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Gilles Lessard and
Amy Chouinard

Organized by the International Development Research Centre and the International Union of Forestry Research Organizations

Bamboo Research in Asia

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IDRC-159e

Bamboo research in Asia: proceedings of a workshop held in Singapore, 28–30 May 1980. Ottawa, Ont., IDRC, 1980. 228 p.: ill.

/IDRC publication/, /bamboo/, /South Asia/, /South East Asia/, /forestry research/ - /botany/, /classification/, morphology/, /ecology/, /physical properties/, /geographic distribution/, /cultivation techniques/, /construction materials/, /musical instruments/, /conference report/, /list of participants/.

UDC: 634.0.287 ISBN: 0-88936-267-X

Microfiche edition available

The cover artwork, which has been reproduced throughout the book, is a line drawing based on a painting by Hui Nien, which has been used in several works on bamboo.

IDRC-159e

Bamboo Research in Asia

Proceedings of a workshop held in Singapore, 28–30 May 1980

Editors: Gilles Lessard and Amy Chouinard

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Contents

Bamboos in the Asia-Pacific Region

Y.M.L. Sharma[1]

This treatise concerns the distribution of bamboos in South and Southeast Asia and the Far East; their usefulness; phenologic characters; and factors influencing their regeneration, method of propagation, and care. Bamboo utilization has taken great strides in countries like Japan, Taiwan, China, and Indonesia and has a great future in the developing countries. Although the general belief is that bamboos are used primarily by the paper industry, nearly 80% of the bamboos produced in the Asian countries are used by the people. The consumption of bamboos for paper is negligible, but bamboos are essential to the economy of the region, and they deserve a better status than "minor forest produce" or "noncommercial species."

Bamboo-shoot farms have been extensively developed in Japan and Taiwan, and trials in similar ventures are needed in the other countries. Bamboo plantations in tropical countries are a good source for housing materials.

More than 10 million tonnes of bamboos are produced annually in the world. Almost all this comes from the East. It is estimated that in China alone there is yearly growth of 3.5 million tonnes. Eight hundred years ago Pou-Sou-Tung, a Chinese poet, wrote "A meal should have meat, but a house must have a bamboo. Without meat we become thin; without bamboo we lose serenity and culture in itself." In China bamboo is one of the four noble plants, the others being the orchid, the plum tree, and the chrysanthemum. The Vietnamese epitomize the closeness of the bamboo in their proverb "the bamboo is my brother." Bamboo is no longer called the "poor man's timber." It occupies a place of pride, being closely interwoven with the life of the people in several ways as well as with industries. It is a subject of fascinating study to the artist, poet, and the scientist. In short, bamboo finds its use from the cradle to the coffin.

Bamboo has been classified as a minor forest produce in several countries. In recent years some countries have identified it as a "nontimber" species. In view of its importance in the industrial sector and its uses in rural and urban sectors, it merits a better status in the community of forest products.

Intensive research on the different aspects of bamboo propagation and utilization is indicated, and there is a need for an international research institute on bamboo in the tropics with a chain of regional research centres and subcentres in each country.

Bamboos occur in tropical, subtropical, and temperate zones. Their genera and species are distributed widely. About 75 genera and 1250 species occur in the different countries of the world. India, Burma, Thailand, and Indonesia figure

[1]International Forestry Consultancy, Bangalore, India.

Bambusa vulgaris in the field; the stalks are yellow.

prominently in their bamboo resources. In Burma alone it is estimated that 4.5 million tonnes of bamboos could be available annually.

Nearly 136 species of bamboos occur in India, notables among them being *Bambusa arundinacea* and *Dendrocalamus strictus*. These occur all over the country as a component of tropical, dry and moist, deciduous forests. Northeastern India has a large number of species like *Melocanna baccifera, B. tulda, B. balcoa, Teinostachyum dulloa, Dendrocalamus brandisi,* and *D. hamiltonii.* The bamboo resources of this region have not been fully exploited due to difficulties in extraction. *Cephalostachyum pergracile, Thyrsostachys oliveri,* and *B. vulgaris* are ornamental bamboos.

Nearly 33 species of bamboos occur in Bangladesh in the North, East, and South, especially in Chittagong hill tracts. About 900 km ^{2} of reserved forests of Sylhet and Chittagong hill tracts can be classed as bamboo forests.

Bambusa polymorpha with new vegetative shoots.

In Burma about 90 species have been recorded, 14 of which are utilized. *Sinobambusa, Chimonobambusa, Arundinaria, Phyllostachys, Bambusa, Thyrsostachys, Gigantochloa, Dinochloa, Oxytenanthera, Dendrocalamus, Dendrochloa, Pseudostachyum, Schizostachyum, Neohouzeoua, Cephalostachyum, Melocanna,* and *Teinostachyum* are the important genera. Bamboos are found all over the country in the nine forest types either as an understory in the forest or as a pure stand. Inaccessibility, transportation, and labour problems have hampered the intensive utilization of bamboos in Burma. *M. baccifera* occurs as pure stands over 7800 km^2 in Arakaan Yoma.

Eleven genera and 55 species of bamboos have been reported in the Philippines under various climatic conditions. Several species of climbing bamboos form dense tangles in the forests. *B. blumeana* is the only thorny species. Bamboos confine themselves generally to marginal lands along streams,

riverbanks, backyards of residences, and hillsides. They are found in Mindanao, Palawan, Kagayan, and Batan. The commonest are *B. blumeana, G. levis, B. vulgaris, D. merrillianus, S. lumampao,* and *S. lima.* Bamboos occur in malawe and dipterocarp forests more often than in any other type. Bamboo forests have been described as representative of different stages of ecologic regression, due to fires, grazing, overexploitation, etc.

Nine genera and 31 species have been reported from Indonesia. It is likely there are more. They are restricted to forest areas that have been exploited, and, other than the climbing species, they do not generally occur in rain forests. More than 90% of the bamboos come from outside the forest areas, i.e., from farm lands and homesteads. People cultivate bamboos on a large scale. *Arundinaria, Bambusa, Dendrocalamus, Gigantochloa, Melocanna, Nastus, Phyllostachys, Schizostachyum,* and *Thyrsostachys* are the important genera.

The tropical climate of Thailand is congenial to bamboos of nearly 12 genera and more than 50 species. The bamboos occur widely in the North, Northwest, and South in evergreen and deciduous forests in a contiguous belt with Burma. The commonest species in Thailand are *T. siamensis, B. blumeana, B. polymorpha, B. nana, B. tulda, D. hamiltonii, D. giganteus, D. brandisi,* and *B. arundinacea.* About 15% of the total land in Thailand, or about 77 100 km^2, has been reported to be under bamboo.

Japan has 13 genera and 670 species, the most important managed ones being *Phyllostachys edulis, P. reticulata,* and *P. nigra.* About 123 000 hectares of bamboo forests, of which most is privately owned and is managed by farmers, exist in Japan. Areas are set apart for culm production and (edible) shoot production separately.

Ten major genera, *Phyllostachys, Pleioblastus, Sasa, Pseudosasa,* etc. occur in Korea, all being single-stem species. About 13 species are cultivated, of which *P. reticulata* is the most important.

Twelve bamboo species, of which four are edible, have been reported in Sabah in Malaysia.

About 26 species of bamboos have been reported from Papua New Guinea. They occur extensively in the savanna of the Western Province. Many villages in the lowlands and highlands have planted the thick-walled bamboos for building and other purposes. *S. lima,* the thin-walled one, is flattened, woven into sheets, and used as cladding for walls in houses. The durability of the sheets is enhanced by impregnation with a preservative to a retention of about 8 kg/m^3. Dip treatment is resorted to for internally used sheets. Thick-walled *B. vulgaris* is increasingly used for furniture, novelties, decoration, artifacts, handicrafts, etc. A "bambusarium" has been established at Lae and in the Agricultural Experimental Station at Laloki (Port Moresby) with species from Southeast Asia, South and North America. Export of bamboo and bamboo articles is low.

One altitudinal variation in Bhutan has influenced the distribution of the bamboo. *D. hamiltonii* occurs in the lower regions and *B. nutans, D. sikkimensis,* and other species at higher elevations.

Four species of bamboo *Greslania* occur in New Caledonia. There are, however, many species of bamboos that have not yet been identified and listed in Southeast Asia.

The habitat of the different species of bamboos varies greatly on account of their specific habits, which are indicators of the different forest types. For example, *B. arundinacea* restricts itself to the moist and low-lying regions, banks of streams and rivers; *D. strictus,* to well-drained slopes; and *Ochlandra* species or *Oxytenanthera,* to the ridges and crests of hills in the deciduous forests of

India. In the semievergreen and evergreen forest areas of South India, the reeds come down to the sides of riverbanks. Good bamboo growth is found under a light-to-moderate canopy of deciduous species. Ecology and habitat of bamboo in the different countries offer much scope for study.

Habit, Development, and Phenology

Bamboos are monopodial, i.e., erect as in *Melocanna* and *Phyllostachys,* sympodial or clump-forming as in *Dendrocalamus, Bambusa, Thyrsostachys,* and climbing as in *Dinochloa.* Between the single-stemmed and the densely clumped forms, there are intermediate types with somewhat open clumps (*D. membranaceus* and *Arundinaria jaunsarensis*). The erect, clump-forming species are characteristic of tropical countries. Those sending out culms singly are characteristic of subtropical or temperate regions. Bamboos vary in size from lofty forms with stems 23 m high and 23 cm thick to mere undershrubs like *Arundinaria* found at high altitudes. Species like *Dinochloa* are scandent, climbing into the crowns of tall trees.

The maximum height is reached in the first season. Soft at first, the culms become hard by deposition of silica in the walls and nodes. A sugar called *Tabashir* consisting of 80% silica with various proportions of alkalies, water, and organic matter is used for medicinal purposes and is produced from some species of bamboos. The culms are hollow with walls varying in thickness according to species; in some cases the cavities are absent, and the culms are solid. Some have prominent branches, others, only small branchlets. Some are thorny, others not.

The culms of different seasons are distinguished by the presence or absence of sheaths and changes in colour.

Bamboos flower either sporadically or gregariously. Gregarious flowering is a remarkable phenomenon occurring like clockwork. It has been recorded in India, Bangladesh, and Burma. When the bamboo gregariously flowers, the whole plant is transformed into a gigantic inflorescence. It has been attributed to several factors, chief of which is drought. Other possible causes lack evidence. Gregarious flowering is followed by death of the clump. *B. arundinacea* and *D. strictus* have gregariously flowered in India in the past as well as recently. The regeneration has not reached a stage suitable for exploitation, and the country is facing an acute shortage of bamboo for industry as well as for the people. In Bangladesh large-scale gregarious flowering has been a major setback in sustained supply of bamboos and a reason for shortage of seed for propagation. In the Philippines, work has been initiated on the causes of gregarious flowering of *S. lumampao* and *G. levis.* In a recent study, Uchimura (428) has put forth several theories about flowering of bamboos, but these need experimental proof. In Indonesia, the climate, which is equatorial with abundant moisture, may be responsible for the absence of gregarious flowering. Whereas records of stray clumps of bamboos flowering in the botanical gardens at Bogor exist, neither sporadic nor gregarious flowering has been observed in the forest areas. In Thailand, despite the occurrence of a large number of species, there is not much information on flowering and subsequent seeding. It is known that flowering and seeding does occur and that most seeds are destroyed by fire. Seeds are being collected in small quantities for experimental work at the Kanchanaburi Province research station. In Korea, recent observations indicate that *Phyllostachys reticulata* and *Pseudosasa japonica* flower abundantly every year. *Phyllostachys edulis, P. nigra,* and *Sasa koriensis* flower rarely.

The periodicity (flowering cycle) of gregarious flowering varies and is as long as 25–30 years in *D. strictus* and 40–60 years in *B. arundinacea*. In Bangladesh, it is 40–50 years in *Neohouzeoua dulloa*, 30–50 years in *Oxytenanthera nigrociliata*, 30–35 years in *M. baccifera*, 20–30 years in *B. tulda*, and 20 years in *D. longispathus*. Records of gregarious flowering exist for India, Bangladesh, and Burma, but for other countries information is wanting. Gregarious flowering and seeding results in profuse development of jungle fowl and rats. When the seed is exhausted, the rodents switch over to agricultural crops.

Development of the Bamboos

Development of bamboos is affected by several climatic and biotic factors. For instance, adequate rainfall and the conditions of the clump have a bearing on the production of new culms. Congested clumps retard the development of new shoots, with only a few culms being produced on the periphery. If a clump is judiciously thinned, new culms are well-distributed.

Fires, grazing, shade, competition, rainfall, temperature, soil characteristics, and topographic features play an important role in bamboo growth. Fires are a menace, and the dry, dead bamboo clumps, which have produced seeds, are a serious fire hazard. In India and Bangladesh animals graze on the seedlings, and rodents cause damage to seeds and seedlings in India, Bangladesh, and Burma. In Bangladesh, bamboo is affected by fungus attack, and some interesting experiments are in progress to isolate the fungus and find appropriate control measures. Insects cause damage to living culms, both new and old, and powder-post beetles cause tremendous damage to cut culms. Shifting cultivation and improper working of clumps also lead to reduced yields of bamboo. In general, providing shade and protection from animals, fire, and unrestricted human activities would result in good growth of bamboos. Edaphic and topographic variations result in the appearance of different species of bamboo.

Propagation of Bamboos

Natural regeneration of bamboos is either by seed or by sprouts from the rhizomes. In India, *B. arundinacea* and *D. strictus* regenerate profusely by seed after gregarious flowering, but grazing and fires damage many of the seedlings. Fencing and introducing rigid fire protection, as well as managing clumps of new bamboos, by the West Coast Paper Mills in Karnataka in India have given good results. In Bangladesh reliance has long been placed on natural regeneration. This is also the case in Burma. Work on natural regeneration of bamboo has been initiated in the Philippines, whereas natural regeneration by seed has not been reported from Indonesia. It is scanty in Thailand as seeds are reported to be destroyed by frequent ground fires. In the temperate countries of Korea and Japan, natural regeneration by seed is unreliable.

Bamboo regenerates naturally by throwing out new shoots from the rhizomes with the advent of favourable conditions early in the rains. The culms put forth their maximum height by the end of the rainy season, extending over 3–4 months. The growth is thus very fast.

Bamboos are propagated artificially by different methods, including planting seed; raising seedlings (naked or in containers); marcotting; layering;

planting rhizomes or offsets; using culm cuttings (vegetative cuttings); and planting nodal cuttings. Seeds can be sown directly in the ground in straight lines or on mounds, but they are rarely available.

Seedlings are raised in nursery beds in drills and allowed to develop for a year after which they are transplanted. An alternative is to sow seeds directly in polythene containers and to plant the seedlings with the onset of the monsoon. Sometimes, when seedlings are 7–10 cm high, they are transferred to polythene bags for further development. To utilize all the available seed, cultivators also prepare dry nursery beds in the forest and use the seedlings whenever necessary.

Marcotting involves bending a 1-year-old culm so that all the nodes are within easy reach of the workers. This is facilitated if an undercut is made at the base of the culm. The branches at the nodes are pruned to about 2.54 cm in such a way that no dormant buds are injured. An admixture of garden soil and leaf mould placed around each node is longitudinally wrapped with coconut fibre. This is then securely tied at both ends. In the Philippines, this method has produced 68.9% success in *B. blumeana.*

In layering, a 1-year-old culm is pruned without injury to the dormant buds and is half-buried in such a manner that the buds along each side of the culm are in a lateral position. About 28% success has been reported for *Bambusa* in the Philippines. Work of this nature is also in vogue at the Forest Research Institute in Bangladesh with *D. hamiltonii.*

In rhizome or offset planting, 1-year-old culm with its root system is dug up, cut to about a metre high, and planted during the rains. This method involves high costs in labour and transportation but has been successfully used for *S. lumampao.*

Culm cutting involves cutting a 1-year-old culm into two-node sections. Each cutting or section is planted obliquely with one node buried. Success rates of 60% for *B. vulgaris,* 28% for *G. aspera,* and 60% for *B. blumeana* have been reported with this method in the Philippines. Combined with treatment by hormones (indole butyric acid), this method produced 45% success in *B. blumeana,* 80% in *B. vulgaris,* and 60% in *D. merrillianus.* It is, however, opined that greater success would have resulted if the experiment had been conducted during the rains.

A nodal cutting comprises two nodes that are laid horizontally and buried level with the ground; a hole is made in the internode, which is filled with water. This method has given success in *B. vulgaris*, the dormant buds sprouting at the nodes.

India has achieved great strides in production of bamboo forests; 160 000 hectares of bamboo plantations have so far been raised in the different states. Bamboo is also being cultivated by villagers all over India in homesteads and village wastelands. Vegetative propagation by rhizomes and offsets is an age-old method and has been adopted by villagers in India, Bangladesh, and Burma. Large numbers of bamboo clumps are planted in village groves in Bangladesh every year. Planting is done by individuals in their backyards or on vacant areas in the villages. Organized and managed plantations do not exist. Though about 10–12 species are cultivated, the commonest are *B. vulgaris* and *B. nutans* because planting material for these two species is readily available. Plantations of bamboo have not been attempted so far in Burma except on an experimental scale. *D. longispathus, B. vulgaris, D. calostachyus, D. giganteus,* and *T. siamensis* are planted and used for domestic purposes by villagers. In the Philippines, villagers plant bamboos to cater to their individual requirements and local trade. The methods used are rhizome planting, marcotting, and offset

planting. Rhizome planting or planting culm cuttings is practiced by villagers in Indonesia. In fact, nearly 13 species are cultivated in Java and are frequently grown with horticultural crops. Cultivation and use of bamboos have been closely linked to the life of the rural community. More than 95% of the bamboo used in Indonesia comes from farmlands and homesteads. *B. arundinacea, G. atter, G. apus*, and *G. verticillata* are the most important ones. In Korea propagation of bamboos is carried out by villagers who mainly use rhizome cuttings. Trials are also in progress to propagate bamboos by seed and seedlings. Normally about 1000 rhizome cuttings of mother bamboos are planted per hectare and manured when necessary; they will form a dense stand in 5 years. In Thailand vegetative methods like rhizome planting or planting of stem cuttings are in vogue. One of the species largely cultivated is *D. asper* for its shoots and windbreaks. In Japan, the cultivation of bamboo by rhizome cuttings has been perfected. Also, intensive work has been done in various parts of China on cultivation and management of bamboo. Much work has been done on *Phyllostachys pubescens.*

Economics of Bamboo Plantations

Bamboo plantations raised artificially solely for pulp and paper would not be profitable, as the mills generally pay a royalty far lower than the cost of raising the plantation. But bamboos raised to meet the needs of rural peoples pay good dividends as long as they are sold by the number of culms. In other words, where large-scale plantations are raised for the pulp industry, a certain proportion of culms should be earmarked for sale to the public. Only then would the proposition be profitable. Bamboos can also be grown with species like *Eucalyptus citriodora*, the yield being both pulpwood and foliage for distillation and production of oil. One plant can be allowed to grow, and the rest pollarded and the leaves distilled for the oil. The oil is now valued at about U.S. $10–11/kg, and a hectare could yield 2–4 kg of oil. The working expenses would not exceed U.S. $2. The distillation could be continued until the bamboos are ready for harvest; thus the cost of bamboos could be recovered.

Care, Management, and Disposal

Bamboo areas should be rigidly protected from fire and grazing animals. About 3–4 weedings around planted seedlings, hoeing around plants, earthing up, and mulching are done during the first 2 years. In areas of low rainfall, bamboos are planted in sunken pits specially designed for moisture conservation in India. The use of fertilizers in artificial regeneration of bamboo — about 56 g of NPK in two split doses — would boost growth. In the case of larger seedlings, the dosage of fertilizer could be more. Intensive treatment is meted out for *Phyllostachys edulis* in Japan, Korea, and Taiwan where bamboo is grown for shoots. Irrigation speeds up the growth of seedlings.

Bamboo forests in India, Bangladesh, and Burma are generally managed according to a "culm-selection method." The dead, dying, and oldest culms are thinned out, care being taken so that one or two mature culms are retained adjacent to the new culms to give stability. A bamboo clump has to be intensively worked if new shoots are to be obtained and to be distributed in the clump properly. Congested clumps, which pose many problems, result from damage by grazing animals, insects, fire, and improper management. To reorient congested clumps, labourers cut tunnels at right angles through the clump and the culms are clear-felled. The culms in the four segments are then thinned. Alternatively,

culms in a clump are clear-felled in the form of a horseshoe; those remaining are thinned. Complete clear-felling of culms or clumps is not advocated, as it results in switchy shoots and losses.

The bamboo areas are usually divided into sections, and felling is rotated so that a section is cut and is left for 2, 3, or 4 years, depending on the felling cycle. In some cases, the felling cycle is as high as 6–10 years in Burma. Most countries have proper felling rules that stipulate the number of old culms to be retained in the clump.

In the thorny varieties like *B. arundinacea* and *B. blumeana*, people tend to extract only the top portions of the culms because of the difficulty in clearing the interlacing thorny branches at the bottom. However, industries first clear the base of the clumps and then extract the culms on a culm-selection basis.

The management practices, especially the felling cycle of 3 years or more, were introduced when bamboo was considered for supply to industries. In countries like India and Bangladesh, where the demand for bamboo is heavy for uses other than traditional ones, e.g., basket weaving, the authorities may have to shorten the felling cycle to maintain quick and sustained supplies to the community. Intensive management would be needed as would experimental data.

In Indonesia, the management practice has been to restrict the removal of the most mature culms from the clumps only when the need arises, but, to date, the bamboos for supply to paper mills have been clear-felled and poorly managed — a fact that has adversely affected further development of clumps in Banyuwangi and South Sulawesi. In many cases the villagers cut the periphery of the clump — a procedure that stops the outward development of rhizomes and prompts new culms to appear in the interior of the clump and to create congestion in the clump and malformation. The management of bamboo in Thailand also has yet to be scientifically oriented. The present felling cycle is 1 year, but there is some move toward adoption of a 3-year felling cycle. No felling rules are enforced; most mature culms are cut and extracted. Other than the bamboos growing in the Reserved Forest, bamboos are not protected, and extraction is not supervised by any authority. Thus bamboo is extracted freely at present, and there are no records to indicate the actual quantity extracted. In Japan where bamboos are managed for culms, rules are strict; fellings are selective, carried out during autumn. The cutting cycle varies from 3 to 5 years for *P. reticulata* and 5–10 years for *P. edulis* when green culms show signs of deterioration.

The general experience in India is that the average yield per hectare from natural forests of bamboo varies from 2.5 to 4.0 tonnes/hectare. From artificially propagated forests one can expect about 6–7.5 tonnes/hectare if the crop is managed properly.

To harvest bamboos, people usually obtain permits, licences, or leases. The period may extend from a few days to years. Tribes and people living in forests are permitted to take their bamboo needs free from forests under government control. Disposal of bamboos by permits or short leases (1–2 years) is detrimental to the crop, because the purchaser has no interest in its improvement. The impact of poor control of harvesting is worst in countries where bamboos are in short supply due to gregarious flowering and seeding and subsequent death of the clumps. In India, states like Karnataka departmentally extract bamboos and distribute them to consumers through forest depots. Consumers are charged a royalty plus extraction and supervision charges. This practice has prevented indiscriminate exploitation of the bamboo.

Where bamboos are conceded on long leases, say 10–25 years, to an industry such as pulp and paper on a royalty basis, the maintenance of the bamboo areas is better because it is in the interest of the consumer. The West Coast Paper Mills in India have their own forestry department. They have fenced the leased bamboo areas, spaced out the natural regeneration of *D. strictus*, and reforested the gaps by artificial planting with the larger species of bamboo *Bambusa arundinacea*. They have also initiated raising of about 200 hectares of plantations of different species on a leased area. Other mills are also thinking of resorting to these practices. Fertilization with NPK, soil working, and moisture-conservation techniques are adopted to further the bamboo's growth. Bamboos are also leased to the paper industries in Bangladesh on a royalty basis. About 3.3 million tonnes (air-dried) bamboos are consumed for domestic purposes in Burma. There are at present only two paper mills in Burma, but one more has been proposed in Arakaan. In Henzada/Bassein areas a rayon mill is expected to be installed. With poor utilization, bamboo stands require better management. In forests other than reserves in Burma, bamboo harvesting for personal use is free of royalty to villagers, as bamboo is an essential commodity in rural communities. In the Philippines, though several bamboo species are considered suitable for paper, the paper mills are not using any bamboos due to scarcity. The disposal of bamboos by the forest department is done through permits of 10 pesos each (peso = U.S. $0.1380) and payment of one-tenth of the market value of the bamboos.

In Indonesia, people cut bamboos and transport them in carts or trucks to selling centres. The price of a culm varies from 150–300 rupiahs (rupiah = U.S. $ 0.0016) in rural areas to 500 rupiahs in urban areas. There appears to be a demand to the tune of at least 600 million pieces of bamboos or 3.3 million tonnes annually. Nearly 30% of the bamboos produced are consumed for housing and other needs like basket making; the rest finds its way to the cottage industries. The new shoots of many species of bamboos, notably *D. asper*, are consumed as food.

In Thailand, the disposal of bamboos to the public and to the paper mills in Kanchanaburi Province, the only area using bamboos for paper, is free of royalty. People are allowed to extract bamboos as and when needed from forests. The question of levying a royalty on bamboo is engaging the attention of the Royal Forest Department. Without such a royalty, there is danger of depletion of bamboo resources. It is all the more important in view of large-scale clearance of bamboos by people shifting cultivation in the hill areas.

In Korea, Japan, and Taiwan, bamboos are disposed of as and when they mature. In Japan, normally bamboo forests contain 6000–7000 culms per hectare, and each year about 1000 culms are harvested.

Bamboo Utilization

The bamboos are used for sprayers, ropes, tholepins, masts, sails, net floats, basket fish traps, awnings, food baskets, beds, blinds, bottles, bridges, brooms, food, lanterns, umbrella handles, fans, brushes, chains, chopsticks, combs, drogues, dustpans, paper, pens, nails, pillows, tobacco and hookah pipes, anchors, fishing nets, fishing rods, flagpoles, hats, ladles, lamps, musical instruments, mats, tubs, caulking materials, scoops, shoes, stools, tables, tallies, traps, joss sticks, back scratchers, walls, buildings, walking sticks, lance staves, thatching and roofing, loading vessels, trays, bows and arrows, water and milk vessels (*chungas*), hedges, furniture, agricultural implements, fodder, fuel, floats

for timber, trellises, flues, handicrafts, sledges, toys, pipes, cooking utensils, tool handles, polo mallets, stabilizers for haystacks, coffins, cart yokes, scaffolding, ladders, containers, stakes, tiles, seed drills, slats, ornamentals, cordage, wrappers, shuttles and afforestation.

In India, bamboos are used for a variety of purposes by people. Nearly 80 paper mills depend wholly or partly on bamboos, as they are the only long-fibred resource easily available in the country and extraction of conifers from the Himalayas is expensive. They are also used in rural and urban sectors, agricultural and horticultural pursuits, and control of soil erosion. Utilization practices, however, are wasteful; when the bamboo is extracted, only a small fraction of its biomass, i.e., the usable portion of the culm, is taken out, and the rest is allowed to go to waste in the forest. In contrast, in countries like Japan, even the twigs and branches are converted into brooms and exported. In Bangladesh, bamboos play a vital role in the rural economy; one wonders at the innumerable uses to which bamboos are put in this country. It is, therefore, imperative for the country to encourage the production of bamboos more in homesteads and the rural sector. In Burma, the industrial utilization of bamboos is 17% of the total production; the remainder is consumed locally for rural and urban needs. There are only two paper mills, using resources from the Pegu Yoma region. A proposal has been to establish another mill to utilize *Melocanna* and other bamboos and hardwoods to the Arakaan Division. Also, a rayon pulp plant is being considered in the Henzada/Bassein Forest Division.

In the Philippines nearly 80% of the bamboos are used for construction and for rural endeavours. There is great demand for bamboos in the cottage industry. The handicraft work has been developed with assistance from technicians from Japan. Bamboos are used in the banana industry for props as protection against wind damage. The people are aware of their personal needs and most raise bamboos. The total area under bamboo in the Philippines is reported to be 7924 hectares, which is 0.03% of the total land area. There is thus a case for increased cultivation to meet internal needs as well as to combat soil erosion. In Indonesia, bamboos are the lifeblood of the people. Some villages raise pure bamboo forests and use them for houses and for many other purposes. In Thailand the bamboos are extensively used in the rural sector, and fishing rods of *Thyrsostachys siamensis* are exported on a large scale. Also, there is a great future for export of bamboo shoots of *Dendrocalamus asper*.

Bamboo Shoots and Shoot Farms

The succulent shoots of bamboos are highly nutritious and palatable. In India, Bangladesh, and Burma, bamboo shoots are used for pickles and in curries only to a limited scale subject to availability. The removal of new bamboo shoots from reserved forest areas is discouraged as it would impede regeneration of bamboos. No forest areas have been earmarked for bamboo shoots. In Thailand, bamboo shoots are consumed in fresh, pickled, and dried forms. Most of the species growing in Thailand produce edible shoots, but the best ones are those of *Dendrocalamus asper, Thyrsostachys siamensis, D. giganteus, D. merrillianus,* and *Gigantochloa albociliata*. Leaves of *Tiliocosa racemosa* (*Menispermaceae*) are added during cooking. Shoots of *D. giganteus* can be eaten raw. Shoots of *D. asper* are exported. In the Philippines, edible bamboos are cultivated at Panabo, Davao del Norte.

In Taiwan, management of *Phyllostachys edulis* and *Dendrocalamus latiflorus* has reached a high degree of specialization, including processing, canning, and export. During 1977, Taiwan exported nearly U.S. $25 million

worth of bamboo shoots. About U.S. $40.8 million worth of bamboo products were exported, exports doubling in the past 4 years. In Japan, 8000 tonnes or more of bamboo shoots are consumed per year, and about the same weight is consumed in Taiwan, even though the population is only one-sixth that of Japan.

In the case of *Phyllostachys* managed for shoots in Japan, the crop is spaced out. The tops are pollarded at 30–40 feet (9–12 m) so that sunlight and warmth prevent snow damage. A temperature of at least 20 °C is needed for shoot production. Shoots are produced in April–May and November. The yield of edible shoots is about 10 tonnes per hectare, valued at about a million yen (yen = U.S. $0.00455), the expenditure being one-tenth to one-third the return, depending on how well the farmer has maintained the area and whether family members or hired hands do the work. The management of bamboo for soft, good-quality shoots involves yearly soil dressing, application of straw litter and farmyard manure.

In Korea, edible shoots are collected when they are about 4–7 cm. From an intensively managed area, it is possible to collect about 10 000 kg shoots per hectare. The average price of shoots is 280 won/kg (won = U.S. $0.001671). Harvesting is only once a year, April–mid-May. Vigorous shoots are retained for later use as mother bamboo. Research on the taste of the shoots is carried out.

Only four edible species of bamboos occur in Malaysia, but bamboo is used in delicate curios, boards, flooring tiles, etc. Such items are also manufactured in Japan and Taiwan and are exported. The treatment of *Phyllostachys edulis* with creosote in Taiwan and supply of treated bamboos for banana props for both internal and external consumption have helped the banana industry. Treated bamboos could also be used for building or cheap houses in rural areas. Short bamboo pieces (about 1 m) treated with creosote are used for oyster cultivation in Taiwan. In Thailand more than 1 million hectares of bamboo resources exist for pulp making, small-scale industries, handicrafts, and conservation of soil. The proper utilization of these resources would greatly benefit the masses. In India, Bangladesh, and Burma, where gregarious flowering of bamboos has occurred, the large quantities of seed were used as food by many people. The grain is powdered into flour and consumed alone or with wheat flour. The dead bamboo has been used by the paper industry.

Bamboo is commonly used in construction. Better-quality bamboos are used for house posts. Smaller and thinner ones are used for roof frames to support country tiles. Split and plaited bamboo sheets are used for walls, ceilings, and roofs. Small, round, pliable bamboos are used for fishing rods, frames for fishing nets, walking sticks, handles of tools, musical instruments, and larger varieties are used for watercraft, bullock carts, and containers. The containers are sometimes dyed, painted, and sold as curios in urban areas. Because it is lightweight, strong, and cheap, bamboo has proved to be useful in rural, urban, and industrial sectors of many countries (Table 1).

Rehabilitation of Bamboo-Seeded Areas

A scheme for rehabilitation of areas where bamboo had flowered gregariously between 1960 and 1965 (*B. arundinacea* and *D. strictus*) was implemented in India. The dead bamboo clumps were all clear-felled and supplied to paper and rayon industries. The areas were burned and were planted with teak stumps and eucalyptus. Sowings of *Eucalyptus citriodora* seed in the burned patches gave excellent results.

Table I. Consumption (%) of bamboos in the Asia-Pacific Region by end-use and a breakdown of the uses by species (country codes in the breakdown are India, In: Bangladesh, Ba; Burma, Bu; Philippines, Ph; Indonesia, Ind; Thailand, Th; Japan, Ja; Taiwan, Tai; Korea, Ko).

Country	Construction		Rural uses	Packaging	Pulp manufacture	Other uses
	Housing	Others				
Bangladesh	50	10	20	5	10	5
Burma	33	32	32	5	–	1
India	16	16	30	7	17	14
Japan	24	7	18	7	4	41
Philippines	80	–	15	2	–	3
Thailand	33	20	6	–	8	33

Walling of native huts
Bambusa tulda (Bu, Ba, Ind)
B. polymorpha (Bu)
B. blumeana (Ph)
B. atra (Ind)
Dendrocalamus asper (Ind)
Gigantochloa nigrociliata (Ind)
Melocanna baccifera (Ba)
Neohouzeoua dulloa (Bu, Ba)
Sinobambusa elegans (In)
Schizostachyum lumampao (Ph)
Thyrsostachys siamensis (Ph)
T. oliveri (Th)

Lance staves
Bambusa blumeana (Ph)
Dendrocalamus strictus (In, Bu)
Ochlandra travancorica (In)
O. scriptorica (In)
Schizostachyum lima (Ind)
Thyrsostachys siamensis (Th)
T. oliveri (Th)

Thatching and roofing
Bambusa arundinacea (In, Ba, Bu, Ind)
B. tulda (In, Ba, Bu)
B. vulgaris (Ind)
B. blumeana (Ph)
B. polymorpha (In, Bu, Ba)
Dendrocalamus strictus (In, Ind)
D. longispathus (Ba, Bu)
D. membranaceus
D. brandisi
D. hamiltonii
Gigantochloa atter (Ind)
Chimonobambusa falcata (In)
Melocanna baccifera (Ba, Bu)
Neohouzeoua dulloa (Ba, Bu)
Oxytenanthera monodelpha (In)
Schizostachyum brachycladum (Ind)

Tea estates
Pseudostachyum polymorphum (In)

Constructions
Bambusa polymorpha (In, Ba, Bu, Ind, Th)
B. balcoa (In)
B. tulda (In, Ba, Bu, Ind)
B. arundinacea (In, Ba, Ind, Th)
B. nutans (In, Bu, Th)
B. khasiana (In)
B. vulgaris (In, Ba, Ph, Ind)
B. burmanica (Ba)
B. pallida (Bu)
B. blumeana (Ph, In)
B. atra (Ind)
Cephalostachyum pergracile (In, Ba, Bu)
Dendrocalamus membranaceus (In, Ba, Bu)
D. hamiltonii (In, Ba, Th, Bu)
D. giganteus (In, Ba, Ind, Bu)
D. longispathus (In, Ba, Th)
D. strictus (In, Bu)
D. calostachyus (Bu)
D. merrillianus (Ph)
D. asper (Ind)
Gigantochloa nigrociliata (In, Ind)
G. verticillata (Bu, Ind)
G. levis (Ph)
Melocanna baccifera (In, Ba, Bu)
Neohouzeoua dulloa (In, Bu)
Oxytenanthera nigrociliata (Ba, Bu)
Schizostachyum lumampao (Ph)
S. brachycladum (Ind)
S. lima (Ind)
Teinostachyum beddomei (In)
Thyrsostachys oliveri
Phyllostachys sp. (Ja, Tai, Ko)

Walking sticks
Arundinaria armata (In)
Dendrocalamus strictus (In, Bu)
Oxytenanthera nigrociliata (Ba, Bu)
Phyllostachys manni

(continued)

(Table 1 continued)

Basket making
Arundinaria intermedia (In)
Bambusa nutans (In, Bu)
B. pallida (In, Th)
B. khasiana (In)
B. arundinacea (In, Bu, Ind, Th)
B. tulda (Ba, Bu, Ind, Th)
B. vulgaris (Ba, Bu, Ph, Ind)
B. villulosa (Bu)
B. flexuosa (Th)
B. polymorpha (Ba, Ind, Th)
B. blumeana (Ph, Ind)
Chimonobambusa falcata (In)
Cephalostachyum pergracile (Ba, Bu)
Dendrocalamus hamiltonii (In, Bu)
D. longispathus (In, Ba, Bu, Th)
D. strictus (In, Bu)
D. giganteus (In, Ba, Ind)
D. merrillianus (Ph)
D. asper (Ind, Th)
Dinochloa compactiflorus (Bu)
Gigantochloa nigrociliata (In, Bu)
G. macrostachya (Bu)
Indocalamus wightiana (In)
Melocanna baccifera (Ba, Bu)
Neohouzeoua helferi (In)
N. dulloa (Bu)
Oxytenanthera ritcheyi (In)
O. nigrociliata (Ba, Bu)
O. monostigma (Bu)
Pseudostachyum polymorphum (Bu)
Schizostachyum diffusum (Ph)
S. lumampao (Ph)
Thamnocalamus spathiflora (In)
Teinostachyum helferi (Bu)
T. griffithii (Bu)
Phyllostachys sp. (Ja, Ko, Tai)

Loading vessels
Neohouzeoua dulloa (In)
Teinostachyum dulloa

Bows and arrows
Bambusa flexuosa (Th)
B. arundinacea (In)
Cephalostachyum capittatum (In)
C. pergracile
Dendrocalamus strictus (In)
Schizostachyum rogersii (Bu)
S. lima (Ind)

Cooking utensils
Bambusa arundinacea (Ind, Ba, Bu, Th)
B. blumeana (Ph)
Cephalostachyum pergracile (In, Ba, Bu, Th)
Gigantochloa atter (Ind)
Neohouzeoua dulloa
Schizostachyum zollingeri

Mats
Arundinaria intermedia (In)
Bambusa nutans (In, Bu)
B. teres (In, Bu)
B. tulda (In, Ba, Bu, Ind, Th)
B. pallida (In, Ba, Th)
B. arundinacea (In, Ba, Bu, Ind, Th)
B. blumeana (Ph, In)
Cephalostachyum pergracile (In, Ba, Bu)
Dendrocalamus strictus (In)
D. hamiltonii (In, Ba, Bu, Th)
D. merrillianus (Ph)
D. membranaceus (Th)
D. brandisi (Th)
Dinochloa distans (Bu)
Gigantochloa levis (Ph)
G. atter (Ind)
G. macrostachya (Bu)
G. apus (Ind)
Indocalamus wightiana (In)
Melocanna baccifera (Ba)
Pseudostachyum polymorphum (Bu)
Schizostachyum lumampao (Ph)
Teinostachyum dulloa (In, Bu)
Thyrsostachys siamensis (Th)

Water and milk vessels (*Chunga*); water buckets; cups; containers
Bambusa pallida (In, Ba)
B. tulda (Ba, Bu)
B. blumeana (Ph)
Dendrocalamus sikkimensis (In)
D. giganteus (In, Ba, Bu, Ind, Th)
D. hookeri (In, Bu)
D. brandisi (Bu)
D. asper (Ind)
D. hamiltonii (Th)
Gigantochloa levis (Ph)
G. asper (Ph)
Melocanna baccifera (Ba, Bu)

Hedges
Bambusa nana (In, Ba, Bu, Th)
B. vulgaris (Ba, Ind)
B. balcoa (Ba, Ind)
B. arundinacea (Bu)
Cephalostachyum pergracile (Bu)
Cephalostachyum burmanicum (Bu)
Dendrocalamus giganteus (In, Ba, Bu, Ind, Th)
Gigantochloa atter (Ind)
G. nigrociliata (Ind)
Oxytenanthera nigrociliata (Ba)
Thyrsostachys siamensis

Fuel
All bamboos and rhizomes of bamboos (In, Ba, Bu, Ind)

(continued)

(Table 1 continued)

Seed food
Bambusa arundinacea (In, Ba, Bu)
Cephalostachyum pergracile (In, Ba, Bu)
Dendrocalamus strictus (In)
Dinochloa compactiflora (Bu)
Melocanna baccifera (Ba, Bu)
Thyrsostachys oliveri (Ba, Bu)

Furniture
Bambusa tulda (Ba, Bu)
B. glaucescens (Ind)
B. vulgaris (Ind)
B. arundinacea (Th)
Dendrocalamus strictus (In, Ba, Bu)
D. membranaceus (Th)
D. brandisi (Th)
D. latiflorus
D. longispathus (Th)
D. asper (Th)
Gigantochloa atter (Ind)
G. apus (Ind)
Melocanna baccifera (Ba, Bu)
Schizostachyum diffusum (Ph)
Thyrosostachys siamensis (Ind, Th)
All thick-walled species (Ph, Ind)
Phyllostachys sp. (Ja, Ko, Tai)

Agricultural implements
Bambusa vulgaris (Ba, Bu, Ind, Ph)
B. balcoa (Ba, Bu, Ind)
B. blumeana (Ph, Th)
B. flexuosa (Th)
Dendrocalamus strictus (In, Bu, Th)
D. merrillianus (Ph)
D. asper (Th)
Ochlandra travancorica (In)
Thyrsostachys siamensis (Th)
T. oliveri (Th)
All thinner varieties (In, Ba, Bu)

Fodder
Arundinaria racemosa (In)
Chimonobambusa densifolia (In)
Cephalostachyum pergracile (In)
Dendrocalamus strictus (In)
D. sikkimensis (In)
Leaves of all bamboos (Ba, Bu, Ind)

Floats for timber; rafts
Bambusa arundinacea (In, Bu, Th)
B. blumeana (Ph, Ind)
Dendrocalamus hamiltonii (In, Bu)
D. longispathus (Ba)
D. distans
D. asper (Ind)
D. membranaceus (Th)
Ochlandra seriptoria (In)
Melocanna baccifera (Ba, Bu)
M. compactiflorus (Th)
Neohouzeoua dulloa (Ba)

Tool handles
Bambusa blumeana (Ph, Th)
B. flexuosa (Th)
B. polymorpha (Ba, Bu, Ind)
Dendrocalamus asper
D. strictus (In, Th)
D. merrillianus (Ph)
Ochlandra travancorica (In)
Teinostachyum griffithii (Ba, Bu)
Thyrsostachys siamensis (Th)
Solid varieties (Ind)

Fencing
Indocalamus wightianus (In, Ba, Bu, Ind, Ph, Th)
All bamboos (In, Ph, Ba, Bu, Ind, Th, Ja, Ko, Tai)

Hookah pipes
Chimonobambusa falcata (In)
Phyllostachys sedan (Bu)
Thamnocalamus spathiflora (In)
T. aristatus
Teinostachyum griffithii

Fishing rods
Arundinaria amabilis (In)
Bambusa glaucescens (Ind)
B. atra (Ind)
Chimonobambusa falcata (In)
C. khasiana (In)
C. intermedia (In)
Dendrocalamus strictus (In)
Schizostachyum zollingeri (Ind)
S. blumei (Ind)
S. lima (Ph)
Thyrsostachys siamensis (Th, Ind)
T. oliveri (Th)
Phyllostachys nigra (Ja)

Shoots for food
Bambusa tulda (In, Ba, Bu, Ph, Ind)
B. arundinacea (In, Ba, Bu, Ind)
B. nana (Bu)
B. vulgaris (Bu, Ph, Ind)
B. blumeana (Ph)
B. glaucescens (Ind)
Dendrocalamus hamiltonii (Ba, Bu)
D. latiflorus (Tai)
D. giganteus (In, Ind)
D. longispathus (Ba)
D. flagellifer (Bu)
D. merrillianus (Ph)
D. asper (Ind, Th)
Dinochloa scandens (Ind)
Gigantochloa nigrociliata (Ind)
G. hasskarliana (Ind)
G. verticillata (Bu, Ind)
G. levis (Ph) *(continued)*

(Table 1 continued)

G. atter (Ind)
G. albociliata (Th)
Phyllostachys edulis (Ta, Ja, Ko)
Schizostachyum brachycladum (Ind)
S. blumei (Ind)
S. zollingeri (Ind)
Sinobambusa elegans (In)
Thyrsostachys siamensis (Th)
All large bamboos — shoots (Th)

General utility
Bambusa arundinacea (In, Ba, Bu)
B. tulda (Bu)
B. pallida (Bu)
B. blumeana (Ph)
B. vulgaris (Ph)
Cephalostachyum pergracile
C. burmanicum
Dendrocalamus strictus (In, Bu)
D. hookeri (In, Bu)
D. hamiltonii (Ba)
D. calostachyus (Bu)
D. merrillianus (Ph)
Dinochloa sp. (Ph)
Gigantochloa levis (Ph)
G. asper (Ph)
Neohouzeoua dulloa
All strong bamboos (Ind, Th, Ja, Ko, Tai)

Punting poles
Oxytenanthera stocksii (In)
Solid varieties (Ba, Bu)
Phyllostachys nigra (Ja)

Sericultural industry — trays for silkworms
Bambusa arundinacea (In)
Dendrocalamus strictus (In)
Thyrsostachys siamensis (Th)
All bamboos (Ba, Ind)

Chicks for doors and windows
Bambusa arundinacea (In, Bu, Ind, Th)
B. polymorpha (Ba, Bu)
B. blumeana (Ph, Ind)
B. vulgaris (Ind)
Dendrocalamus strictus (In)
D. longispathus (Th)
D. membranaceus (Th)
Melocanna bambusoides
Neohouzeoua dulloa (Ba, Bu)
Schizostachyum lumampao (Ph)
S. zollingeri (Ind)
Thyrsostachys siamensis (Th)
T. oliveri (Th)
All bamboos (Ja, Ko, Tai)

Pipes
Bambusa arundinacea (Bu)
Neohouzeoua dulloa (Bu)
Teinostachyum griffithii (In, Ba)

Haystack stabilizers
Bambusa vulgaris (Ba, Bu)
B. tulda (Ba, Bu)
B. blumeana (Ph)
Dendrocalamus strictus (In)
All bamboos can be used (Ind)

Horticultural pursuits
Bambusa arundinacea (In, Bu)
B. polymorpha (Ba)
B. blumeana (Ph)
Dendrocalamus strictus (In)
Melocanna baccifera (Ba, Bu)
All bamboos (Ind, Th)
Other strong species (Ph)

Cremation; coffins
Bambusa arundinacea (In)
Dendrocalamus strictus (In)
All bamboos

Cradles
Bambusa arundinacea (In)
Dendrocalamus strictus (In)

Scaffolding
Bambusa arundinacea (In)
Dendrocalamus strictus (In)

Cart yokes
All large-sized, hard and solid bamboos (In)

Ladders
Bambusa arundinacea (In)
Dendrocalamus strictus (In)

Musical instruments (flutes; marimba; horns; clarinets; flageolets; saxophones; piccolos; drums; etc.)
Arundinaria sp.
Arundinaria mitskayamensis (Ph)
Dendrocalamus strictus (In, Th)
D. longispathus (Th)
Gigantochloa atter (Ind)
Schizostachyum lima (Ind)
S. blumei (Ind)
All small-sized bamboos (Ph)

Containers for cleaning grains
All bamboos (In)

Protection during grain pounding
Bambusa arundinacea
All large-sized bamboos (In)

Cart sheds; roofs
Bambusa blumeana (Ph)
Dendrocalamus merrillianus (Ph)
All bamboos (In)

Stakes for foresters
Thyrsostachys siamensis (Th)
T. oliveri (Th)
All bamboos (In)

(continued)

(Table 1 continued)

Country tiles
Bambusa arundinacea (In)
Pan trays
Neohouzeoua dulloa (In)
Teinostachyum dulloa (Bu)
Seed drills
Dendrocalamus strictus
Containers to administer medicine to animals
Bambusa arundinacea (In)
Fishing implements; floats; pens; traps
Bambusa polymorpha (Ba, Bu, Ind)
B. atra (Ind)
B. vulgaris (Ba, Bu)
B. blumeana (Ph)
Gigantochloa levis (Ph)
Melocanna baccifera (Ba, Bu)
Neohouzeoua dulloa (Ba, Bu)
Schizostachyum blumeana (Ind)
S. lumampao (Ph)
Boat roofs
Bambusa arundinacea (In)
B. tulda (Ba, Bu)
B. blumeana (Ph)
Melocanna baccifera (Ba, Bu)
Ornaments
Bambusa vulgaris (Ind, Ba, Bu, In, Ph)
B. nana (Ph)
B. vulgaris var. *striata* (Ph)
B. glaucescens (Ph)
B. polymorpha (Ind)
B. atra (Ind)
Cephalostachyum pergracile (In)
Dendrocalamus giganteus
Phyllostachys aurea (Ind)
Schizostachyum brachycladum (Ind)
S. zollingeri (Ind)
Thyrsostachys siamensis
Culm sheaths (irrigation)
Bambusa blumeana (Ph)
Climbing species of bamboos (Ph)
Dendrocalamus longispathus (Bu)
Gigantochloa macrostachya (Bu)
G. levis (Ph)
Cordage
Bambusa vulgaris (Ph)
B. atra (Ind)
Dendrocalamus strictus (Bu)
D. merrillianus (Ph)
Dinochloa scandens (Ind)
Pseudostachyum polymorphum (Bu)
Inner layer of culm sheath as cheroot wrapper
Dendrocalamus hamiltonii (Bu)
Plaited shoes
Dinochloa compactiflora (Bu)
Boat masts
Bambusa blumeana (Ph)
Dendrocalamus brandisi
Gigantochloa levis (Ph)
Joints for cooking glutinous rice
Cephalostachyum pergracile (Bu)
C. burmanicum (Bu)
Bridges
Bambusa blumeana (Ph)
B. vulgaris (Ph)
B. arundinacea (Ph)
Boat plying rods
Bambusa polymorpha (Ba, Bu, Ind)
B. glaucescens (Ind)
Melocanna baccifera (Ba, Bu)
Rickshaw hoods
Bambusa vulgaris (Ba)
Pea sticks
Thamnocalamus spathiflora (In)
Barbecue skewers
Bambusa blumeana
Trellises
Bambusa arundinacea (In)
B. blumeana (In)
All large-sized bamboos
Flues
Bambusa blumeana (Ph)
B. glaucescens (Ph)
Schizostachyum lumampao (Ph)
Hats
Bambusa blumeana (Ph)
B. vulgaris (Ph)
Barrels for toy cannons
Bambusa blumeana (Ph)
Gigantochloa levis (Ph)
Sledges (transport)
Bambusa blumeana (Ph)
Dendrocalamus merrillianus (Ph)
Handicrafts
Bambusa blumeana (Ph, Ind)
B. vulgaris
Dendrocalamus asper (Ind)
Dinochloa scandens (Ind)
Gigantochloa verticillata
G. atter
G. apus
Nastus elegantissimus
Schizostachyum lima (Ph)
S. brachycladum
S. blumei (Ind)
All bamboos (Th)
Sprayers
Bambusa blumeana (Ph)
Polo mallets
Bambusa blumeana (Ph) *(continued)*

(Table 1 concluded)

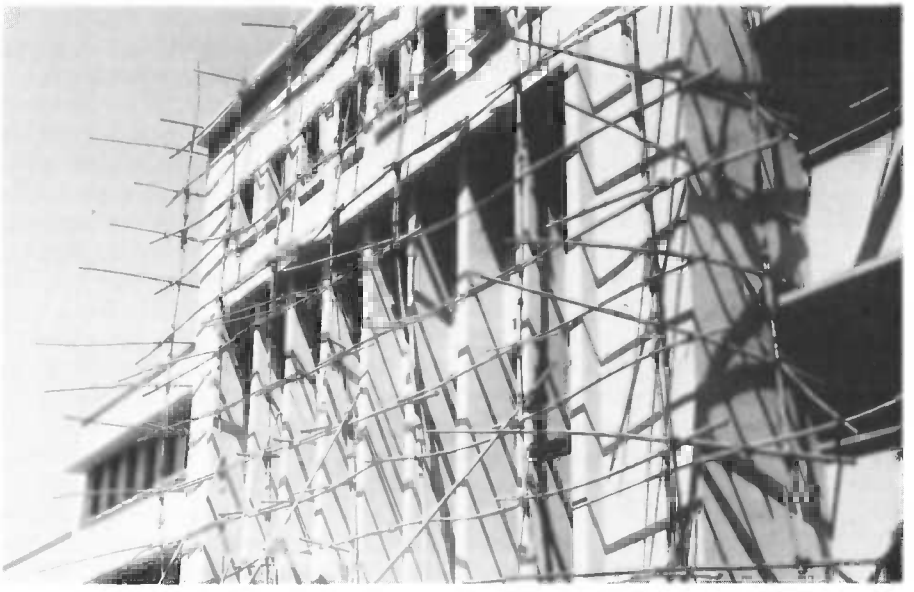
Umbrella handles
Melocanna baccifera (Ba, Bu)
Oxytenanthera stocksii (Ind)
Teinostachyum griffithii (Ba, Bu)
Thyrsostachys siamensis (Bu)
Shuttles
Bambusa blumeana (Ph)
Piculan
Bambusa glaucescens (Ind)
Tobacco drying
Dinochloa scandens (Ind)
Nastus elegantissimus (Ind)
Phyllostachys edulis (Jap)

Eyeliner
Dinochloa scandens(Ind)
Jaundice treatment
Bambusa vulgaris (Ind)
Ladders
Bambusa arundinacea (Ind)
Dendrocalamus strictus (Ind)
Afforestation of riverbanks and soil conservation areas; shelter belts; windbreaks
All bamboos

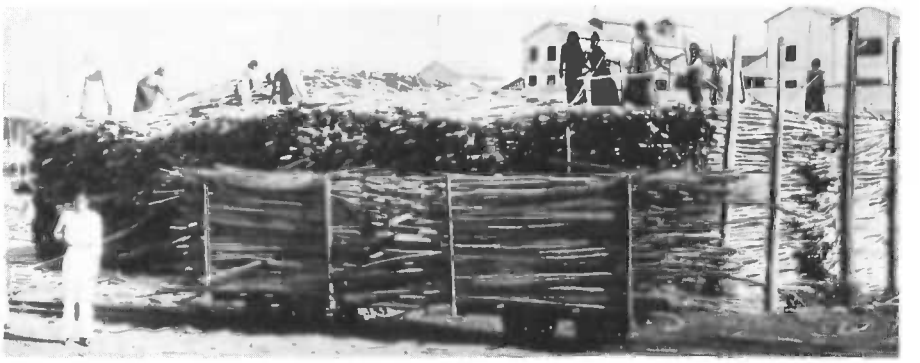
Research: Past, Present, and Future

There is great scope for research on bamboos in all the countries of the region. During the Eighth World Forestry Congress (held in Jakarta), the question of how to coordinate research on bamboo was discussed. Today, meaningful coordination of research activities on bamboos in the region and exchange of information among researchers are still needed.

In the past, research in India concentrated on *Dendrocalamus strictus*, and not much was done on other species. The same was the case in Burma. Bamboo research had not received the necessary importance in any other countries except Japan and perhaps China. In fact, it has gained importance only during the last 5–6 years. Now research is in progress on methods of seed storage, identification of bamboos by the characters of the culm sheaths on the new shoots and rhizomes. India had a symposium on bamboos in 1963 and another in 1980 in South India, and there is extensive literature available, although it needs to be collected and published. This task can only be done by a specialized agency



Bamboo scaffolding in India.



Bamboo for paper in India.

financed by an international body because it means extensive travel all over the countries and collection of information.

India now plans to establish three major centres of research and development of bamboos. The station in the North will oversee study of *Dendrocalamus strictus* and *Bambusa arundinacea*. The station in the East will take care of *Melocanna baccifera*, and the station in the South will take care of *Bambusa arundinacea, Dendrocalamus strictus*, and *Ochlandra* species. Imaginative research involving distant crosses like the bamboo–sugarcane cross, attempted decades ago at Coimbatore, is being considered. If this endeavour were successful in selection of quick-growing bamboo varieties, bamboo farming could be taken up on a large scale.

In a recent Southern Forest Research Worker's Conference held at Dharwar, India, during March 1980, the need for research centres on bamboos in each state was stressed. The lines of research suggested were

- Raising bamboo orchards as germ-plasm banks;
- Breeding better varieties;
- Propagating bamboos with tissue culture;
- Undertaking trials on fertilization and irrigation;
- Stepping up propaganda encouraging bamboo cultivation;
- Investigating effective measures for storage and distribution of seeds;
- Initiating experiments on natural regeneration;
- Experimenting with bamboo shoot farms; and
- Researching preservative treatments of bamboos and their use in rural housing.

These suggestions apply to many other countries of the region as well. In view of the large number of species of bamboos in the tropics, intensive research is needed on the ecologic and phenologic aspects of the bamboos.

Experiments on vegetative propagation techniques are in progress at the Forest Research Institute, Chittagong, Bangladesh; if easy methods of vegetative propagation could be devised, the bamboo industry could be revolutionized. Bangladesh has raised a large bamboo orchard of several species near Dacca as a source for germ plasm, and other useful work is being carried out at the Forest Research Institute in Chittagong.

In the Forest Research Institute, College, Laguna, Philippines, considerable work is in progress. One of the important experiments is creating deformity in bamboos for their use in housing. Bamboos (*Bambusa vulgaris*) have been made to grow into square, rectangular, and triangular shapes for low-cost housing, handicrafts, decorative items, and cottages. The project is financed

by UNDP (United Nations Development Programme). These artificially shaped bamboos are expected to be stronger than the round bamboo.

Japan has successfully grown artificially shaped bamboos. Production is simple, like moulding hollow blocks, but needs practice. A wooden frame (mould) is made in the desired shape, and it is installed on the young bamboo shoot. After about 6 months the frame (mould) is removed from the bamboo, which has taken on the desired shape. The culm is cut when it matures. The wooden frame can be used again. In Japan and Taiwan if ornamental bamboo culms are needed, a mixture of sulfuric, nitric, and hydrochloric acids with water and clay is prepared and painted over the green culm with a brush; this process produces ornamental patches on the culm. Other ongoing research on bamboo in the Philippines deals with anatomy, preservation, and harvesting methods.

As a complement to identification of species of bamboos based on the culm sheath and its characteristics, experiments should be initiated to find out whether the internodal length and diameter of the culm at a particular internode — for example, the third from the base — are constant for the species. Such a characteristic would form a useful rule of thumb for identification.

In view of the acute demand for bamboos, the possibility of harvesting bamboos annually has to be investigated and in fact is being looked into by the University of Agricultural Sciences, Dharwar, India.

Research on the single-stemmed and nonclump-forming species suited as windbreaks has to be initiated in the different countries. Also research on seasoning and treatment of bamboos with easily procurable and cheap methods needs to be initiated in all countries so that bamboo, a cheap material for construction, can replace timber.

Research on induced flowering and on the methods of establishing bamboo plantations, their management techniques, economic evaluation, and chemical treatment is needed.

Research of interest is being carried out in the herbarium attached to the Royal Forest Department and in the Kanchanaburi Research Centre in Thailand. The Royal Forest Department of Thailand has established five regional research centres on bamboo in the different climatic zones of the country, but the research programs are faced with a shortage of funds. Thailand is centrally situated among the countries of the Asia-Pacific Region from Pakistan to Indonesia, and the Kanchanaburi Research Centre should be converted into an international research centre on bamboos. Regional research centres should be established in the other countries of the region. Financial support should come from international organizations, participating countries, and banking institutions.

What Is to Be Done?

For bamboo to play a greater role in the development of the region, I feel that specific action other than initiation of research is warranted. For example, an aggressive social forestry practice is needed in countries like India where the dry zone is vast with few or no forests of economic value. Bamboo is one of the species for social forestry; it also can be extensively used in urban areas in parks for ornamental purposes, landslide areas, and along drainage channels.

In areas where shifting cultivation and soil erosion are problems (India, Bangladesh, Thailand) or where soil stabilization is of immediate necessity (Bangladesh), bamboo belts should be grown along contours, other crops being grown in the space between the belts. Bangladesh has an agreement with the

Swedish International Development Authority to raise about 32 000 hectares of forest plantations in this region; bamboo should be one of the species raised.

In Indonesia there is considerable scope for raising bamboos under various social forestry practices; financial support could be provided through forest cooperatives and also through Perum Perutani (forest corporation). The Perum Perutani and the reforestation wing of the Forestry Department should be able to tackle large-scale planting of bamboo to restock cleared areas. Bamboos can be grown alone or mixed with other species like tea and *Albizzia falcatoria*. In Thailand, also, there is great scope for bamboo propagation, especially *Dendrocalamus asper* and *Bambusa blumeana*, the latter being already grown as windbreaks around farms.

A field where there is great scope to increase the potentialities of bamboo is the underplanting of teak plantations after the first or second thinnings. Teak and bamboo form a natural mixture, the bamboo acting as an understory. This practice should be possible in India, Bangladesh, Burma, Thailand, and Indonesia.

A survey of bamboo wealth is urgently needed in all the countries of the Asia-Pacific Region. Forest departments throughout the region have so far relegated bamboo to a secondary position to teak, softwoods, and industrial woods. Bamboos, which are essential to the economy, should be given equal status with the best of timbers.

In the context of the economy in India, bamboo should be one of the species to be given priority in afforestation plans now being drawn up.

The possibilities of establishing bamboo shoot farms in different countries should be explored.

In almost all states in India and in Indonesia, forest corporations have been established to grow fast-growing and other timber species. These corporations should take up large-scale and intensive production of bamboo, adopting techniques suitable to the locale in either pure or mixed stands. In India, Bangladesh, Burma, Indonesia, and Thailand, bamboos are being cleared for afforestation with teak and other woods. Wherever forests with bamboo are taken up for clear-felling, some natural bamboo clumps should be retained.

Bamboos in government forests should not be given free to anyone except in emergencies, such as for rehabilitation of fire or flood victims. All bamboos in areas other than private lands should be extracted by a government agency, i.e., the department of forests or forest corporations, and sold to the public or industry. Additional staff should be employed for this task. Clump-forming bamboos should be worked on a "culm-selection" basis in a felling cycle of, say 2–4 years, and clumps should not be clear-felled. The working of the clumps should be on a thinning cycle.

Gregarious flowering is a rare phenomenon. In countries where bamboos have not seeded or where seed is scanty, bamboo seeds from other countries should be obtained, and large nurseries should be raised.

In view of the excellent scope that bamboos offer for many articles, artisan training centres should be established in each country where there are large varieties of bamboos. Training expertise could be obtained from Japan, China, and other countries. This would increase employment and would even earn foreign exchange.

Participants of workshops such as this one should take note of the vital role played by bamboos in the rural and urban life of the people of the different countries of the Asia-Pacific Region, recognize bamboos on an equal footing with other timber species, implement projects to develop this natural asset, and

initiate more experiments in various aspects of bamboo development. It may not be out of place here to suggest that an international study team connected with bamboo be constituted with necessary funding to undertake the preparation of a document of all aspects of bamboos occurring in countries other than those of the Asia-Pacific Region like tropical Africa, South America, and other like countries to make the story complete. It would also be worthwhile to establish a high-level monitoring team to visit at frequent intervals the different countries, review the research on bamboo, and report to the International Union of Forestry Research Organizations for purposes of coordination.