittagong
Northeast (Stratum-VI)	Comilla (Part- Brahmanbaria), Mymensingh (Part- Netrokhona Kishoreganj) and Sylhet

7. HARVESTING PRESCRIPTIONS

Forest Extraction

a. Overexploitation repeated cuttings of bamboos more than one time in a year from a unit area of the forest must be stopped. In reality it is the field labourers who themselves select, cut and harvest the bamboos from the forest. Therefore, they need training and education by the foresters about the existing bamboo cutting rules (Appendix 3). An audio-visual aid may be utilized to educate the labourers, contractors and permit holders before entering into the bamboo forest for the purpose of harvesting. FDTC may conduct such training programme for the natural bamboo forests. Forest Extension Department and NGOs may take the task of training the farmers about the village bamboo groves. NGOs trainers may be trained by FDTC/BFRI/Forest Extension or by all the three agencies.

The areas of bamboo mahals in Sylhet forest are large ranging from 400-1,000 ha. The field staff of related forest divisions are not sufficient to look after and supervise the whole felling operations inside such big land areas. The big mahals may be divided into a number of small mahals. Strict superior supervision must be ensured.

b. New roads and paths are to be established in the inaccessible areas of the forest to facilitate the bamboo extraction. Construction of overhead ropeway may be useful as KPM did in the Chittagong Hill Tracts.

c. Following the prescribed bamboo cutting rules properly produces negligible wastage. Thorough supervision is needed to advise and guide the labourers. The present cutting rules (Appendix 3) are perfectly adequate, if followed, to preserve and sustain the resource

During harvesting a bamboo culm must be cut at the soil level and saw/hacksaw must be used to avoid splitting or tearing of the stem. The thin top portion of the bamboo must not be chopped off and left at the forest. To encourage the labours to bring full bamboo by shoulder load they must be paid a higher wages rates than at present. This will lead to a substantial reduction in the wastage of bamboo during harvesting. It may be mentioned that the top and butt portion of the bamboo which are now left at the field contains longer fibres and higher amount of cellulose respectively which are essential ingredients for producing quality pulp.

Besides this, to discourage the present practice of wastage contractors engaged in harvesting must be penalized if such wastage are found by the supervising authority.

Cutting terms and conditions must be rigidly incorporated in the contract documents.

Village Cutting Systems

The villagers should be educated by forest/agriculture extension workers in the following cutting system for bamboos. Audio-visual aids may be utilized to train and motivate the farmers about the proper bamboo harvesting technique.

About 75 - 85% of new culms emerge towards the outside of a clump. That is, new culms always emerge centrifugally in the clump. So bamboos in the periphery of a clump are comparatively young and immature. Bamboos towards the centre of a clump are comparatively old. Generally more than three year old culms are regarded as mature bamboos. Therefore to obtain mature bamboo one must cut bamboos from the centre of the clump.

For maintaining the sustainable growth bamboos should not be harvested every year from a clump. Felling should be stopped at least for three years so that culms in the clump attain maturity. Therefore, in a homestead at least four clumps need planting which harvesting may be started sequentially in all these clumps. Thus culms will be harvested from each clump at three year intervals.

On the basis of above principles the following steps of bamboo harvesting has been described.

a. A 60-100 cm wide path has to be made inside the clump so that one can enter into the central part to start felling and dragging out the mature culms. As the path will be made from periphery towards the centre it is likely that a few number of young culms may have to be cut. So one must make path from that side of a clump where minimum number of young culms are sacrificed.

b. Most of the mature culms from the central part of the clump have to be cut. As for example, at least seven to eight out of 10 mature culms from centre of the clump have to be harvested. The remaining unharvested culms should be left scattered throughout the clump. These mature hard bamboos, altogether, will provide mechanical support to the young immature culms of the clump against the strong wind and storm. This felling procedure produces a clump open from one side and the central mature culms are cut and dragged out. This type of felling is horseshoe method of felling of culms (Figure 4).

c. Take the following care when culms are cut and dragged from the clump.

   1. The number of harvested culms should not exceed the number emerged last year. for example, a clump has 15 culms, out of which four and six culms emerged in 1990 and 1991 respectively. Thus the clump has six one year old and four two year old culms in the felling year 1992. To keep the clump productive and healthy, do not cut more than five to seven mature culms.

   2. Before entering into the clump, branches, if any, on the lowest nodes need trimmed thoroughly to facilitate harvesting operation.

   3. Cut culms in a slanting manner just above the lower most node to minimise the wastage. Rainwater will not stagnate at the remaining stump portion of the felled culms and will not harbour pests and fungi.

      When the felling is done far above the ground, buds on the nodes of the stumps of the felled culms become activated and produce twigs and branches. Thus a congested and bushy condition is created in the clump and interfere in future felling operation;

4. Clear the trimmed out branches and twigs from the harvested culms from the clumps.

5. Carefully uproot the dead and rotten stumps of the felled culms as a sanitary cleaning. Add soil and organic manure (cowdung/rice husk/rotten water hyacinth) at 3:1 ratio to the clump after digging out such stumps. Use these stumps as fuel.

6. Don't allow felling during the culm emergence period. Harvest culms from September to April. Felling of culms is more desirable in the month of November to January as culms posses less amount of starch during this time of the year. Thus harvested culms become less vulnerable to powder post beetles (ghoon) attack.

7. Prohibit felling during the year of flowering. At the end of flowering felling of the all dead culms should be delayed at least nine months so that regenerating seedling can establish on the ground. However, *B. vulgaris* and *B. balcooa*, the two major bamboo species in the villages of Bangladesh, do not flower frequently and if they at all flower do not produce any seeds. Therefore, harvesting of culms in these species may be carried out when the culms are flowering. As other bamboo species of the country produce fertile seeds, culms should be harvested after seed collection.

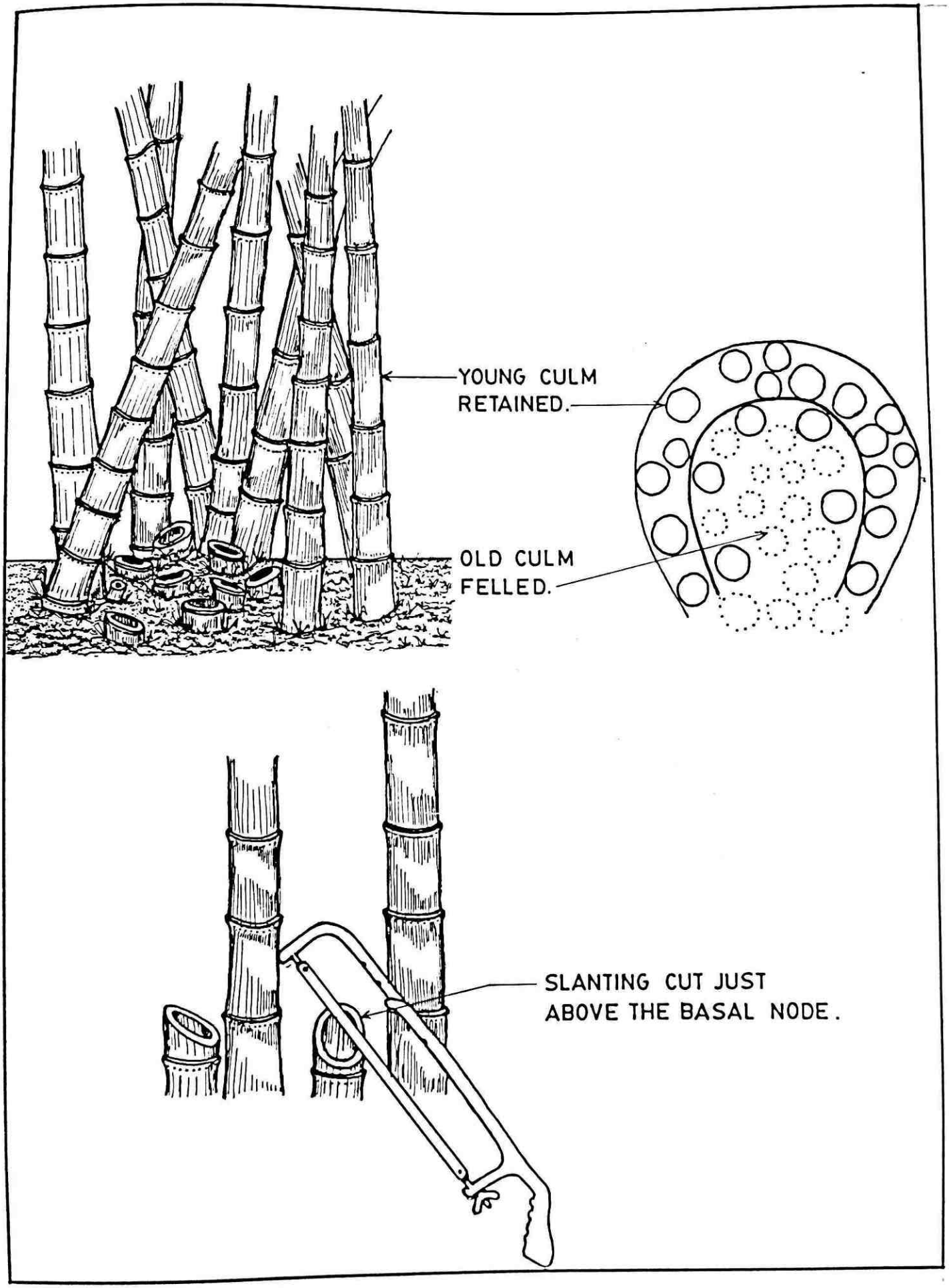


Figure 4 - Horseshoe pattern of bamboo felling

APPENDIX 4
SUPPLY AND DEMAND ESTIMATES

PROJECT 372001/8
FORESTRY MASTER PLAN
BANGLADESH TA 1355-BAN

ASIAN DEVELOPMENT BANK
MANILA PHILIPPINES
DATE: 30 JUNE 1992

BAMBOO

APPENDIX 4
SUPPLY AND DEMAND ESTIMATES

TABLE OF CONTENTS

1. ASSUMPTIONS FOR SUPPLY AND DEMAND

Natural Forest Supply

a. Chittagong and Cox's Bazar Forests (Stratum-V)

- Based on the last 5-10 years historical bamboo outturn data (numbers) of relevant Forest Divisions.
- Sporadic flowering in muli bamboo has started since 1988 and likely to continue for 6-10 years and as a result 3-5% increase in outturn due to the sporadic clump death (1988/89 -1998/99).
- 10-30% increase in outturn number is likely due to the large scale death of the clumps as a result of expected gregarious flowering at the end of the century (1998/99-2003/04).
- Fall in outturn by 45-30% due to the final sporadic (Troup 1921) and completion of flowering in the remaining flowering clumps. (say from 2003/04 - 2009/10).
- 10-30% gradual increase in outturn number as regarding muli seedlings take 10-12 years to attain merchantable size in natural forest condition. (2009/10 - 2019/2020).

b. Sylhet Forests and Tea Gardens (Stratum-VI)

- Based on the last 5-10 years historical outturn data collected from Sylhet Forest Divisions permits from Tea Gardens, and SPPM.
- Gradual decrease by 5-10% mainly due to over exploitation and repeated cutting in different bamboo mahals and filled bamboo groves in the Tea Gardens.
- Initially 2 - 3% increase in outturn due to the sporadic clump death as a result of expected sporadic flowering in muli (say in 1994/95). Then the outturn of dead flowering clump likely to intensity and may continue upto the end of the century (1995/96 - 2002/03).
- Large scale death of clumps due to expected gregarious flowering and as a result the outturn likely to increase by 15 - 35% (2003/04 - 2008/09).
- Sharp fall in outturn by 50-35% due to the final sporadic and completion of flowering (2008/09 - 2012/13).

c. Chittagong Hill Tracts Forests (Stratum-VIII)

- Based on the last 5 - 10 years historical outturn data (number) on bamboo collected from the different Forest Divisions of CHT and KPM.
- Sporadic flowering in muli bamboo started in 1986 and likely to continue for 6 - 10 years and the law and order situation in the Hill Tracts is expected to improve gradually; so 5 -7% annual increase in number of bamboo outturn is expected 1986/87 - 1996/97).
- 15 to 35% increase in outturn number likely due to the large scale death of clumps in the pure muli bamboo forest as a result of expected gregarious flowering at the end of the century (1996/97 - 2001/02).
- Sharp fall in outturn by 50 - 35% due to the final sporadic and completion of flowering. (From 2001/02 - 2007/08).
- 10 to 30% gradual increase in outturn number as regenerating seedlings take 10 - 12 years to produce merchantable sizes of culm in natural forest condition (2007/08-2017/18).

Village Forest Supply

- Data on the standing mature and immature culm were collected stratum wise from the present village inventory by FMP Project.
- The number of mature and immature culm were added together to get the total picture of culms in a clump. As a thumb rule, usually, one third of total number of culm is harvested from a clump. We have divided the figure of total number of culm by 3, to find out the annual outturn.
- Keeping in mind that the present condition of yield from village grove will continue if no development work to further develop the propagation and management is taken up.

Demand

- Based on the domestic consumption, industrial both pulp and paper and small scale cottage, and transport (Boat, Bullock cart, Rickshaw hood).
- Industrial demand assessed from the annual requirement of KPM and SPPM. The small scale industrial requirement was estimated from BSCIC Annual Survey Report.
- The domestic demand, mainly constructional and agricultural implements, estimated basing on the previous report

of Douglas (1981) on bamboo consumption. The estimate is tentative.

- Demand estimates are made on the basis of 1991 population census and projection of population is based on the trend of past growth rates.

2. PROJECTED NATIONAL BAMBOO CONSUMPTION

(Million Culms)

Item	North-West	North-Centre	West	South	South-East	North-East	CHT	All Total
1993								
Domestic[a]	151.89	109.94	80.35	66.05	89.01	73.49	5.31	576.04
Urban Housing	4.00	11.04	3.53	1.97	6.64	2.65	0.29	30.12
Industrial[b]	12.40	10.05	9.08	3.14	7.63	29.25	28.58	100.13
Total:	168.29	131.03	92.96	71.16	103.28	105.39	34.18	709.29
1998								
Domestic[a]	164.05	118.47	86.70	71.37	96.05	79.33	5.68	621.65
Urban Housing	4.56	12.59	4.02	2.25	7.57	3.02	0.33	34.34
Industrial[b]	13.02	10.55	9.53	3.30	8.01	30.71	30.01	105.14
Total:	181.63	141.61	100.26	76.91	111.63	113.06	36.02	761.12
2003								
Domestic[a]	176.02	126.90	93.00	76.58	102.96	85.12	6.09	666.67
Urban Housing	5.11	14.10	4.51	2.52	8.48	3.38	0.37	38.46
Industrial[b]	13.67	11.08	10.01	3.46	8.41	32.25	31.51	110.39
Total:	194.80	152.08	107.52	82.56	119.85	120.75	37.97	815.52
2008								
Domestic[a]	188.16	135.45	99.37	81.86	109.95	90.97	6.51	712.27
Urban Housing	5.67	15.65	5.00	2.79	9.41	3.76	0.41	42.69
Industrial[b]	14.01	11.36	10.26	3.55	8.62	33.05	32.30	113.15
Total:	207.84	162.45	114.63	88.20	127.98	127.78	39.22	868.11
2013								
Domestic[a]	200.34	144.01	105.77	87.15	116.97	96.84	6.93	730.08
Urban Housing	6.24	17.21	5.50	3.07	10.35	4.13	0.45	46.96
Industrial[b]	15.41	12.49	11.29	3.90	9.48	36.36	35.53	124.47
Total:	221.99	173.71	122.56	94.12	136.81	137.33	42.91	901.50

Note: a = Rural house construction, agricultural implements, community building.
b = Pulp and Paper, cottage, transport (boat, rickshaw hood and bullock cart).

3. REGIONAL POTENTIAL BAMBOO SUPPLY-DEMAND

(Million culms)

Regions	Source	1993	1998	2003	2008	2013
NORTH-WEST	Natural Forest Supply	-	-	-	-	-
	Village Forest Supply	201.1	201.1	201.1	201.1	201.1
	Total Supply	201.1	201.1	201.1	201.1	201.1
	Demand	168.3	181.6	194.8	207.8	222.0
	Surplus/Deficit	+32.8	+19.5	+6.3	-6.7	-20.9
NORTH-CENTRE	Natural Forest Supply	-	-	-	-	-
	Village Forest Supply	88.2	88.2	88.2	88.2	88.2
	Total Supply	88.2	88.2	88.2	88.2	88.2
	Demand	131.0	141.6	152.1	162.5	173.7
	Surplus/Deficit	-42.8	-53.4	-63.9	-74.3	-85.5
WEST	Natural Forest Supply	-	-	-	-	-
	Village Forest Supply	86.6	86.6	86.6	86.6	86.6
	Total Supply	86.6	86.6	86.6	86.6	86.6
	Demand	93.0	100.3	107.5	114.6	122.6
	Surplus/Deficit	-6.4	-13.7	-20.9	-28.0	-36.0
SOUTH	Natural Forest Supply	-	-	-	-	-
	Village Forest Supply	48.2	48.2	48.2	48.2	48.2
	Total Supply	48.2	48.2	48.2	48.2	48.2
	Demand	71.1	76.9	82.6	88.2	94.1
	Surplus/Deficit	-22.9	-28.7	-34.4	-40.0	-45.9
SOUTH-EAST	Natural Forest Supply					
	Potential supply[a]	42.3	54.0	77.0	20.9	13.0
	Less: Inaccessible[b]	4.2	5.4	6.1	1.8	1.0
	Overexploitation[c]	8.6	8.1	3.8	1.1	0.7
	Available Supply	29.5	40.5	67.1	18.0	11.3
	Recorded	22.7	31.4	54.8	14.9	9.3
	Unrecorded	6.9	7.3	12.3	3.1	2.0
	Village Forest Supply	31.5	31.5	31.5	31.5	31.5
	Total supply	61.0	72.0	98.6	49.5	42.8
	Demand	103.3	111.6	119.9	128.0	136.8
	Surplus/Deficit	-42.3	-39.6	-21.3	-78.5	-94.0

3. REGIONAL POTENTIAL BAMBOO SUPPLY-DEMAND, (cont'd)

(Million culms)

Source	Source	1993	1998	2003	2008	2013
NORTH-EAST	Natural Forest Supply	39.8	33.0	35.3	69.5	28.8
	Potential supply[a]	-7.3	-6.0	-6.3	-10.4	-4.3
	Less: Inaccessible[b]	-3.7	-3.0	-3.1	-3.5	-2.3
	Overexploitation[c]	28.8	24.0	25.9	55.6	22.2
	Available Supply	27.6	22.9	24.6	50.8	20.4
	Recorded	1.2	1.1	1.3	4.8	1.8
	Unrecorded	71.9	71.9	71.9	71.9	71.9
	Village Forest Supply	100.7	95.9	97.8	127.5	94.1
	Total supply	105.4	113.1	120.7	127.8	137.3
	Demand	-4.7	-17.2	-22.9	-0.3	-43.2
	Surplus/Deficit					
CHITTA-GONG HILL TRACTS	Natural Forest Supply	111.6	135.1	181.3	48.4	23.9
	Potential supply[a]	-22.3	-27.0	-36.3	-9.7	-3.0
	Less: Inaccessible[b]	-18.9	-20.3	-9.7	-2.0	-1.0
	Overexploitation[c]	70.4	87.8	135.3	36.7	15.9
	Available supply	62.0	78.6	119.5	26.1	12.7
	Recorded	8.4	9.2	15.8	10.6	3.0
	Unrecorded	-	-	-	-	-
	Village Forest Supply	70.4	87.8	135.3	36.7	15.9
	Total supply	34.2	36.0	38.0	39.2	42.9
	Demand	+36.2	+51.8	+97.3	-2.5	-27.0
	Surplus/Deficit					
ALL REGIONS	Natural Forest Supply	193.7	222.1	293.6	138.8	65.7
	Potential supply[a]	-33.8	-38.0	-48.7	-21.9	-8.3
	Less: Inaccessible[b]	-31.2	-31.4	-16.6	-6.6	-12.3
	Overexploitation[c]	128.7	152.3	228.3	110.3	49.4
	Available Supply	112.3	132.9	198.9	91.8	42.6
	Recorded	16.5	39.4	29.4	18.5	6.8
	Unrecorded	527.5	527.5	527.5	527.5	527.5
	Village Forest Supply	656.2	679.8	755.8	637.8	576.9
	Total supply	706.3	761.1	815.5	868.1	901.5
	Demand	-50.1	-81.3	-59.7	-230.3	-324.6
	Surplus/Deficit					

[a] includes an average 2% area loss annually

[b] 10-20% less due to inaccessibility, about 10% in Chittagong and Cox's Bazar forest, and 20% in Sylhet and CHT. After large scale death of bamboo due to gregarious flowering from the year 2003 the less in supply due to inaccessibility become comparatively low.

[c] Similarly about 5-15% decrease in the outturn due to the over exploitation and absence of management.

APPENDIX 5
PLANTATION DEVELOPMENT PROGRAM

BAMBOO

APPENDIX 5
PLANTATION DEVELOPMENT PROGRAM

TABLE OF CONTENTS

1. ANNUAL PLANTATION PLAN OF MULI SEEDLING AND BRANCH CUTTING

Year	Proposed Plantation (ha)		Expected Yield of Culm (million nos.)			Plantation and Maintenance Cost (million/taka)		
	SDL	BCT	SDL	BCT	Total	SDL	BCT	Total
1993	500	50	-	-	-	3.40	0.43	3.83
1994	700	75	-	-	-	6.31	0.84	7.15
1995	1000	100	-	-	-	10.91	1.35	12.25
1996	1500	150	-	-	-	18.26	2.41	20.67
1997	2000	200	0.67	0.02	0.69	29.25	4.06	33.31
1998	2500	300	1.73	0.06	1.79	39.07	6.79	45.86
1999	3000	500	3.38	0.11	3.49	50.60	11.26	61.86
2000	4000	700	5.98	0.20	6.18	67.13	17.23	84.36
2001	5000	1000	9.39	0.33	9.72	85.20	25.88	111.08
2002	-	1500	14.54	0.53	15.07	64.26	39.28	103.54
2003	-	2000	20.82	0.84	21.66	61.22	56.11	117.33
2004	-	-	29.29	1.30	30.59	54.64	56.17	110.81
2005	-	-	40.20	1.93	42.13	39.80	70.48	110.28
2006	-	-	45.85	2.90	48.75	-	90.73	90.73
2007	-	-	51.84	4.22	56.06	-	105.90	105.90
2008	-	-	57.87	5.00	62.87	-	109.90	109.90
2009	-	-	64.00	5.70	69.70	-	105.10	105.10
2010	-	-	70.27	6.38	76.65	-	93.96	93.96
2011	-	-	75.74	6.74	82.48	-	75.58	75.58
2012	-	-	80.94	7.01	87.95	-	43.60	43.60
2013	-	-	87.47	7.01	95.00	-	43.60	43.60

SDL = Seedlings BCT = Branch Cutting

2. ANNUAL BRANCH CUTTING PLANTATION TARGETS AND CULM PRODUCTION

Area(ha)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
50	0.02	0.03	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
75		0.03	0.04	0.05	0.06	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
100			0.04	0.05	0.07	0.08	0.09	0.10	0.10	0.10	0.10	0.10	0.10
150				0.06	0.08	0.10	0.12	0.14	0.16	0.16	0.16	0.16	0.16
200					0.08	0.10	0.13	0.16	0.18	0.21	0.21	0.21	0.21
300						0.12	0.16	0.20	0.24	0.27	0.32	0.32	0.32
500							0.40	0.27	0.33	0.40	0.47	0.53	0.53
700								0.28	0.37	0.47	0.56	0.65	0.65
1000									0.40	0.53	0.67	0.80	0.80
1500										0.60	0.80	1.00	1.00
2000											0.80	1.03	1.03
Total 6575	0.02	0.06	0.11	0.20	0.33	0.53	0.84	1.30	1.93	2.90	4.22	5.00	5.07

3. ANNUAL PLANTATION TARGETS OF MULI SEEDLINGS AND CULM PRODUCTION

(Million Culms)

Area(ha)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
500	0.67	0.80	0.93	1.06	0.96	1.40	1.53	1.67	1.80	1.43	2.33	2.33	2.33	2.33	2.33	2.33	2.33
700		0.93	1.12	1.31	1.49	1.68	1.96	2.15	2.33	2.52	2.71	3.27	3.27	3.27	3.27	3.27	3.27
1000			1.33	1.60	0.07	1.87	2.13	2.40	2.80	3.07	3.33	3.60	3.87	4.67	4.67	4.67	4.67
1500				2.00	2.40	2.80	3.20	3.60	4.20	4.60	5.00	5.40	5.80	7.00	7.00	7.00	7.00
2000					2.67	3.20	3.73	4.27	4.80	5.60	6.13	6.67	7.20	7.73	9.33	9.33	9.33
1500						3.33	4.00	4.67	5.33	6.00	7.00	7.67	8.33	9.00	9.67	11.67	11.67
3000							4.00	4.80	5.60	6.40	7.20	8.40	9.20	10.00	10.80	11.60	14.00
4000								5.33	6.40	7.47	8.53	9.60	11.02	12.27	13.33	14.40	15.00
5000									6.67	8.00	9.34	10.66	12.00	14.00	15.34	16.67	18.00
Total 20200	0.67	1.73	3.38	5.98	9.39	14.54	20.82	29.29	40.2	45.85	51.84	57.87	64.00	70.27	75.74	80.94	87.47

4. ANNUAL PLANTING AND CULTURAL EXPENDITURE, TK/PROPAGULE

Item	1		2		3		4		5		6		7		8		9		10	
	BCT	SDL	BCT	SDL	BCT	SDL	BCT	SDL	BCT	SDL	BCT	SDL	BCT	SDL	BCT	SDL	BCT	SDL	BCT	SDL
Cost of propagule	9.0	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planting in pit	4.0	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maintenance operation Fertilizer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dung/compost	2.0	2.0	4.0	4.0	6.0	6.0	8.0	8.0	10.0	10.0	12.0	-	13.0	-	14.0	-	15.0	-	15.0	-
- Urea	1.0	1.0	1.0	1.0	1.5	1.5	2.0	2.0	2.5	2.5	3.0	-	3.5	-	4.00	-	4.5	-	5.0	-
- TSP	0.5	0.5	0.5	0.5	0.8	0.8	1.0	1.0	1.3	1.3	1.5	-	1.8	-	2.00	-	2.2	-	2.5	-
- MP	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.5	-	0.7	-	1.0	-	0.9	-	1.0	-
Soil adding	-	-	-	-	-	-	7.0	7.0	7.0	7.0	10.0	-	10.0	-	10.0	-	12.0	-	12.0	-
Weeding	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	-	4.0	-	5.0	-	5.0	-	5.0	-
Insecticide/fungicide	-	-	2.0		2.0		3.0	-	3.0	-	5.0	-	7.0	-	6.0	-	6.0	-	6.0	-
Harvest/Transport. BCT = 6 culm/labour SDL = 100 culm/labour									8.0	1.6	8.0	1.6	8.0	1.6	8.0	1.6	8.0	1.6	8.0	1.6
Royalty Tk. 400/1000 culm										0.4		0.4		0.4		0.4		0.4		0.4
Total (Taka):	19.7	19.7	11.7	9.7	14.6	12.6	25.4	22.4	36.3	27.3	44.0	2.0	46.0	2.0	50.0	0.5	54.0	2.0	55.0	2.0

Notes: 1. BCT = Branch Cutting 2. SDL = Seedling

5. COST OF PLANTATION AND MAINTENANCE OF BRANCH CUTTING, (Tk Million)

Area(ha)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014			
50	0.43	0.19	0.19	0.43	0.73	0.88	0.96	1.00	1.07	1.09										
75		0.65	0.29	0.29	0.64	1.10	1.32	1.44	1.50	1.61	1.64									
100			0.87	0.39	0.38	0.86	1.45	1.76	1.92	2.00	2.14	2.18								
150				1.30	0.58	0.57	1.28	2.18	2.64	2.88	3.00	3.22	3.27							
200					1.73	0.78	0.76	1.71	2.90	3.52	3.84	4.00	4.29	4.36						
300						2.60	1.16	1.14	2.56	4.36	5.28	5.78	6.00	6.43	6.54					
500							4.33	1.94	1.91	4.28	7.26	8.80	9.60	10.00	10.72	10.90				
700								6.06	2.72	2.67	5.99	10.16	12.32	13.44	14.00	15.00	15.26			
1000									8.66	3.88	3.82	8.56	14.52	17.60	19.20	20.00	21.44	21.80		
1500										12.99	5.82	5.73	12.84	21.78	26.40	28.80	30.00	32.16	32.70	
2000											17.32	7.76	7.64	17.12	29.04	35.20	38.40	40.00	42.88	43.60
Total 6575	0.43	0.84	1.35	2.41	4.06	6.79	11.26	17.23	25.88	39.28	56.11	56.17	70.48	90.73	10.59	109.90	105.10	93.96	75.58	43.60

6 COST OF PLANTATION AND MAINTENANCE OF MULI SEEDLINGS, (Tk Million)

Area (ha)	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
500	3.40	1.54	1.91	2.28	3.98								
700		4.77	2.17	2.67	3.19	5.57							
1000			6.82	3.08	3.82	4.56	7.96						
1500				10.23	4.62	5.73	6.84	11.94					
2000					13.64	6.16	7.64	9.12	15.92				
2500						17.05	7.70	9.55	11.40	19.90			
3000							20.46	9.24	11.46	13.68	23.88		
4000								27.28	12.32	15.28	18.24	31.84	
5000									34.10	15.40	19.10	22.80	39.80
Total 20200	3.4	6.31	10.9	18.26	29.25	39.07	50.6	67.13	85.2	64.26	61.22	54.64	39.8

APPENDIX 6
FINANCIAL ANALYSIS

BAMBOO

APPENDIX 6
FINANCIAL ANALYSIS

1. FINANCIAL ANALYSIS OF BAMBOO PLANTATION (PER HA): BRANCH CUTTING (BARIALA BAMBOO)

CASHFLOW

1. INFLOW	YEAR 1	2	3	4	5	6	7	8	9	10+
					Taka					
Bamboo Sale 1_/	0	0	0	0	24,000	31,980	40,020	48,000	55,980	64,200
TOTAL	0	0	0	0	24,000	31,980	40,020	48,000	55,980	64,200
2. OUTFLOW										
Cost of cutting and plantation 2_/	5,980	0	0	0	0	0	0	0	0	0
Cost of fertilizer 3_/	1,480	1,480	2,220	2,960	5,720	6,800	7,600	8,400	9,040	9,400
Intereculture Operation & Harvesting 4_/	1,200	2,400	1,600	5,600	8,800	10,800	11,600	11,600	12,400	12,400
TOTAL	8,660	3,880	3,820	8,560	14,520	17,600	19,200	20,000	21,440	21,800
Net Benefit Before Financing										
TOTAL	(8,660)	(3,880)	(3,820)	(8,560)	9,480	14,380	20,820	28,000	34,540	42,400
FIRR = 37% NPV @ 12%	$10,514									
Switching Values to bring FIRR to 12%			Revenue	37%	Cost	60%				
FINANCING										
Borrowers' contribution	866									
Long-term loan	7,794									
Short-term loan	0	3,880	3,820	8,560	14,520	0	0	0	0	0
TOTAL	8,660	3,880	3,820	8,560	14,520	0	0	0	0	0
DEBT SERVICE 5_/										
Long-term	0	2,081	2,081	2,081	2,081	2,081	2,081	2,081	2,081	0
Short-term	0	4,501	4,431	9,930	16,843	0	0	0	0	0
NET FINANCING	8,660	(2,702)	(2,693)	(3,451)	(4,405)	(2,081)	(2,081)	(2,081)	(2,081)	0
Net cashflow after financing	0	(6,582)	(6,513)	(12,011)	5,075	12,299	18,739	25,919	32,459	42,400

1_/ Assuming that harvest of bamboo will start from the 5th year @ 400, 533, 667,800, 933 and 1,070 pieces annually at 3 years rotation from each clump. Selling price has been assumed at TE 60 per bamboo.

2_/ Requirement of cutting per ha is 400 at a spacing of 5 m and a mortality rate of 15 percent and the price per cutting has been estimated at TE 13 per cutting.

3_/ Includes full cost of compost and chemical fertilizers and the cost has been estimated on an incremental basis based on the actual requirements of these inputs

4_/ Includes cost of fertilizer applications, insecticides, thinning, weeding and harvesting

5_/ Planters'contribution at 10 per cent, balance in long term loan at interest rate of 16% p.a. repayable in 8 years including one year grace period. Interest on short-term loan is also 16% p.a.

2. FINANCIAL ANALYSIS OF BAMBOO PLANTATION (PER HA): MULI SEEDLING

CASHFLOW

1. INFLOW	YEAR 1	2	3	4	5	6	7	8	9	10+
					Taka					
Bamboo Sale 1 /	0	0	0	0	6,665	8,000	9,335	10,665	12,000	14,000
TOTAL	0	0	0	0	6,665	8,000	9,335	10,665	12,000	14,000
2. OUTFLOW										
Cost of seedling plantation 2 /	4,140	0	0	0	0	0	0	0	0	0
Cost of fertilizer 3 /	1,480	1,480	2,220	2,960	5,720	0	0	0	0	0
Interculture Operation & Harvesting 4 /	1,200	1,600	1,600	1,600	2,240	640	640	640	640	640
TOTAL	6,820	3,080	3,820	4,560	7,960	640	640	640	640	640
Net Benefit Before Financing										
TOTAL	(6,820)	(3,080)	(3,820)	(4,560)	(1,295)	7,360	8,695	10,025	11,360	13,360
FIRR = 18% NPV @ 12%	$5,213									
Switching Values to bring FIRR to 12% :			Revenue	-21%	Cost	26%				
FINANCING										
Borrowers' contribution	682									
Long term loan	6,138									
Short-term loan	0	3,080	3,820	4,560	7,960	0	0	0	0	0
TOTAL	6,820	3,080	3,820	4,560	7,960	0	0	0	0	0
DEBT SERVICE 5_/										
Long-term	0	2,081	2,081	2,081	2,081	2,081	2,081	2,081	2,081	0
Short-term	0	3,573	4,431	5,290	9,234	0	0	0	0	0
NET FINANCING	6,820	(2,574)	(2,693)	(2,811)	(3,355)	(2,081)	(2,081)	(2,081)	(2,081)	0
Net cashflow after financing	0	(5,654)	(6,513)	(7,371)	(4,650)	5,279	6,614	7,944	9,279	13,360

1_/ Assuming that harvest of bamboo will start from the 5th year @ 1333, 1600, 1867, 2133, 2400 and 2800 pieces annually at 3 years rotation from each clump. Selling price has been assumed at Tk 5 per bamboo

2_/ Requirement of cutting per ha is 400 at a spacing of 5 m and a mortality rate of 15 percent and the price per cutting has been estimated at Tk 9 per seedling

3_/ Includes full cost of compost and chemical fertilizres and the cost has been estimated on an incremental basis based on the actual requirements of these inputs.

4_/ Includes cost of fertilizer applications, insecticides, thinning, weeding and harvesting. No maintenance costs have been assumed after year 5.

5_/ Planters'contribution at 10 per cent, balance in long term loan at interest rate of 16% p.a. repayable in 8 years including one year grace period. Interest on short term loan is also 16% p.a.

APPENDIX 7
PRESERVATION TREATMENT

BAMBOO

APPENDIX 7
PRESERVTIVE TREATMENT

1. LIST OF EXTENSION FOREST NURSERIES

Forest		Civil Districts	Number of	
Circles	Divisions		Mouzas	Nurseries
Bogra	Dinajpur	Dinajpur	2042	2
28	(4)	Thakurgaon	651	1
		Panchagar	434	1
	Rangpur	Rangpur	1194	2
	(8)	Kurigram	585	2
		Gaibandha	1105	1
		Nilphamari	98	2
		Lalmonirhat	443	1
	Bogra	Bogra	1703	2
	(4)	Jaipurhat	720	2
	Pabna	Pabna	1300	2
	(4)	Sirajganj	1461	2
	Rajshahi	Rajshahi	1642	2
	(8)	Naogaon	2561	2
		Nawabganj	769	2
		Natore	1268	2
Jessore	Kushtia	Kushtia	746	2
25	(6)	Chuadanga	3690	2
		Meherpur	201	2
	Jessore	Jessore	1313	2
	(10)	Jhenidah	953	2
		Narail	441	1
		Magura	539	1
		Khulna	767	2
		Bagerhat	759	1
		Satkhira	967	1
	Faridpur	Faridpur	995	1
	(5)	Gopalganj	625	1
		Madaripur	516	1
		Rajbari	857	1
		Sariatpur	603	1

Forest		Civil Districts	Number of	
	(4)	Jhalakhati	428	1
		Pirojpur	485	1
Plantation	Bhola (1)	Bhola	382	1
6	Patuakhali	Patuakhali	265	1
	(2)	Barguna	272	1
	Noakhali	Feni	512	1
	(3)	Noakhali	907	1
		Luxmipur	458	1
Central	Dhaka (Ext.)	Dhaka	974	1
29	(8)	Narsingdi	726	2
		Narayanganj	898	2
		Gazipur	704	1
		Manikganj	1314	1
		Munshiganj	637	1
	Tangail (3)	Tangail	2137	3
	Mymensingh	Jamalpur	859	2
	(8)	Serpur	467	1
		Mymensingh	2211	3
		Kisoregonj	967	1
		Netrokona	1625	1
	Sylhet	Sylhet	1667	1
	(5)	Moulavibazar	911	2
		Sunakganj	1369	1
		Habiganj	1286	1
	Comilla	Comilla	2645	3
	(5)	Chandpur	1842	1
		Brahmanbaria	998	1
Chittagong	Chittagong-4	Chittagong	1021	4
7	Cox's Bazar-2	Cox's Bazar	189	2
	Bandarban-1	Bandarban	96	1
Rangamati	Rangamati-1	Rangamati	156	1

Source: Bandarban, Department of Forest, 1992. (Personnel communication).

2. EXPENDITURE FOR BAMBOO PRESERVATION TREATMENT*

Item		Const. Taka
1.	Sap displacement method (Whole bamboo)	
a)	Instrument for treatment: handpump (locally made) bucket, with mug, clump, rope, etc. (life of the instrument and accessories is about 5 years, so annual cost is Tk.160.0and per day about Tk.1.00)	800
b)	Preservation treatment (per whole bamboo, 10.7 m long)	
1.	Preservative (CCB): 206 g; Tk 68.0 per kg.	14.00
2.	Labour (2 man days: 16 bamboo/day; Tk 50/labour)	6.25
3.	Cost for using the instrument 1.00	
	Rate of increase of cost of bamboo due to preservative treatment: 28.3%	Total: 21.25

c) Usefulness of preservative (life span)
Untreated bamboo : 2 year
Treated bamboo : 15-20 years

2. Soaking treatment (bamboo fence, strips, etc)

a) Construction of tank (brick and cement) 10,000
rectangular : 3m x 0.6m, say life 10 yrs.
so annual cost is Tk.100 and daily cost Tk.0.33
basing 300 working days a year

b) Preservative treatment (for bamboo fence 6m x 2.3 m)

1.	Preservative (CCB) : 325 g. Tk 68 per kg.	22.10
2.	Labour (2 mandays: 4 nos fence 4 times a day) Tk. 50 per labour	6.25
3.	Equipment (preservative tank) cost	0.33
		28.68

Rate of increase of cost of a fence due to preservative treatment : 9.6%
Cost of fence : Tk. 300.00
Cost of treatment : Tk. 28.68

c) Usefulness of preservative (life span)
Untreated fence : 4 years
Treated fence : 15-20 years

* Source: Salehuddin, A.B.M. 1991

3. PRESERVATION TREATMENT PROGRAM (MILLION CULMS)

Year	Net Annual[b] Production	Taka, Million
1993	8.66	13.15
1994	9.09	13.85
1995	9.54	14.53
1996	10.02	15.26
1997	10.52	16.03
Total	47.83	72.82
1998	11.05	16.83
1999	11.60	17.67
2000	12.18	18.55
2001	12.79	19.48
2002	13.43	20.45
Total	61.05	92.90
2003	14.77	22.50
2004	16.25	24.75
2005	17.87	27.22
2006	19.66	29.94
2007	21.62	32.93
Total	90.17	137.34
2008	23.78	36.22
2009	26.16	39.84
2010	28.77	43.82
2011	31.65	48.20
2012	34.81	53.02
Total	145.17	168.08
Total	344.22	471.14

(a) On average the life span of a treated bamboo is about 15 years, so the bamboos treated in 1994 rots in 2009, and needs replacing, and so on.

APPENDIX 8
REFERENCES

APPENDIX 8
REFERENCES

Ahmed, K.J.(1954) Methods of increasing growth and obtaining natural regeneration of bamboo types in Asia. In: Proceedings of 4th World Forestry Congress. Dehra Dun, India, 3:389-392;also in Tropical Silviculture II. FAO, Rome, 1957, pp. 287-297.

Abedin M.Z. and Quddus, M.A. (1990) Supply, demand and cultivation of bamboo in Bangladesh. Findings of a Rapid Appraisal. OFRD/BARI, Joydebpur, Gazipur 1707, Bangladesh (Unpublished report).

Banik, R.L. (1979) Flowering in baijja bans (Bambusa vulgaris). Letter to the editor, Banop Biggyan Patrika 8(1&2) : 90-91.

Banik, R.L. (1980) Propagation of bamboos by clonal methods and by seeds. In: Bamboo research in Asia (Eds. G.Lesserd and A. Chouinard). Proc. of a workshop, Singapore, 28-30 May: IDRC, Ottawa, Canada, oo. 139-150.

Banik, R.L. (1981) A short note on the flowering of Dendrocalamus strictus Nees. (Lathibansh) in Chittagong - Short communication, Bano Biggyan Patrika 10(1&2) : 94-96.

Banik, R.L. (1983) Emerging culm mortality at early developing stage in bamboos. Baon Biggyan Patrika. 12(1&2) : 47-52).

Banik, R.L. (1986) Observations on special features of flowering in some bamboo species of Bangladesh. In:Bamboo production and utilization (Ed. Higuchi, T.). Proc. of the project Group ps.04.,18th IUFRO World Congress; Ljubljana, Yugoslavia, Sept. 7-21, pp. 56-60.

Banik, R.L.(1987a) Seed germination of some bamboo species. India Forester 113(8):578-586.

Banik, R.L. (1987b) Techniques of bamboo propagation with special reference ot prerooted and prerhizomed branch cuttings and tissue culture. In: Recent research on Bamboos (Eds. Rao, A.N., Dhanaranjan, G., Sastry, C.B.) Proc. of the International Bamboo Workshop. Hangzhou, China, IDRC, pp. 160-169.

Banik, R.L. (1988a) Investigation on the culm production and clump expansion behaviour of five bamboo species of Bangladesh. Indian Forester 114(9):579-583.

Banik, R.L. (1988b) Management of wild bamboo seedlings for natural regeneration and reforestation. In: Bamboo - current research. Proc. of the Intl. Bamboo Workshop, Cochin, India, pp. 92-95.

Banik, R.L. (1989) Recent flowering of muli bamboo (Melocanna baccifera) in Bangladesh: an alarming situation for bamboo resource. Bano Biggyan Patrika 18 (1&2):65-68.

Banik, R.L. (1991) Biology and propagation of Bangladesh Bamboos, Ph.D Thesis, D.U.

Banik, R.L. and Alam, M.K. (1987) A note on the flowering of Bambusa balcooa Roxb. Bano BiggyanPatrika 16(1&2):25-29.

Batten, R L (1992) Personal Communications

Alam, M. K.

BBS (1989) Statistical Year Book of Bangladesh, BBS, Govt of Bangladesh.

BBS, (1990) Report on Survey of farm forestry, 1988. Bangladesh Bureau of Statistics, Govt of Bangladesh, April 1990.

BBS (1991) Statistical Year Book of Bangladesh, BBS, Govt of Bangladesh.

Biswas, S. (1988) Studies on bamboo distribution in north-eastern region of India. Indian For. (Bamboo special-1), 114(9):514-531.

Boa, E. R. and Rahman, M.A.(1987) Bamboo blight and the bamboos of Bangladesh. Forest Pathology Series Bull 1. BFRI, British Technical Co-operation, Overseas Development Administration, U.K.

Brandis, D. (1899) Biological notes on Indian bamboos. Indian Forester 25(1): 1-25.

Brandis, D. (1906) Indian Trees. Periodical experts. Book Agency, Delhi, p. 767.

BSCIC (1983) Cottage Industries of Bangladesh.

BSCIC (1991) Upublished Report.

Byron, R.N. (1981) Supply and demand of Forest Products and future development strategies: Future consumption of wood and wood products in Bangladesh. UNDP/FAO/Planning Commission (Govt. of Bangladesh) Project BGD/78/010. Field Document No. 4.

Choudhury,M.U (1967) Working plan of Cox's Bazar Forest Division for the period from 1968-69 to 1977-78. Govt of East Pakistan Forest Department.

Choudhury,M.R. (1984) A study on supply and demand of bamboos and canes in Bangladesh. FAO, part of Project BGD/78/010. Field Document No. 9, Dhaka.

De Milde,R. et al (1985) Assistance to the forestry sector Bangladesh: The high forest in the Chittagong District. FAO/UNDP Project BGD/79/017, September 1985.

Douglas, J.J.(1981) — Supply and demand of Forest Products and future development strategies: Consumption and supply of wood and bamboo in Bangladesh. UNDP/FAO/Planning Commission (Govt. of Bangladesh) Project BGD/78/010. Field Document No. 2.

Drigo,R. et al (1988) — Assistance to the Forestry sector Phase-II. Bangladesh: Inventory of Forest Resources of Southern Sylhet Forest Division FAO/UNDP Project BGD/85/085.

Fangming, Tao (1988) — Distribution of bamboo in relation to its ecological condition in Qianshan Country of Anhui province. J. Bamboo Research 7(1):38.

FAO (1982) — Village forest inventory : Bangladesh Project findings and recommendation. FAO/UNDP, FO:DP/BGD/78/020, Terminal report.

FAO (1986) — Supply and demand of forest products and development strategies: Bangladesh - Project findings and recommendations. UNDP/FAO Rome, FO: DP/BGD/78/010. Terminal Report.

Gamble, J.S. (1896) — The Bambuseae of British India. Annals of the Royal Botanic Garden, Calcutta. Vol. 7, Priented at the Bengal Secretariate Press, Calcutta, London. p.133.

Glenn, H.E. (1950) — Bamboo reinforcement in portland cement concrete. Bulletin no. 4. The Clemson Agricultural College of South Carolina., Engineering Experiment Station, Clemson, p. 171.

Hammermaster, E.T. (1981) — Village forest inventory of Bangladesh: Inventory results. UNDP/FAO Project BGD/78/020. Field Document No. 5.

Hasan, S.M. (1973) — Seeding behaviour of Bangladesh bamboos. Bano Biggyan Patrika. 5(2):21-36.

Hossain, K.M.I. (1962) — Bamboos of East Pakistan with particular reference to muli bamboo and its flowering. Pakistan. Jour. For. 12:194-201.

Hossain, A (1992) — Personal communications.

Hossain, A. and Sharwardy (1990) — Ten year fibrous raw material collection plan for Karnaphuli Paper Mills Limited (Unpulbished)

Hsiung, W. (1987) — Bamboo in China: new prospects for an ancient resource. Unasylva No. 156.39(2):42-49.

Huberman,M.A. (1959) — Bamboo silviculture. Unasylva 13(10:36-43.

Kasahara, K. (1981) — Alternation of mutation frequency caused by unusual environment before and after flowering of bamboos. In: Bamboo Production and Utilization (Ed. Higuchi, T.) Proc. of the Congress Group 5.3 A, XVII IUFRO World Congress Kyoto, Japan, September 6-71, pp. 70-76.

Kondas, S. (1981) — Bamboo biology, culm potential and problem of cultivation. In: Bamboo production and utilization (Ed. Higuchi, T.). Proc. of the 17th IUFRO World Congress, Kyoto, Japan, pp. 184-190.

Kurz, S. (1877) — Forest flora of British Burma Vol. I: Introductory, Bamboo jungles and savannahs., p. 549; and Vol.II Gramineae, Delhi, India, p. 613.

Liese, W. (1985) — Bamboos - biology, silvics, properties, utilization. Eschborn, Germany. p. 132.

McClure, F.A. (1966) — The bamboos: a fresh perspective. Harvard university Press, Cambridge, Mass, U.S.A.p. 347.

Numata, M. (1987) — The ecology of bamboo forests -- particularly on temperate bamboo forests. Bamboo Jour. Np. 4:118-131.

Ohlsson, B.O. (1984) — Supply and demand for forest products and future development strategies. UNDP/FAO (Planning Commission of Bangladesh) Project BGD/78/010. Field Document No. 8.

Parker, R.N. (1931) — A little known burmese bamboo. Indian Forester. 57:108-110.

Prasad, J. (1948) — Silviculture of ten species of bamboo suitable for paper manufacture, Indian For. 74(3):122-130.

Ramakrishanan, P.S. Toky. O.P. (1983) — Some aspects of environmental degradation in N.E. Hill area of India. In: Studies in ecodevelopment of Himalaya, Mountains and Men. (Ess. Singh, T.V. and Kaur. J.) P.149.

Rao, K.S. and Ramakrishnan,P.S. (1988) — Leaf dynamics of two bamboo species Neohouzeua dulloa A. Camus and Dendrocalamus hamiltonii Nees and Arn. in successional environments in north-east India. Proc. of the Indian National Sc. Acad. part b, Biological Sciences 54 (1): 63-69.

Sandwell 1992 — Statistician Report, Bangladesh Forestry Mater Plan, Project 372001/8, Asina Development Bank (TA No 1355-BAN)

Seth, S.K. (1954) — Natural reqeneration and management of bamboos. Proc. of the 4th World For. Congr. Dehra Dun. Tropical Silviculture II:298-303.

Schimper,A.F.W. (1895) Numata, M. 1987 — Planzengeographic auf physiologischer Grundlage, Fisher, jena (quoted in: The ecology of bamboo forests ---- particularly on temperate bamboo forests. Bamboo Journal No 4: 118-131)

Shigematsu, Y. (1937) — On the calorific power and fuel value of bamboo stems. Japan Jour. Forestry. 19(120:661-671

Soderstrom, T.R. and Calderon, C.E.(1976) — Curtains for this bamboo The mysterious flowering of Ma-duke. Pacific Horticulture 37(3) 7-14

Sharma, Y.M.L. (1980) Bamboos in the Asia-Pacific region. In: Bamboo Research in Asia. (Eds. Lessard, G. and Chouinard, A.). Proc. of Workshop, Singapore. IDRC/IUFRO pp. 99-120.

Salehuddin, A B M (1991) Improve method of bamboo preservation and utilization (in Bangla) BARC, Dahka

Troup, R.S. (1921) The Silviculture of Indian trees, Vol. II, Oxford, The Clarendon Press, pp. 785-1195.

Uchimura, E. (1980) Bamboo cultivation. In: Bamboo Research in Asia (Eds. Lessard, G. and Chouinard, A.) Proc. of a workshop, Singapore 28-30 May; IDRC, Ottawa, Canada, pp. 151-160.

Uchimura, E (1987) Growth environmental and Characteristics of some tropical bamboos. Bamboo Journal No. 4:51-60

Waheed Khan, Pradesh.(1960) Ecology and potentiality of bamboo forest of Bilaspur Div. Madhya M. P. Indian Forester. 86:575-580.

Watanable, M. and and Hamada, H. (1981) How long is the flowering interval of bamboo. In: Bamboo production utilization (Eds. Higuchi, T.). Proc. of the Congress Group. 5.3A, 17th IUFRO World Congress Kyoto, Japan, Sept. 6-17, pp. 77-83.

White, D. G. and Bamboo for controlling soil erosion. Jour. Am. Soc. Agron. 37: Childers, N.F. (1945) 839-847.

Zahiruddin, A. S. M. (1967) Industrial utilization of bamboo with special reference to harvesting and transportation problems.