RECENT FLOWERING OF MULI BAMBOO (*MELOCANNA BACCIFERA*) IN CHITTAGONG HILL TRACTS AND RAT INFESTATION: ECO-ENVIRONMENTAL ASPECTS

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Prepared by

M. **Khairul Alam, Ph. D.**

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Introduction

Bamboos, commonly grown as woody bamboos, belong to the family Poaceae (Gramineae). They often have tree like habit and can be characterized as having woody, usually hollow culms, complex rhizome and branch systems.

The most interesting aspect of bamboo biology seems to be the flowering habit. Some bamboos flower every year, others at short intervals, and perhaps the majority at long intervals. In species that bloom after long intervals, the flowering is gregarious with all plants in population flowering simultaneously or close to it. Most of the bamboo species die after gregarious flowering. Recently Muli bamboo – *Melocanna baccifera* and Kali bamboo – *Gigantochloa andamanica* have started blooming in Bangladesh

Like many other countries of Asia bamboo play such important roles in everyday life of people of Bangladesh that hardly there is any homestead without a bamboo grove. Bamboo plays a significant role in the rural economy of Bangladesh. The rural people have been traditionally using this raw material to meet up their daily needs. Major construction materials of our rural housing are bamboos. It is also linked with other agricultural production systems like betel-leaf production, vegetables cultivation, etc. About 85.8% needs of household articles and construction of the rural population are being met by bamboo and rattan (Banik, 2000). Millions of people are directly or indirectly dependent on this resource for agriculture, housing, cottage and handicrafts industries, house hold furniture and other activities. It is also an important source of raw materials for pulp and paper industries in the country. Beyond traditional handicrafts and practical daily products, China's bamboo sector has become a fast emerging rural industry. High-grade parquet flooring blocks, tiles, furniture, boards, and many other composite products are made from bamboos. Shoot processing has developed as an industry in China.Thus it plays an important role in reducing timber consumption, protecting natural forests, poverty alleviation, employment/income generation, environmental improvement and rural socio-economic development. There are an estimated 1000 or so species of bamboo belonging to about 80 genera in the world, of

these about 200 species of which are found in SE Asia and belonging to approximately 20 genera.

Hill people of Chittagong Hill Tracts use bamboo even in more ways that can not be always noted. Bamboo shoots are edible. The hill people of Chittagong Hill Tracts meet the need of their food supply from the harvest of bamboo shoots during the rainy season when there is shortage of food grains. It is also sold in local markets and generates cash.People of Chittagong Hill Tracts can not think that men can survive without bamboo.

Bamboos of Bangladesh

In Bangladesh so far 28 species and one variety of bamboo under seven genera have been recorded from Bangladesh (Alam, 2001). The genera are: *Bambusa, Dendrocalamus, Gigantochloa, Schizostachyum, Melocalamus, Melocanna and Thyrsostachys*. Most of the species in the country belongs to the genera *Bambusa* and *Dendrocalamus*. The remaining genera are reported to have only 1-2 species each. Among the 29 taxa of bamboos, seven are found to grow naturally in the forests of Bangladesh. Forest bamboos are generally thin-walled (thickness <1 cm) in nature and shorter than village bamboo (4-15 m long). The remaining species referred as village bamboo have been cultivated in the plain land. At present, village bamboos constitute 80% of the total national supply. Village bamboos are generally thick-walled (thickness 1.5-2.5 cm) in nature and taller than the forest bamboos (17-35 m long) (Banik 1990).

In Bangladesh there are two distinct bamboo production areas: the forests and villages. Naturally grown bamboo species have been found in the semi evergreen and deciduous forests in the hills of Chittagong Hill Tracts, Coxes Bazar, Sylhet and northern Mymensingh of Bangladesh. Most bamboos are found in well-drained, sandy loam to clay loam soil with a pH range of 5.6 to 6.5. Saline and waterlogged soils are not suitable for bamboo. In forests the entire stock is natural.

In village groves bamboos are planted and cultivated for domestic consumption and raw materials for cottage industries. Distribution of the village bamboos depends on the human factors such as utility, availability of propagules locally and human migration.

Bamboos of Chittagong Hill Tracts

Bamboos in Chittagong Hill Tracts occur both naturally in forests and cultivated states. *Bambusa burmanica, Bambusa tulda, Dendrocalamus longispathus, Gigantochloa andamanica, Melocanna baccifera and Schizostachuym dullooa common forest bamboos occurring* in Chittagong Hill Tracts. *Melocanna baccifera* constitutes 70 – 95 percent of the total bamboo resources present in different hill forests of Bangladesh. Other than forest dwelling bamboos farmers also plant bamboo in their homesteads. Common among them are *Bambusa polymorpha, Dendrocalamus giganteus and Dendrocalamus longispathus* which is also a forest dwelling species.

List of bamboos occurring in Bangladesh along with their local names, climate, soil and growing conditions is given in **Annex1**.

Bamboo Ecology

Bamboos have an extremely wide range of global distribution that occurs in the tropical, sub-tropical and temperate regions of all continents except Europe and western Asia, from lowland to 4000 m altitude. Soderstrom and Calderon (1979) stated that the presence of some bamboos from a latitude as far north as 46^0 as far south as 47^0. Bamboos of non-clump forming time grow in Low Mountain zones of 30-36^0 north latitude, while clump forming bamboo grow in zones between 25^0 each of north and south latitude (Uchimura, 1981). **Bamboos growing in Bangladesh are clump forming type.**

Distribution and growth of bamboos are influenced by temperature. High temperature usually acts favorably on growth of bamboos. The mean annual rainfall in bamboo growing areas is over 1000 mm. Growth type of bamboo is highly correlated with temperature provided annual rainfall remains over 1000 mm. The mean annual rainfall in different parts of Bangladesh ranges from 1270 – 5080 mm. In January the mean annual

temperature is 17.8^0 C. April is generally the hottest month with a mean temperature of 26.7^0C. Humidity is one of the governing factors for bamboo growth. In Bangladesh humidity during monsoon remains more than 80 per cent. The shoots from rhizome develop during the pre-monsoon, and grow during the rainy season. Elongation of the culms takes place during the rainy season and continues still the post rainy season.

Bamboos grow in well-drained loamy soils. Soil texture, soil depth, slope and minor changes in drainage condition do not affect the growth of bamboo species very much. Bamboo can grow in the soil of pH 3.5, but the optimal soil reaction ranges between pH 5.0 -6.5. Though soil is not a limiting factor, water logging may affect the cultivation of bamboos. As bamboos can not stand water logging, it is not found in cultivation in areas which are subject to seasonal inundation.

It is interesting to note that the natural habitat of bamboo is restricted to the high rainfall hilly areas of the world, and the species with net-like extensive rhizome system might had been selected naturally for protecting the forest soil (Banik, 1989).

Light is an important factor in respect to the distribution of natural bamboos. *Melocanna baccifera* seems to be light demander. Bamboos grow in forests in varied conditions. It grows as pure and as under storey in timber areas.

Generally, if not always forest bamboos are found in association with other woody plants. All natural forest bamboos of Bangladesh other than *M. baccifera* grow as an under storey of the moist evergreen and semi-evergreen forests. *M. baccifera* also grow as pure brakes. Rhizome type of *M. baccifera i*s a factor in spreading in clear areas.

In villages, bamboos are cultivated in small clusters in and around the homesteads or as small groves. Distribution of village bamboos depends on the human factors such as utility, availability of propagating materials locally, and human migration.

Flowering Biology

The most interesting aspect of bamboo biology seems to be the flowering habit. Some bamboos flower every year, others at short intervals, and perhaps the majority at long intervals. In species that bloom after long intervals, the flowering is gregarious with all plants in population flowering simultaneously or close to it. Most of the bamboo species die after gregarious flowering.

Dransfield and Widjaja (1995) described following three main flowering types in bamboos:

Gregarious: a whole plantation flowers over a period of 2-3 years and then dies (e.g. *Bambusa bambos, Dendrocalamus strictus, Melocanna baccifera),* although the rhizomes may still be alive in some species. Gregarious flowering in *M. baccifera* results in complete death of aerial culms and underground rhizomes.

Sporadic: individuals flowers seasonally or occasionally, and only the flowering culms die afterwards, while the rhizomes continue to live (e.g. *Gigantochloa scortechinii*); and

Continuous: individuals produce flowers all year round; the culms that produce flowers do not die (most *Schizostachyum* species).

Also in few cases flowering in bamboo seedlings were recorded. Banik (1991) recorded such flowering in seedlings of *Bambusa tulda* and *M. baccifera* from Bangladesh and regarded as **precocious** flowering.

Grazing and incidence of fire increase the intensity of flowering (Dwivedi, 1990).

Based on behavior of flowering intensity and duration of flowering, the flowering clumps can be grouped into three groups (Banik, 1991), as:

1. **Complete flowering:** clumps that complete within one year and then die (*M. baccifera, Bambusa bambos*);
2. **Part flowering**: clumps that complete flowering within two or more years, then die or revive and stop flowering (*Bambusa balcooa*); and
3. **Continuous flowering:** clumps in which flowering occurs every year during flowering phase, and clumps do not complete flowering and die after flowering (*B. nutans, B. tulda*).

Gregarious flowering usually takes place in three phases: **1. preliminary sporadic flowering, 2. gregarious flowering, and 3. final sporadic flowering**. The length of each stage may vary considerably, and the first and third stages may be so prolonged as to include the second which may not be very marked (Troup, 1921).

Gregarious flowering may take place over a comparatively small area or may extend over hundred

Symptom of flowering: The absence of new culms in the previous year is generally held to be a sign of prospective flowering in the following season. Flower buds are visible about September or October, and flowering takes place in December or January. During blooming the branches become mostly leafless.

of square kilometers. In many cases it has been observed to commence in one locality and to spread like a wave to definite direction, taking few years to extend over the tracts of whole flowering area. This may be termed as a **'flowering wave'.** After gregarious flowering, seeds germinate at the beginning of the rainy season and best germination is obtained in bare soil. After germination the ground is carpeted with green seedlings.

Flowering Cycle: Bamboos have an erratic flowering habit and most of bamboos die after flowering. The period between two flowerings (flowering of a culm from a seed originated culm) is generally regarded as the flowering cycle. Estimation of flowering cycles are based on past flowering records.

Flowering of *M. baccifera* - muli in Bangladesh: The first flowering reports from Chittagong south, Chittagong north and Chittagong Hill Tracts were of around 1863 to 1866. In Chittagong south the last flowering was reported to occur in 1952 which was sporadic and continued for eight years up to 1958 or 1959. Thereafter a gregarious flowering took place and continued for two years during 1960 and 1961. During this time the species flowered in Bangladesh like a wave covering an area of about 10,00 sq. miles in four (1957-1961) years time (Hasan 1973). Before that, as per record, the species flowered sporadically during 1901 to 1905. Last sporadic flowering of *M. baccifer*a in Bangladesh was recorded from Chittagong north and CHTs (Kumalchari, Hyanko, Fatikchari, etc.) during 1986. Recently in 2007 this species has gregariously flowered in Sajek, Thanchi, Ruma, Bilaichari, Barkal and other areas in Chittagong Hill tracts. It has also flowered in north-eastern hill forests of the country. In 2008 the gregarious flowering is in progress in many other parts of the region. Comparing the present flowering with that of late 1950s and early 1960s that the *flowering cycle of muli bamboo in Chittagong Hill Tracts is 50 ± 5 years.* Muli shows three phases of flowering covering complete culms with a wave of 8-10 years over an extended tracts. **The culms completely die after flowering.**

Melocanna population in CHTs and northern Chittagong have similar duration of interseeding period to the most of the areas of Assam and Mizoram though these two regions area located in two different latitudes. In some areas of Mizohills the species also exhibited longer (48-50 years) flowering interval (Banik, 1998). The estimated flowering cycle for the species is 40-47 years in Sylhet forests of Bangladesh, bordering the neighboring areas of Cachar hills and Surma Valley of India. The species also exhibited long flolwering cycle in north Mymensingh areas of Bangladesh bordering the Indian province Meghalaya. Similarly in Myanmar the species also exhibited long duration of intereseeding period. So, obviously, there exists climatic variation, even though most of the *Melocanna* population flowered synchronously in these two regions (Banik, 1998).

Exact flowering cycles for bamboos are known for few species. Estimation of flowering cycles for most of the bamboos occurring in Bangladesh, based on past records is 30±5, 45±5, 50±5years (Alam, 1995a). Banik (2000) forecasted the large scale flowering of muli bamboo – *M. baccifera* in the forests to be at the beginning of the 21st century, and tentatively during 2006± years. Kali – *Gigantochloa andamanica* had flowered in Pablakhali in 1978 and recently flowered in Chittagong Hill Tract. It seems that flowering cycle of *G.anadamanica* is 30 years.

Assuming the estimated flowering cycles of 50±5years for *M. baccifera* and 30±5 years for *G. andamanica* it may be forecasted that next flowering in *M. baccifera* will be during 2056 – 2015 and in *G.andamanica* during 2035 -2040.

Genetic diversity in terms of flowering nature: Bor (1953) stated that the locality has some effect upon the flowering is proved by the fact that one single species does not flower in all climates at the same time though all the members of that species in a definite circumscribed climate do flower simultaneously. This indicates the occurrence of genetic variability or genetic diversity in bamboos. The nature of flowering, behavior of culms and clumps in flowering is a good indicator to identify the genetic diversity within the bamboo species (Alam, 1995a). During investigation in Chittagong Hill Tracts during 8th – 12th April 2008 clumps of *M. baccifera* in many areas were found not in flowering that indicates existence of genetic diversities in the area. A number of *M. Baccifera* populations exist in Bangladesh-India-Myanmar region. In most of the occasions they are isolated from each other by flowering (reproduction) time. In this vast region there exist two distinct populations, one with 30-35 years and the other with 40-50 years of flowering cycle (Banik, 1998). Diversities of flowering cycle among the populations of *M.baccifera* indicate that there might be existing genetic variability within vast natural habitat. For future conservation of *M. baccifera* these variations need to be explored.

Melocanna baccifera (Roxb.) Kurz

Synonym: *Melocanna babmusoides* Trin.

Local names: Muli, paiyya, bajali, nail, tarai

Geographical distribution: *M. baccifera* occurs naturally in Bangladesh, Myanmar, and north eastern India. It is occasionally cultivated and has been introduced and planted in many botanical gardens in Soth-east Asia. It has also been recorded from easter Sikkim growing along roads.

Ecology: It grows well in plain or lower hills on well drained deep clay soil to very deep loamy soil, ph 4.5-6.0. Annual rainfall ranges from 2000-5000 mm with a long dry season from November to March, temperature range 5 to 37^{o}C, suitable undergrowth, thrives well on moist sandy, clay, loam alluvial soil, on well drained residual soils, sandy rough slopes and top of the hills. It is a light demanding species and mostly occurs in pure stands, also mixed with other vegetation. Pure stands often result from shifting cultivation (Alam,1995).

Botanical description: Clum forming bamboo; culms diffused in the clump. Culms 10-20 m high, 3-7 cm diameter, green when young, straw coloured when old; longest internodes 20-25 cm long. Young shoots smooth, light purple or purplish green; ligule with long hairs, soon caducous, blades linear, green. Leaves 15-30 cm long, 2.5-5 cm broad, oblong lanceolate, apex acuminate, leaf sheath thick, ligulate; auricles very small with silvery bristles. Inflorescence a large compound panicle of one-sided drooping, spicate branches, bearing clusters of 3 to 4 spikelets in the axils. Fruit fleshy, pear-shaped,the talk is inserted at the thick end and the apex terminates in a curved beak.

Flowering: Flowering gregarious; flowering cycle 50±5 years as cited above. The culms in a clump do not always flower synchronously; some clumps may have clums in two or more different phenological states. During flowering year culms in a clump start producing floral shoots always at the apex of thin leafy branches, generally in the month of September to October. These floral shoots are leafless, somewhat brown, and 12-60 cm long. After about two and a half months the floral shoots start blooming during

November to December. The floral buds are borne at nodes along one side of the axis of a floral shoot and thus the pseudospikelets are produced on one side of the branches.

Soon after blooming in the apical floral shoot, all the leaves below it on the branches turn yellow and gradually wither. The buds on the axils of the withered leaves then start producing short panicles. Accordingly within a few weeks the main and secondary branches become leafless and form a large compound panicle. Thus finally all the branches on the culms become leafless and produce flowers. All the leafless flowering culms in a clump look like a giant inflorescence.

Fruiting: Fruit setting starts within a week of pollination. Pollination, fruit setting and maturation take place within next four to five months, April and May. However, fruit maturation is quicker in early part of seeding season. Both flowering and fruiting in a clump are simultaneous.

Fruits: Fruits or caryopses of *M. baccifera* are fleshy, onion or pear like (*Bacoid cayopses, baccate caryopses*), big and green. The caryopses are not covered with any glume, and their weight varies from 7 to 150 g, length from 35 to 110 mm and diameter 22 to 60 mm (Banik, 1991). However, a field forester usually terms the caryopsis (fruit) as "seed". Sometimes, a "seed" may weigh up to 275 g. In general one kg contains 45 – 70 seeds.

"Seed" Production: Seed production is poor in sporadic flowering condition where possibility of cross-pollination is very low. Gregarious flowering over a large tract of land facilitates cross-pollination resulting higher production of viable "seeds". One medium sized full-grown clump usually produces 5 – 7 kg "seeds" in one flush and 25 – 40 kg within whole flowering period before dying. In general, "seed" production is optimum during May to June and poor from later part of September to November.

"Seed" germination and viability: Fresh "seeds" germinate in higher percentage (70 – 80%). Germination starts within 5 – 7 days of sowing and continues for the next 20 – 25 days (Banik, 1991). Big and heavy seeds (above 50 g per seed) usually give healthy seedlings whose survival rate is also higher (70 – 80%) rate. During later part of flowering season, September to November, a few "seeds" were found in germinating

stage even on the flowering culms (vivipary germination). The seeds have 35 – 40 days viability period.

Natural Regeneration: Dead standing mother clumps influence better growing of bamboo seedlings by providing partial shade. Harvesting or burning of dead mother bamboos within 2 – 3 months of seed germination hinders the regeneration process by destroying almost all the bamboo seedlings. Therefore, felling operation of dead bamboos in the early stage of regeneration should be discouraged to obtain higher survival and establishment of regenerating bamboo seedlings. As the flowering mother clumps are leafless and dead, the forest floor becomes exposed to the sun, and the population of weeds and vines increases. Regenerating bamboo seedlings thus face competitions for their survival. Frequent weeding, vine cutting and protection from grazing or predation are found essential in protecting, nursing and enhancing the natural regeneration of wild seedlings of *Melocanna* bamboo.

Artificial regeneration: By a single-culm clump division it can be propagated vegetatively.

Gigantochloa andamanica (Kurz) Kurz

Synonym: *Oxytenanthera nigriciliata (sensu* Munro) ; *Oxytenanthera auriculata*(Kurz) Prain

Local names: Kali bans, kaliseri, kalizori

Geographical distribution: Assam, Myanmar, Andaman islands, Thailand and Bangladesh.

Ecology: In the dry mixed forests, occurring along the fringes of the forests. It is usually found as isolated clumps in disturbed scrubby forests and drier hills. The species could be seen gregariously on the flat ground and low elevations along the streams in the moist semi-deciduous forest, sandy-loam soils, pH4.5 -6.5.

Botanical description: A clump forming bamboo. Clumps very dense, as each culm always remains in contact with other culms. Culms dull green, covered with persistent culm-sheaths towards the base; sometimes longitudinal yellow stripes in lower internodes; 4-12 m tall with 2-5 cm diameter at the base. Branches from lower-mid culms. Leaves in complements of 9-15, blades lanceolate, 6-30 cm long.

Flowering: Flowering initially sporadic and finally gregarious, while in gregarious flowering the whole clump blossoms and the culms die after flowering. While in blossoms the culms become deciduous. During the flowering years peak flowering period is May-June. Recently *G. andamanica* has flowered in Chittagong and Chittagong Hill Tracts (in 2007 and 2008). Previous records indicate that it flowered in Publakhali in 1978 that indicates its flowering cycle is about 30 years.

Flowering cycle: About 30±3 years.

Fruit: A slender caryopsis (dry wheat like), about 10 mm long. Fruiting during June – September.

Regeneration: Natural regeneration takes through seedlings when the species flowers. Seedlings look like sender grass seedlings. Vegetative propagation through offset planting.

Impact of *M. baccifera* flowering on environment

"Seed" predation and impact on human: Gregarious flowering of *M. baccifera* produces huge number of fleshy fruits. There are reports that fruits are readily devoured by cattle, elephants, bison, deer, pig and other animals (Troup, 1921). Bor (1953) states that the fruit is edible and mentioned the fruits as an additional source of food when this bamboo flowers. During a recent visit to Chittagong Hill Tracts during 8th -13th April 2008 had the chance to meet members of at least four ethnic communities, but met none

> The seed-shed attracts seed predators, mostly rats. Significant increases in rodent populations have been reported in the past, a response to the increase in food supply as a result of seed setting. Seeds will however germinate, or be washed away, or crushed into the ground. As a result, the food supply will decrease; causing rodents to search for alternative supply, often to crops and granaries. In addition to eating the bamboo flowers and seeds, rats have destroys other plants such as papayas, chili, gourd and paddy. *This leads to a food crisis as farmers have no alternative livelihoods.* Thus flowering of *M. baccifera* has an impact on socio-economic conditions and human ecology in the area.

who had eaten the fruit. One person told that he had heard of eating it by someone near Rainghkong. But bison and cattle feed on it.

Gregarious flowering of bamboos starts in September-October, immediately after the rainy season. After about two and a half months the floral shoots start blooming during November to December. Peak flowering is during December-February when the leafless flowering culms in a clump look like a giant inflorescence. Fruit ("seed") setting and maturation take place within next four to five months, April and May. "Seed" production is optimum during May to June and poor from later part of September to November. By the end of summer there are enough seeds for increase of rat population. Then starts the rainy season. The transition from the summer to the rainy season is very rapid and crucial. With the onset of rains, bamboo seeds germinate in a few days. Now, instead of bamboo seeds in the forest layer there is lush green seedlings. All on a sudden there is a decline of foods for the rodents. But there is sufficient food for herbivores.

In places where there are large bamboo forests, the sudden decline of food diverts thousands of rats towards cultivated jhums, and ultimately to the paddy fields in the valleys and plains, thus bringing about a famine.

There is a dynamic interaction between *M. baccifera.* flowering, bamboo-seed predators (mainly rats), sudden shift from the summer to the rainy season, and rapid transformation of bamboo seeds into seedlings (not a gradual depletion) is a cause of famine during the year of gregarious flowering of *M. baccifera.*

Impact on the habitat and vegetation: Most *M. baccifera* occurs in pure brakes. Unlike many other bamboos *M. baccifera* dies completely including aerial culms and underground rhizomes. Complete dying results denudation of habitats. These complete dying of whole bamboo clumps have definitely impacts on habitat. But much is not known about impact of *M. baccifera* flowering on the habitats. Kurz (1877) stated about the bamboo jungles in Burma that when all bamboos die after gregarious flowering then numerous light loving plants and shrubs and tree seedlings spring up. At such periods one can not predict with any certainty whether the next generation will be again a pure

bamboo jungle or whether the saplings of the trees will not get the supremacy, keeping down the young bamboo as undergrowth. After gregarious flowering millions of seedlings will cover the soil, but only a fraction that may come to maturity. For a few years after a gregarious flowering and seeding the forests are littered with a mass of dead culms that are often bound with herbaceous climbers and form dense impenetrable tangles.

Local human interaction can regulate the nature of coming vegetation. Slash and burn is the major farming practice in Chittagong Hill Tracts. Generally hill people prefer bamboo growing areas to burn for preparing *jhum*. While the aerial bamboo culms are burnt, they sprout again from underground rhizomes. This cause repeated weeding operations in *jhum* fields. As all bamboos die after gregarious flowering there is mostly no chance of new bamboo sprout. So, shifting cultivators prefer gregariously-flowered bamboo brakes for preparing *jhums*. Thus it hinders natural regeneration of bamboos and other vegetation.

If a bamboo regenerated land is cleared and burnt for shifting cultivation there might be a shift from normal regeneration, otherwise such clearings due to dying of gregarious flowering of bamboo may be reverted into a forest of mixed vegetation.

Fire may cause damage to regenerated bamboo and tree growth. Grazing also causes damage to young bamboo seedlings.

Impact on boidiversity and plant genetic resources: As coping mechanisms people to some extent depend on non-traditional food plants like yams, aroids, and other plantand animal species. To meet the demand of the hungry people this causes over harvest and that ultimately affect local level biodiversity and genetic resources.

Impact on seed security and agro-biodiversity: Rat infestation that causes damages not only to crops but, also disrupts seed security. Hill farmers maintain their own seed stock from their harvests. During gregarious flowering in M.baccifera due to rat infestation in the jhums farmers cannot stock their seeds for next sowing. Along with food crisis this affects future crop production.

Needs identified in terms of eco-environment with particular reference to bamboo resources

Bamboo is intricately linked with the lives and livelihoods of hill people. It has been mentioned earlier that hill can not think the existence of any area without bamboo. *M. baccifera* – muli is the predominant and major bamboo speies naturally growing in different forest areas of Bangladesh. It forms pure as well as scattered bamboo vegetation in the forests of Bangladesh extending over 90,000 ha area. This species constitutes 70 - 90 % of the total bamboo forests of the country.

Gregarious flowering of bamboo causes not only famine for the time being but, also depletion of bamboo resources at least for four to five years. So, this resource is also to be replenished. During the recent visit to Chittagong Hill Tracts we could identify following issues:

- **Management of bamboo resources:** To ensure future sustainable supply of this resource it needs immediate management operations. This management operation should include both:
    - *Natural regeneration:* to allow the seeds that drop on the ground to germinate and grow. It needs regular weeding and other management operations that ensure the establishment of a natural bamboo stand and becomes harvestable by 4-5 years.
    - *Aided regeneration:* is the artificial generation that can be made trough planting of seeds. Seed is the cheapest planting material. Muli bamboo flowers gregariously once in 50 years producing huge quantity of seeds. As whole bamboo brakes die after flowering vast chunk of land becomes vacant for planting. So, artificial regeneration through planting seeds is very important and essential for replenishment of bamboo resource in Chittagong Hill Tracts.
- **Value added bamboo based commodities development:** Bamboo is a raw material for versatile commodities from kitchen wares, agricultural implements, handicrafts to industrial products. So, for a sustainable livelihood in Chittagong Hill Tracts and other parts of the country there are ample opportunities to add values to this natural resource.

- **Enhancement of marketing efficiency of bamboo and other non-timber forest produces:** Remote areas of Chittagong Hill Tracts are endowed with bamboo and other non-wood forest resources. These resources could not be efficiently utilized due to poor marketing facilities. Even dying bamboos are burnt for preparing of *jhum* fields. Easy transportation and other facilities are needed to enhance marketing efficiency of local produces and products.
- **Integration of bamboo cultivation with timber and other non-timber forest products:** One of the aspects of bamboo ecology is that it grows as a under storey with other vegetation. So, bamboo plantations can be made in an admixture of timber and non-timber species, as mixed cultures always ensure more sustainability.

Opportunities for replenishment of bamboo resources

There exist lot of opportunities for replenishment of bamboo resources along with biodiversity management and livelihood enhancement in Chittagong Hill Tracts. Somme opportunities centering bamboo resources are as follows:

- **Bamboo as a sustainable resource:** One of the biological advantages of the bamboo resource is that it has a very long life cycle (from seed to seed). The culms that have many fold uses are the aerial stems. This grows annually from the underground rhizome system and can be harvested perpetually every year with minimum management efforts. Once a bamboo clump becomes harvestable after 3-5 years of planting, it goes on producing new culms every year, and every year matured culms can be harvested. This is a tremendous benefit of planting bamboo as a plantation crop.
- **Lands available for promotion of bamboo production:** Chittagong Hill Tracts occupy 10 percent land area of the country. About 1816,993 acres land of Chittagong Hill Tracts (72.91% land) are hill that have classified as Type-D land by Forestal Survey of 1966. This category of land is not suitable for agriculture or horticulture but suitable for forestry. Bamboo can be grown in this category of lad and also partially other categories of land can be brought under bamboo production areas.

- **Availability of planting materials:** With flowering of *M. baccicera* millions of seed have become available that will make planting cheaper. This chance is meeting once in about 50 years.
- **Market potentials of different value added products:** Bamboo products and products from other non-wood resources have very good domestic and international market potentials. Different ethnic communities in the hills have their own cultural brands and craftsmanship that can be utilized in developing value added products with market potentials.
- **Technical capacities available:** Technical capacities are available at Bangladesh Forest Research Institute (BFRI), Chittagong on production, management and product development technologies on bamboos, and other land uses. BFRI has also expertise on cultivation and management of non-wood forest species.
- **Traditional local institutions for natural resource management:** One of the essential advantages of Chittagong Hill Tracts is the existence of traditional institutions headed by Headmen and Karbaries among all ethnic communites in Chittagong Hill Tracts that will help in developing resources and their management through any model like, Forest User group, Community Forestry or Co-management, etc.
- **Existence of Common Village Forests:** Most of ethnic communities in remote areas still maintain a common village forests around the village or in the vicinity that is managed by the community. These wooded lands are maintained for ecological services like maintenance of mini watersheds, protection the village from warm and fire. It also supplies non-timber forest produces and often timber is harvested for community use only. Bamboo production can be incorporated with this existing norm in the essence of community resource development and management.

Recommendations

Considering the ecological and production services provided by bamboos, its flowering ecology, impacts of bamboo flowering on ecological and socio-economic environments,

opportunities of its regeneration and replenishment following immediate and mid-long term recommendations are proposed:

Immediate

- **Aided regeneration:** Bamboo brakes die after flowering and seeds are predated by rats and other animals. Seeds also lose viability within few days after dropping from the mother plants. So, immediate actions should be taken to replenish bamboo resources from seeds through *community involvement*.
- **Awareness development and sensitization:** Hill people know that bamboo flowers at about 50 years interval and dies after flowering. They are quite aware about the rat infestation following gregarious flowering of bamboos but not aware about the coping mechanisms and future regeneration of resources. So, and awareness development and sensitization program is needed immediately.
- **Development of "Bamboo Management Plan":** Most of the bamboos flower in its life and die after flowering. In muli – *M.baccifera* flowering starts in an area and a 'flowering wave' continues for about 6-10 years. So, all bamboos in an area do not die in a single year but continues for 6-10 years in different areas in different years. Also there exists different genotype of the species in a geographical region that protects the species extinction. Considering flowering ecology, impacts of gregarious flowering on environment, existence genetic variability in the species, their conservation and sustainability of bamboo resources particularly muli, a "Bamboo Management Plan" needs to be developed immediately in consultation with stakeholders. Management will also consider the future economic growth of the area.

Mid- and long term

After developing the management plan, following that one, mid- and long term activities should be taken. Some of mid- and long term actions may be:

- **Bamboo plantations with different genotypes:** As there exists different genotypes of muli bamboos in the area, bamboo plantations should be initiated with different flowering genotypes to avoid gregarious flowering at a time.

- **Bamboo plantations with different species:** Planting bamboos species other than the one that at the time of large scale flowering of alternate resource for sustenance of livelihood is available.
- **Value added bamboo based commodities development:** Bamboo is a raw material for versatile commodities from kitchen wares, agricultural implements, handicrafts to industrial products. So, for a sustainable livelihood in Chittagong Hill Tracts and other parts of the country there are ample opportunities to add values to this natural resource.
- **Marketing of vale added products:** Markets need to explored and developed with vale added commodities development. Linking of producers with consumers through efficient marketing will ensure sustained production of natural resources. Employment opportunities and cash generation by developing commodities from selective species like bamboo will reduce pressure on other elements and thus will help in conserving biodiversity.
- **Integration of bamboo cultivation with timber and other non-timber forest products:** Different bamboo production models like, pure bamboo plantation, bamboo + timber tree plantation or bamboo + timber tree + non-timber (medicinal plants) plantations can be designed based on local need, access to markets.
- **Integration of bamboo as component in common village forest:** Integration of bamboo as major component in existing Common Village Forests will help easy production and conservation of resources.
- **Strengthening of bamboo research and development as backstopping**

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Annex 1: List of bamboos occurring in Bangladesh

Sl. No.	Scientific name	Local names	Climate, soils and growing condition	Occurrence in Bangladesh
1.	*Bambusa balcooa*	*Borak, teli barua, shil barua, teli barua, hill barua, balku, baro bans, balku,balkoa, gitabora, boro-bansa,bhaillo-bans*	Grows well in flat alluvial deposits, pH 5.5-8.0, rainfall 1500-5000 mm and a distinct drought period, sensitive to water logging and cyclone.	It is found in central, northern to north-western parts of Bangladesh. It is also found in Chittagong, Comilla and greater Sylhet.
2.	*B.bambos*	*Kanta bans, ketua bans*	Grows well in humid tropical wet condition to alluvial deposits, pH 5.5-8.0, rainfall 1500-5000 mm and a distinct drought period sensitive to water logging and cyclone.	It is found in cultivation in many districts of Bangladesh.
3.	*B. bambos* var. *spinosa*	*Bish kanta*	Similar to that of *B. bambos*.	It is found in cultivation in northern districts of Bangladesh, particularly in Dinajpur and Thakurgaon districts.
4.	*B. burmanica*	*Mitinga, mirtinga*	Grows well in evergreen to mixed evergreen forests, pH 5.5-7.5, rainfall 1500-6000 mm and a distinct draught period.	It occurs in the forests of Chittagong, Chittagong Hill tracts, Cox's Bazar, and Sylhet. Also occurs in villages in vicinity to forests of Chittagong and Sylhet.
5.	*B. cacharensis*	*Bethua, jamabethua, sonarati*	Grows well in well-drained alluvial to sandy-alluvial soils, pH 5.5-7.5, rainfall 2800- 6000 mm.	Occurs mostly in village groves in the districts of Moulvi Bazar and Sunamgonj.
6.	*B. comillensis*	*Dhlibans, kanak-kaich*	Grows well in alluvial to sandy alluvial soils, pH 5.5-7.5, rainfall 1500-5500 mm and a distinct draught period.	In Bangladesh it occurs in the homesteads of Brahaman Baria and Comilla

				districts, and some parts of Noakhali district.
7.	*B. jaintiana*	*Chikoin, konkoi, tentua, tengra, tengal*	Grows well in well-drained alluvial to sandy-alluvial soils, pH 5.0-6.5, rainfall 2800- 6000 mm.	Occurs mostly in village groves in the districts of Sylhet, Sunamgonj, Moulvi Bazar, Habigonj, Brahan Baria, Dhaka and Gazipur.
8.	*B. multiplex*	*Choi-bans*	Cultivated up to 1500 m ltitude, grows well in various soil types.	Cultivated s hedges in many districts.
9.	*B. nutans*	*Mahal, mal, makhala, mokhla, bakhal, morol*	Grows well in well-drained alluvial to deep alluvial soils, moist and moderately high rainfall (4000-6000 mm) areas with temperature range 4 to 37^{o}C.	The species is cultivated in the homesteads of most of the districts of Bangladesh, but most common in northern, eastern and north-eastern part of the country.
10.	*B. polymorpha*	*Pharua, wapia*	Grows well in deep and well drained soil in moist and moderately high rainfall area (3500-5000 mm), pH 4.4-7.0, temperature 3-35^{o}C.	It occurs in the hill forests of Chittagong, Chittagong Hill tracts, Cox's Bazar and Sylhet.
11.	*B. salarkhanii*	*Jeotha, kurajowa, kantajali, keskijowa*	Grows well in well-drained alluvial to deep alluvial soils, pH 4.4-7.0, moist and moderately high rainfall (4000-6000 mm) areas with temperature range 4 to 37^{o}C.	The species is common in homesteads of most of the districts of Bangladesh.
12.	*B. tulda*	*Aille, keyitta, talla, trala, mitinga*	Grows well on flat alluvial deposits and also at low hill slopes, thrives under dry stony sites, ph 5.5-7.0	It is a common village bamboo occurring most of the districts, and also occurs in mixed evergreen hill forests.
13.	*B. ventricosa*	*Ghati bans*	Grows naturally in low altitudes.	Often cultured as pot plants in many nurseries
14.	*B. vulgaris*	*Bangla bans, baijja bans,*	Grows best at low altitudes, thrives under wide range of	Occurs throughout the country, but

		bargiya bans, bashini, jai, jawa bans, orag,	moisture and soil conditions, well adapted to banks of rivers and lakes.	common in southern and eastern districts.
15.	*B. vulgaris* var. *striata*	*Sharna-bans*	Grows in similar conditions of *B. vulgaris.*	Found in cultivation in some homesteads.
16.	*Dendrocalamus asper (=D. brandisii)*	*Brandisi*	Grows well at 400-500 m altitude above sea level, annual average rainfall 2400 mm, in any type of soils but grows well in heavy soils with good drainage, pH 4.5 -6.5	In cultivation in bamboo garden of Bangladesh Forest Research Institute.
17.	*D. giganteus*	*Budhum bans, kanchan bans, raja bans*	Occurs naturally humid tropical high land, up to 1200 m altitude, tolerates -2^{o}c. Can grow in tropical low land on rich alluvial soils.	It is cultivated in Buddhist temples of Chittagong and Chittagong Hill Tracts (CHT) and other areas of country.
18.	*D. hamiltonii*	*Pencha bans*	It grows well in moist and moderately high rainfall areas of subtropical forests, susceptible to biotic interference,	In Sylhet forests.
19.	*D. longispathus*	*Khang, orah, rupai*	Grows well in deep and well drained soil in moist and moderately high rainfall area (3500-5000 mm), pH 4.4-7.0, temperature 3-35^{o}C.	It occurs in the hill forests of Chittagong, Chittagong Hill tracts, Cox's Bazar and Sylhet.
20.	*D. membranaceus*	*Motabans*	In its natural habitat the annual average minimum temperature is 21 ^{o}c, the average annual rainfall is 950 mm with dry season, in any type of soils but grows well in heavy soils with good drainage, pH 4.5 -6.5	In cultivation in bamboo garden of Bangladesh Forest Research Institute.
21.	*D. strictus*	*Lathibana*	Optimum mean annual temperature between 20 – 30 ^{o}C, rainfall 1000-3000 mm, very draught resistentsandy-loam soils with good draiage, pH 5.5-7.5.	Found in cultivated states in many districts.

22.	*Gigantochloa andamanica (=Oxytenanthera nigrociliata)*	*Kalibans, kaliseri, klijori*	It is usually found as isolated clumps in disturbed scrubby forests and drier hills. The species could be seen gregariously on the flat ground and low elevations along the streams in the moist semi-deciduous forest, sandy-loam soils, pH4.5 -6.5.	In the hills of Cox's Bazar, Chittagong, Chittagong Hill Tracts and Sylhet.
23.	*G.apus*	*Tendu?*(Mymensingh)		Recorded only from Mirpur Botanical Garden
24.	*G. atroviolacea*	*Kalabans*		In cultivation in Baldha Garden, Mirpur Botanical Garden and BFRI Bambusetum.
25.	*Melocalmus compactiflorus*	*Lotabans, dharalbans*	Grows well in deep and well drained sandy soils, pH 4.5-6.0.	In the forests of Cox's Bazar.
26.	*Melocanna baccifera*	*Mulibans, paiyyabans*	Grows on deep clay soil to very deep loamy soil, ph 4.5-6.0. Annual rainfall 3000-5000 mm, temperature range 5 to 37^{o}C, suitable undergrowth, thrives well on moist sandy, clay, loam alluvial soil, on well drained residual soils, sandy rough slopes and top of the hills.	It occurs in the forests of Sylhet, Chittagong, and Chittagong Hill Tracts. It also occurs in Garo hills and some other parts of Tetulia of Panchagar.
27.	*Schizostachyum dullooa (= Neohouzeaua dullooa)*	*Dolubans*	It prefers shade and generally occurs on the moist, well-drained and fertile valleys as under story in the deciduous forests.	Occurs in the forests of Sylhet, Chittagong and Chittagong Hill Tracts.
28.	*Thyrsostachys oliveri*	*Rangooni-bans, burma bans*	Deciduous to mixed deciduous forests, wide range of soils, can stand draught	Cultivated in Dhaka, Mymensingh, Sylhet, Chittagong and Hill Tracts.
29.	*T. regia (=T. siamensis)*	*Siambans*	Grows in wide range of soils with good drainage, an annual rainfall of 800-100 mm	Occasionally found in cultivation