Industrialization of the Bamboo sector

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1.1 Bamboo – Its Characteristics and Uses

The many characteristics of bamboo make it an enduring, versatile and highly renewable resource. Bamboo has more than 1,500 documented uses, ranging from fuelwood to light bulbs, medicine, poison and toys to aircraft manufacturing. Over 1,000 million people live in houses made of bamboo or with bamboo as the key structural, cladding or roofing element.

- Its biological characteristics make it a perfect tool for reducing carbon dioxide levels in the atmosphere. It generates more oxygen than equivalent strands of trees, lowers light intensity, protects against ultraviolet rays and is an atmospheric and soil purifier.

- Bamboo is an enduring and versatile natural resource. The great diversity of species makes bamboo adaptable to many environments.[2] It tolerates extreme precipitation from 30 to 250 inches of annual rainfall. A dense bamboo cover also offers stakes to trees, fodder to animals and food to humans.

- Bamboo grows very fast and has a short growth cycle. Bamboo not only grows much faster than wood, it also needs relatively little water. It is the fastest growing canopy, growing three times faster than most eucalyptus species. Commercially important species usually mature in four to five years (versus 10 to 25 years for most soft woods). Annual harvests are subsequently possible.

- Bamboo prevents soil erosion. Its anti-erosion properties create an effective watershed, stitching the soil together along fragile river banks, deforested areas, and in places prone to earthquakes and mud slides. The sum of stem flow rate and canopy intercept of bamboo is 25% which means that bamboo greatly reduces rain run-off, preventing massive soil

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[2] It provided the first re-greening in Hiroshima after the atomic bomb blasts in 1945.

erosion. Thus, bamboos help control landslides, keep flooded rivers along their natural course and slow the speed of the water flow.

- Bamboo is foremost in biomass production, with up to 40 tonnes per hectare per year in terms of culms only in managed stands. An estimated one-quarter of the biomass in tropical regions and one-fifth in subtropical regions comes from bamboo.

- Bamboo has been used in ancient medicine. Bamboo has for centuries been used in Ayurveda (for example, *Chawanprash*) and Chinese acupuncture. The powdered hardened secretion from bamboo is used internally to treat asthma, coughs and can be used an aphrodisiac. In China, ingredients from the root of the black bamboo help treat kidney disease.

- Bamboo is one of the world's best natural engineering materials. Due to its high tensile strength, it is an essential structural material in earthquake architecture and is one of the strongest building materials. Its strength-to-weight ratio is better than that of teak wood and mild steel. Bamboo's tensile strength is 28,000 lb per square inch versus 23,000 for mild steel. This makes bamboo wood a potential alternative, at least in some applications, to steel which requires more energy for manufacturing/production. Its strength and flexibility make it a viable material for building shelters that offer protection against hurricanes and earthquakes.[3] In Bangladesh, 73% of the population lives in bamboo houses. Bamboo based pre-fabricated houses also can be constructed quickly with new and emerging techniques and is thus an important post-disaster relief material. It is extensively being used in Tsunami rehabilitation in India. Bamboo reinforcement in concrete piles is used by the Indian Railways.

- As a food source, bamboo shoots have provided nutrition for million of people worldwide. In Japan, the antioxidant properties of pulverized bamboo bark prevents bacterial growth and it is used a natural food preservative. Taiwan alone consumes 80,000 tons of bamboo shoots annually constituting a $50 million industry.

[3] In Limon, Costa Rica, only the bamboo houses from the National Bamboo Project stood after their violent earthquake in 1992.

- Bamboo is a viable replacement for wood. Its qualities of strength, light weight and flexibility make it a viable alternative to tropical timber that is used in the furniture and building materials industries.

- It is a critical element of the economy. Bamboo and its related industries provide income, food and housing to over 2.2 billion people worldwide. There is a 3-5 year return on investment for a new bamboo plantation.

- Bamboo is a renewable resource for agro-forestry products. Bamboo is a high-yield renewable natural resource. Ply bamboo is now being used for wall panelling, floor tiles, for paper making, briquettes for fuel, raw material for housing construction, and rebar for reinforced concrete beams. It can be used to produce many items of daily use that are currently made out of plastic or other less eco-friendly materials.

- Bamboo is being used as an input or raw material in certain industries. It has been primarily been used in the paper industry in bulk quantities as a raw material for paper pulp. Bamboo is also used in manufacturing wood substitutes, composites, utility products including Venetian *Agarbatti* (incense sticks).

- Bamboo is also a source of energy. Gasifiers can produce electricity using bamboo as fuel. These can also be used for thermal applications replacing furnace and diesel oil. Charcoal and its processed form in powder and briquettes can also be manufactured. It is superior to other sources of charcoal in terms of calorific value. Bamboo charcoal can also be used as a raw material for activated carbon manufacturing which is used as adsorbent in different industries like vegetable oil, beverage, pharmaceuticals etc. Goldsmiths prefer bamboo charcoal in making jewels.

In sum, bamboo's excellent growth, environmental, mechanical and engineering properties make it a fine alternative to tropical timber. Its potential for different value added products and application make it an extremely important material for dispersed employment generation and economic activities. Perhaps these properties and potential usage coupled with increased urgency of environmental issues ought have been sufficient to change the attitude towards bamboo, and solved the problems of tropical deforestation. However it is not so. Bamboo is still dubbed the "poor man's timber", representing a social stigma.

1.2 Bamboo based Products – An Appraisal

Literature regarding the multiple uses of bamboo highlights the utility of bamboo for house construction, bamboo ply, agricultural implements, handicraft, irrigation, brooms, medicine, food, fuel, fodder, paper & pulp etc, especially bamboo as a perfect substitute for some wood based products. The products that can be made from Bamboo can be broadly be categorized into:

1. Wood Substitutes and Composites,
2. Industrial Use and Products,
3. Food Products,
4. Construction and Structural Applications.

Apart from this broad classification various handicraft and cottage industry products are also made from bamboo. However, this category of products is not discussed as bamboo based industrialisation and its prospects limit the scope of the study. Also the input of bamboo as a resource raw material in the paper and pulp industry is also not explicitly dealt with as a bamboo based product but discussed in the next chapter under the resource situation in India.

1.2.1 Wood Substitutes and Composites

This category of products essentially comprises of boards and sticks of varying descriptions and uses, and which can further be used to manufacture finished products like wooden floors or blinds or goes into another industry as an input like incense sticks.

Bamboo Based Panels: China started producing bamboo panels in the early 19th century. At present more than 20 different types of panels are produced in Asia. Bamboo fibre is longer than wood fibre, which gives bamboo some technological advantages. The panels are widely used in modern construction as structural elements or as forms for concrete mouldings. They are also used for flooring, roofing, partitions, doors and window frames. Bamboo panels have some advantages over wooden board due to their rigidity and durability. Various types of bamboo veneers, panels and boards can be broadly classified as follows: veneers, strip boards, mat boards, fibreboards, particle boards, medium density boards, combinations of these, and combinations of these with wood and other ligno-cellulose materials and inorganic substances. Composites of bamboo and jute are also possible to make panels.

Bamboo Flooring: Bamboo flooring is a quality product that can be used widely and has a large, global consumer market. It has certain advantages over wooden floors due to its smoothness, brightness, stability, high resistance, insulation qualities and flexibility. Bamboo flooring has a soft natural lustre and maintains the natural gloss and elegance of bamboo fibre. This flooring is attractive to the demanding markets in Europe, Japan and North America. The estimated annual production of bamboo flooring in China was 17.5 million square metres in 2004, with about 65% being exported (Customs General Administration of China, 2004).

Bamboo Sticks for Blinds and Incense Industry: The art of making screens and blinds from bamboo is not new to India. For centuries, people have woven elegant screens from bamboo that have provided privacy, protection from the sun and added aesthetic appeal to living spaces. Mechanised blind making units can be economically viable enterprises. Again, bamboo sticks making units can substitute the wood that is used in the incense stick, and that industry in India is estimated to be worth US$400 million. It can also be used in match sticks.

Bamboo Furniture: Traditional bamboo furniture uses natural round or split bamboo. A new type of 'pack-flat,' 'knockdown' furniture uses glue-laminated bamboo panels. Unlike the traditional design, this furniture may be shipped in compact flat packs, to be assembled on the spot. The new design overcomes many of the problems of traditional bamboo furniture, such as high labour and transportation costs, low productivity, instability, varying quality and susceptibility to insects and fungi. At the same time, it retains the distinct physical, mechanical, chemical, environmental and aesthetic features of bamboo. Export of laminated bamboo furniture is growing rapidly. However, trade statistics currently do not capture the value, owing to the absence of a special code for bamboo furniture. It is usually classified as wooden furniture.

1.2.2 Industrial Products

Traditionally the industrial use of bamboo has been in the paper and pulp industry. Apart from this, the industrial products from Bamboo, essentially comprises of converting into fuel or electricity through gasification. Through pyrolysis, bamboo can be converted into three valuable products - bamboo charcoal, oil and gas. Changing the pyrolysis parameters can change the product shares depending on the purpose and market conditions. Bamboo based producer gases can be used as a substitute for petroleum. Bamboo charcoal is an excellent fuel for cooking and barbequing. There can also be the use of activated charcoal. This is used as a deodorant, purifier,

disinfectant, medicine, agricultural chemical and absorbent of pollution and excessive moisture. The industrial use is using bamboo waste for gasification and thereby producing electricity.

Bamboo for Paper and Pulp: Several bamboo-producing countries, such as China and India, use bamboo in paper and pulp. Bamboo paper has practically the same quality as paper made from wood. Its brightness and optical properties remain stable, while those of paper made from wood may deteriorate over time. The morphological characteristics of bamboo fibres yield paper with a high tear index, similar to that of hardwood paper. The tensile stiffness is somewhat lower compared with softwood paper. The strain strength is between that of hardwood and softwood papers. The quality of paper may be improved by refining the pulp.

Bamboo Charcoal for Fuel: Bamboo charcoal is traditionally used as a substitute for wood charcoal or mineral coal. It can serve as a fuel, absorbent and conductor. The calorific value of bamboo charcoal is almost half that of oil of the same weight. Activated bamboo charcoal can be used for cleaning the environment, absorbing excess moisture and producing medicines. The absorption capacity of bamboo charcoal is six times that of wood charcoal of the same weight. China is a leader in its production. At present, Japan, the Republic of Korea and Taiwan Province of China are the main consumers, but its importation is rapidly expanding in Europe and North America. There are three main reasons contributing to the success of bamboo charcoal in international trade:

- bamboo grows faster and has a shorter rotation compared with tree species;
- the calorific value and absorption properties of bamboo charcoal are similar to or better than those of wood charcoal; and
- it is cheaper and easier to produce.

Bamboo Based Gasifier for Electricity: Gasification of bamboo can produce energy and a range of valuable by-products. It reinforces a commitment to clean and renewable electricity and thermal energy. It can utilise waste generated by processing operations, substitute the use of fossil fuels, and lower operating costs. Bamboo can be cut into small pieces and used in the Gasifier. The requirements for the gasification units are a small proportion of the total availability. A 100 Kw Gasifier would require only about 1000 tonnes per annum, the equivalent of a truckload every three days on the average. An added advantage of gasification of bamboo is that 15% of the biomass would also be available as a by-product in the form of high grade charcoal. In the case of a 100 Kw Gasifier, around 135 tonnes of charcoal would be available each year to meet local

needs of fuel. It is clean, cheap & renewable source of energy. Further, it does not depend on quality, species, and maturity of bamboo.

Bamboo based fibre and fabric: The most recent advancement in bamboo is the manufacturing of fibre for making yarn and into various fabrics. There are several spinning mills using 100 per cent bamboo yarn, and Indian companies such as Raymond, BSL Ltd of Bilwara group and Paramount Textile Mills Ltd, Madurai, have already launched fabrics made out of bamboo. Bamboo fabrics are naturally anti-microbial and due to the presence of micro pores in the fabric absorb, they three times more moisture than cotton, making it a superior product.

Apart from the ones outlined above, bamboo extracts contain valuable elements that can also used an input in several industrial products. For example, bamboo can be used in pharmaceuticals, creams, and beverages. Traditional medicines like *Chawanprash* use bamboo extracts.

1.2.3 Food Products

Under this category, it is essentially bamboo shoots that are consumed after being cooked. Bamboo shoots carry the potential of value added economic activity at the entrepreneurial and community level through cultivation, processing and packaging. Its use in food and cooking goes far back in history. China earns US$130 million annually from exports of edible bamboo shoots. About 200 species of bamboo can provide edible and palatable bamboo shoots.[4] Fresh bamboo shoots are delicious and healthy, with high fibre content. Bamboo vegetables can be found in Chinese grocery stores and restaurants worldwide. After cooking the shoots are still crisp, because cooking does not destroy their texture. Cooked bamboo shoots can be stored in containers and shipped worldwide.

1.2.4 Construction and Structural Applications

Advances in structural engineering and the development of bamboo composites have opened new vistas for lightweight, durable and aesthetic construction for a variety of applications, enabling informed choices for housing, community and functional structures.

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[4] Within monopodial bamboos, the main species are *Acidosasa edulis, Chimonobambusa quadrangularis, Phyllostachys heterocycla var. pubescens, P. praecox, P. dulcis, P. iridescens, P. makinoi, P. nuda, P. prominens, P. sulphurea cv. viridis, P. vivax, Pleioblastus amarus* and *Qiongzhuea tumidinoda*. Within sympodial bamboos, the main species are *Bambusa rigida, B. pervariabilis, Dendrocalamus latiflorus, D. asper, D. brandisii, D. hamiltonii, Dendrocalamopsis oldhami, D .beecheyana, D. beecheyana var. pubescens, D. stenoaurita, D. vario-striata* and *Schizostachyum funghomii*.

Bamboo housing: There are three main types of bamboo housing, a) traditional houses, which use bamboo culms as a primary building material; b) traditional bahareque bamboo houses, in which a bamboo frame is plastered with cement or clay; and c) modern prefabricated houses made of bamboo laminated boards, veneers and panels. These buildings are usually cheaper than wooden houses, light, strong and earthquake resistant, unlike brick or cement constructions. New types of prefabricated houses made of engineered bamboo have distinct advantages. They can be packed flat and transported at a reasonable cost. They are better designed and environmentally friendly. Bamboo materials are widely available and can be cultivated at a low cost.

The properties and uses of bamboo vary at different stages of growth and its appropriateness at different stages of growth is as follows:

Up to 30 days - Bamboo shoots to be used as food
Between 6-9 months - for basketry
Between 2-3 years - for laminates and boards
Between 3-6 years - for construction

Bamboo gradually loses strength after the sixth year and up to 12 years.

1.3 Bamboo based Industrialisation – Prospects and Problems

This natural resource has played a major role in the livelihood of rural people and in rural industry, especially in tropical regions. Over 2.2 billion people the world over are dependent on bamboo and its related industries for income, food, and housing. Although the rural communities have traditionally been using bamboo, the utilisation has been highly localized as bamboo has often been viewed as an inferior substitute of timber. For example, although over 1 billion people in the world live in bamboo houses, yet there has been little effort to build such houses (using pre-fabricated structures or otherwise) commercially. Traditionally, bamboo has been harvested in the natural forest and its use has been limited to temporal constructions and low-quality utensils prone to rapid decay. Consumption or utilisation has therefore been direct and restricted to poorer people with low income and low purchasing power. Market linkage has as a consequence been weak or non-existent in most countries including India.

Yet, bamboo, as noted, has versatile uses as building material, paper pulp resource, scaffolding, agriculture implements, weaving material, plywood and particle board manufacture, basketry, furniture, pickled or stewed bamboo shoots, medicines, etc. Resource management and technical

improvements can convert this fast-growing grass into a durable raw material for construction purposes and a wide range of semi-industrialised products.

New industrial applications and modern construction design have both demonstrated bamboo's huge potential, but the bamboo sector in China is the only one reported to be thriving. The Chinese has been able to successfully industrialize the use of bamboo by integrating the bamboo sector with domestic and international markets. In the last 20 years China has established an integrated chain of bamboo plantations, its semi-processing and industrial product manufacturing such as bamboo flooring, furniture, furnishings, charcoal and fresh bamboo shoots for the domestic and export markets. Its focused intervention to harness bamboo's potential has led to increase in its productivity by more than 10 times since 1970 when it was 2-3 tonnes/ha/annum.

The combined value of internal and commercial uses of bamboo in the world is about rupees 50,000 crores annually. This is supposed to double by 2015. More than half of the world's consumption of bamboo is in China. China's export of bamboo products is close to rupees 10,000 crores. As against this, India's size of the domestic bamboo economy is estimated at rupees 2043 crores. The market potential was, however, estimated at rupees 4463 crores, which could grow to rupees 26,000 crores by 2015 (Planning Commission, 2003).

The bamboo sector in most other countries is still a part of the informal and backward rural economy. There has been an inability to grab the large potential, which has been successfully demonstrated by the Chinese bamboo industry. This raises the question of the bottlenecks facing bamboo development. Many of these inhibiting factors are at the policy level and are additional to a lack of knowledge among the important stakeholders and a widespread stigma of bamboo as a poor man's timber. In India it has been no different. Both the law and lack of awareness about its industrial application has been the primary bottleneck inhibiting a bamboo based industrialisation process from taking shape. Presently it is underutilized and found in abundance.

The biggest impediment towards a bamboo based sector from developing has been the irregular and scant supply of bamboo for entrepreneurial use. The paper and pulp industry in India, which has been traditionally using bamboo for over half a century, has constantly innovated to reduce the use of bamboo in its manufacturing process due to this uneven and scant supply. And after the consumption of the paper mills (who usually have long term contracts with the forest departments), very little is left for any other application. This pattern is true for all Indian states.

The present regulatory regime in India is the unambiguous culprit for this irregular and inadequate supply

An efficient regulatory institution is essential for markets to grow in a sustainable manner, especially where environment concerns are coupled with business development. Transaction costs must be minimal, information availability maximal with a clear focus on maintaining the forest cover. Unfortunately, the regulatory structure as regards the bamboo industry has remained caught in the quagmire of archaic forest laws, whereby bamboo is defined to be a tree, and therefore felled bamboo is classified as timber. which is subject to transit and trade restrictions. Bamboo is also subject to harvesting permissions in many parts of the country if grown on private lands and which then becomes the basis for imposing the need for transit permits. This has resulted in throttling of the bamboo sector and has discouraged private plantations. The irregular and scant supply of bamboos for processing, despite the world's largest area under bamboos has been a natural corollary.

Clearly the expansion of a bamboo based sector has not happened due to the restrictions in place. If the restrictions are removed, the sector still might not grow, but can impact livelihood benefits percolating down. This should justify an initial policy initiative through subsidies, incentives and other handholding measures. Economic subsidy can be justified when social benefits outweigh private benefits. So in the bamboo sector the understanding of livelihood benefits is crucial understand.

The economic and social benefits for example, from activities related to bamboo based value added products and applications was worked out to be 8.6 million jobs (new) in the Tenth Plan, besides building up large bamboo resource and market opportunities worth rupees 6,500 crore with an investment of rupees 2,600 crore, enabling 5 million families of artisans and farmers crossing the poverty line, according to the National Bamboo Mission[5]. The expansion of handicraft, cottage and tiny sector can potentially create 3 million jobs, according to estimates of the Planning Commission (2003). On the other hand, generation of power through gasifiers using bamboo resources exemplifies assiduous application of technology that can alleviate the present power shortage in most states and thus help improve the overall economy.

[5] See http://agricoop.nic.in/bamboo/bamboomission.htm

There has been a growing awareness in recent years about the importance of bamboo being an important means of economic growth and of improving the socio-economic conditions of the rural poor. Bamboo as an industrial material can substitute wood to a great extent and that too at low cost. Bamboo has been traditionally harvested from forest lands in India and the homesteads which may have a few clumps of one of the many species of bamboo for household use but very little intervention in terms of purposive planting has been done in the past. Convincing and informing users and policymakers of bamboo's versatility may fit in with a strategy of poverty alleviation and reducing pressure on tropical forests. Smallholders at the forest fringe can, in particular, improve their livelihood by processing bamboo or growing it in their backyard. Bamboo as a resource needs to be seen as a form of development, with the primary value addition done closer to the resource in order to reap the livelihood benefits. At the same time, a large stock of bamboo contributes to broader environmental goals of erosion control, reforestation and watershed management.

In India, bamboo is mostly found in the forests. As per Forest Survey of India (1999) estimates, 9.6 million hectares forest area of the country contains bamboo amounting to 12.8% of the forest cover. India has the largest area under bamboo in the world, which is estimated around 11.36 million hectares. India is also very rich in bamboo diversity. It is the second richest country in the world in terms of genetic resources, after China.[6] Sharma (1987) reported 136 species of bamboos, across 22 genera, occurring in India. Out of these, nineteen are indigenous and three are exotic. Naithani (1993) reported 124 indigenous and exotic species, under 23 genera, to be found naturally and/or under cultivation in India.

The distribution is, however, not uniform. The rich areas are confined to the North-Eastern parts of the country, Siwalik Hills of Uttar Pradesh, Bastar, region of Madhya Pradesh, Western Ghats in South India and the Andaman Islands. The North-East is the richest source. Fifty-eight species of bamboo belonging to 10 genera are distributed in the North-Eastern States alone. Around two-thirds of the growing stock or 66% of the growing stock of bamboo in India is found in the North-Eastern States, but with just 28% of the total area under bamboo in the country. Madhya Pradesh has the second highest area under bamboo, estimated at 20.3% of the area and with 12% of the growing stock. The details of the bamboo growing areas (in forests) and growing stock of major states is given in Table 1.

[6] China with 300 species is leading in genetic diversity of bamboo.

Table 1: Major Regions/States by Area under Bamboo.

State/region	Area (percentage)	Growing stock (percentage)
North East	28.0%	66%
Mizoram	8.45%	13.18%
Assam	7.54%	16.23%
Arunachal Pradesh	4.21%	11.91%
Manipur	3.39%	13.88%
Meghalaya	2.89%	5.34%
Tripura	0.86%	1.04%
Nagaland	0.70%	4.43%
Madhya Pradesh	20.3%	12%
Maharashtra	9.9%	5%
Orissa	8.7%	7%
Andhra Pradesh	7.4%	2%
Karnataka	5.5%	3%
Others	20.2%	5%

Source: Madhab Jayanta (2003) and the National Horticulture Mission at (http://agricoop.nic.in/AgriMinConf/National_hort_Mission.ppt.)

Clearly from the table above, states like Manipur and Arunachal Pradesh, within the North East and Orissa otherwise, have much higher productivity than rest of the states.

1.4 Productivity in India

The annual yield of bamboo per hectare varies around 2 tonnes per hectare per annum, depending upon the intensity of stocking and biotic interferences. It is however, known that yield in rain fed areas can be increased 4 to 5 times in five years if protection from grazing is ensured and proper management practices (soil working, fertilisation and thinning) are adopted (Lakshmana, 1994). The yield per hectare is very low compared to other countries such as Japan, China, Taiwan and Malaysia. As compared to China and Taiwan, India's productivity is one fourth to one fifth. India has a long way to go on scientific cultivation of bamboo. Unfortunately, bamboo has no parent in the governmental set up. Only in the homesteads, farmers take care of bamboo. But the lack of scientific approach to cultivation prevents higher productivity.

With regard to the potential productivity of bamboo from forest areas in India, two observations can be made. Firstly, the present actual productivity is far less than the potential and in either case less than what is noticed in the homesteads. Moreover, even in the homesteads, bamboo cultivation is seldom accorded the attention and silvicultural requirements, which would come in when bamboo plantations are undertaken.

As per the Orissa Bamboo Policy, the potential productivity of bamboo forest areas in Orissa is estimated to be 250,000 Metric Tonnes per annum, but actual productivity have been around 70,000 Metric Tonnes per annum, much below the potential. For Maharashtra, the potential productivity of bamboo forest areas have been estimated in the Draft Maharashtra Bamboo Policy to be 1,200,000 Metric Tonnes per annum, but actual productivity over last few years have been around 200,000 Metric Tonnes per annum. On the other hand, it is estimated that about 50,000 tonnes of bamboo is extracted from homestead areas in Orissa, with an average productivity of 5-6 tonnes per hectare per annum, much above the productivity level of bamboo in forest areas. In fact, the Orissa Bamboo Policy acknowledges that there is a need to enhance the productivity up to 20 – 25 Metric Tonnes per hectare per annum through scientific cultivation, superior clones and species change. Correspondingly, in Maharashtra, around 25,000 tonnes is extracted from homestead areas, with an average productivity of 3-4 tonnes per hectare per annum, which also is much above the productivity level of bamboo in the forest areas. Similarly, the current yield in Andhra Pradesh is 7 tonnes per hectare per annum from forest plantations, while in the managed plantations it was found to be 12 tonnes per hectare per annum.

Traditionally the forest department's bamboo harvesting policy systematically maximizes dry bamboo output for paper mills rather than green bamboo output for artisans and mature bamboos (2-4 years old) for the industrial needs (apart from the paper industry). In fact, if bamboo forests are carefully worked and green bamboos/mature bamboos regularly harvested, bamboo output of an average clump would jump. Till date the management of state bamboo resources has many constraints with lack of post harvest treatment and technology for product development, inadequate trained manpower and inadequate infrastructure for large scale harvesting in the event of gregarious flowering.

In India bamboos have been primarily grown in forests, which are government owned land. The exceptions, as noted earlier, were Nagaland and Kerala. Although it is a well established fact that

bamboos in India are primarily harvested for supplying to the paper and pulp industry as a raw material, and otherwise used by the rural communities for self consumption, it is very difficult to obtain even rough estimates of the consumption or utilisation pattern. Tiwari (1992) has done the only estimate on consumption pattern and this is given in the Table 2 below. There are two points to note in his consumption pattern outlined. First, the estimates of Tiwari (1992) do not include pre-fabricated houses using bamboo. In the housing sector, bamboo is used in different ways as a building material for roof structure in form of purlins, scaffolding, rafters, reapers, as reinforcement in foundations and in mud walls, flooring, doors/windows, walling, ceiling, water storage tanks, man-hole covers and even for roads in slushy areas. The other point to note is that the estimated percentage used in the paper and pulp industry was 35% in 1992. This fact looks quite circumspect.

Bamboo as a resource in India has been used as an input for the paper and pulp industry. For example, in Orissa, around 98% of bamboo extracted from forests is supplied to the paper mills.[7] The balance quantity is utilized by the local communities for their livelihood and utility products. Of the estimated 50,000 tonnes/annum extracted from homestead areas, around 30% is supplied to the paper mills and balance is utilized for construction, fencing, crafts, agriculture implements and other utility products. This scenario is not much different in other states. In Maharashtra, around 85% of the bamboo extracted is supplied to the paper mills and the balance quantity is utilized by the local communities.[8]

In Assam, the overwhelming industrial use for bamboo is still for pulp and paper. The paper mills in the State have a capacity of 800,000 tonnes per annum, met largely from Assam, but to a lesser extent from the neighbouring States. Much of the bamboo utilized in these spheres comes from the forests through a system of contracts, leases and departmental operations. According to a survey report of the State Forest Department of Jharkhand for example, 75% of bamboo is used for pulp and paper, 23% for household and constructional needs, and 2% for bamboo based cottage industries. Similarly in Andhra Pradesh, the growing stock of bamboo is 3.8 million tonnes, and about 2 lakhs metric tonnes are removed annually. Of this, around 1 lakhs tonnes or 50% is supplied to the three paper mills in the State and the remaining is made available to domestic sectors and *Burood* societies.

[7] Draft Orissa Bamboo Policy, Annexure I
[8] Draft Maharashtra Bamboo Policy, Annexure I.

Table 2 Consumption Pattern of Bamboos in India

Uses	Percentage Consumption
Pulp	35 %
Housing	20 %
Non-residential	5 %
Rural uses	20 %
Fuel (non – industrial)	8.5 %
Packing, including basket	5 %
Wood based industries and Transport	2.5 %
Furniture	1 %
Others, including ladders, mats etc.	3 %
Total	**100 %**

Source: Tewari, D.N. (1992)

As noted before, the estimated annual harvest of bamboo in India is 13.47 million tonnes against the current domestic demand of 26.69 million tonnes. Therefore there is already a substantial shortfall in the supply of bamboos in India.

1.5 Bridging the Supply Gap

Given that the demand for bamboo as a resource for the paper and pulp industry as well as for the industrialisation needs of the sector is outstripping supply and will continue to do so, there are three things that need to be done. The first is to embark on a systematic plan to rejuvenate the degraded bamboo forest areas by the forest department. The second measure would be to increase the yield. Therefore, better management and harvesting techniques needs to be adopted along with a systematic working plan for bringing in degraded forest lands under bamboo cultivation. The present system of using the paper mills to do the harvesting is not sustainable. We need a system of 'Selective Felling' wherein the more matured bamboos are cut and the younger ones are left untouched. Since bamboos in India grow in clumps, and some of them are of the thorny variety (like in Kerala), the method of selective felling that is used is like a 'horse shoe'.

Thirdly, however, since the bamboo from state forests continue to be contractual to the paper and pulp mills, promotion of private plantations of bamboo is essential, especially for meeting the

industrialisation needs of the bamboo based products and applications. This can be a prioritized activity for the Forest Department and giving a thrust to bamboo resource management as part of natural resources management activities, by promoting seedling distribution and plantation activities to regenerate the replenished bamboo resources. This process can also involve the local communities, for that can have desirable outcomes as has been demonstrated in the Andhra Pradesh Community Forest Management (APCFM) project (which was with the help of the World Bank). About 50,000 hectare of degraded bamboo forests were targeted for treatment and the targeted was exceeded by more than 5 thousand hectare (or by more than 10%) by 2005. This can help in the development of site-specific forest inventory, forest management, and integration with working plan, and with the help of other related technical practices including adaptive Research and Development, can enable the bamboo based industries to emerge as a viable livelihood enhancement and poverty reduction strategy.

The total forest cover in India, as per the Forest Survey of India, 1999 Report was estimated to be 63.73 million hectare, out of which 25.51 million hectare is degraded forest and another 5.19 million hectare is scrub. Thus, total degraded forest is thus about 30.70 million hectare. Thus substantial addition to the existing bamboo stock can be achieved, especially through concerted effort by the forest department. The average productivity of bamboo from forests is around 5 tonnes per hectare per annum or less, and which can easily be increased by at least five times, to 25 tonnes per hectare per annum or more. Increasing productivity requires proper management of the bamboo forests.

Bamboo resource management is a labour-intensive activity. Unless adequate attention is paid, bamboo would become a congested weed among other vegetation. It has to be properly managed for high yields. Field operations include decongestion, saucer weeding, mounding for young clumps, staggered trenches near the clumps to impound moisture, fire control measures, etc. Selective felling of mature bamboo culms duly retaining 6 to 8 culms per clumps to support the clump is a silvicultural operation that ensures health of the clump apart from fetching the desired revenue.

Congestion in Bamboo culms is a common problem, caused by mismanagement. Unrestricted cutting along the periphery of clumps, browsing of young shoots at the edges by cattle, continued removal of young tender shoots for food, digging of rhizomes for making sticks, prevent living rhizomes from spreading outwards. They consequently, develop within the clump, and the new

culms so produced create congestion. In very bad cases, clumps appear as tangled mass of twisted and crooked bamboos, impenetrable and unworkable. Proper management is both a preventive and a remedial step.

The other aspect of increasing productivity is linked to the harvesting agency. If the paper mills are engaged as local contractors to extract the bamboo, they do not have any incentive to undertake selective felling. Selective felling requires more time and effort. Moreover, the paper mills are not selective about the maturity of the bamboos as payment is made on the basis of weight. Also bamboos of all age can be used as raw material for the paper mills. Therefore they tend to clear fell the entire clump. Extraction needs to be supervised by the forest department. Ultimately, it is the local forest dependent communities, who as wage labourers would extract the bamboos. So the forest department needs to shoulder more responsibility and not absolve themselves of the duty to undertake scientific management and harvesting of the bamboo clumps. This will also increase productivity.

In India, bamboo is not only grown in forests but is also raised in homesteads and farms. However this is of very limited quantity and is essentially restricted to Nagaland and Kerala. It can be planted under agro-forestry system and practices.[9] Despite having abundant bamboo resources, and having the largest area under bamboo in the world, India faces a shortage of bamboo supply for its various industries. This is only likely to widen further, even if just the needs of the paper industry is taken into account and who are the primary users (from industry) of bamboo in India.

Industrialisation of a bamboo based sector provides potential for development, generating livelihood for the poorest of the poor and without any damage to the environment. This opportunity for a win-win situation is yet to be harnessed in India due to a lack of awareness and procedural legal impediments, which can easily be overcome, provided the State plays a pro-active role. The vast and yet untapped potential needs cultivation, primary processing close to the rural poor, integrated processes with one time subsidy towards establishment and transfer of technology and a coordinated, sustained national level effort towards marketing these products.

[9] Bamboo plantations mainly of *Dendrocalamus strictus* are being raised by different state forest departments. However, there are two main problems: (i) availability of planting stock and (ii) protection of plantation areas.

Bamboo is in the process of being 'rediscovered' in India. Its attributes and potential are increasingly being recognized.

The Planning Commission had prepared a report on National Mission on Bamboo Technology and Trade Development, which is under the Ministry of Agriculture. According to the report, the Indian bamboo industry had a size of rupees 2,040 crore in 2003, while the domestic market potential was rupees 4,463 crore, that is, there was scope to increase the size of the industry by at least 2.2 times. Assuming a growth rate of 15-20% it was projected to be worth rupees 26,000 crore industries by 2015. The size of the domestic bamboo industry has also been estimated to be rupees 6,505 crores, according to Pacific Bamboo Resources. The annual bamboo harvest (poles and shoots) in India was slightly over US$23 million according to FAO (Pabuayon and Espanto, 1997).

1.6 Constraints facing the Sector and Stakeholder Views

In order to understand the constraints facing the sector, two routes were explored. The first related to looking at secondary documented sources of constraints facing the sector and the second was the various roundtables that were conducted in the course of the study in various parts of the country in order to understand the stakeholder responses from the people associated with the resource use, including government officials and representatives from various bamboo based industry. Several site visits were also undertaken to get a primary view of the process and the practical difficulties encountered. Based on these two routes the findings are briefly mentioned below.

There were several constraints that were identified in the course of the roundtables and field visits as well as from secondary sources. These can be listed as follows:

- The regulatory constraint on transit of bamboo as well as on harvesting from private plantations,
- The irregular supply of bamboo to industries,
- Poor market linkage of the products,
- Technology application for new product design along with testing, certifying of products,
- Lack of an institute on bamboo application and technology,
- Lack of application of known scientific methods in plantation, poor post-harvest treatment, and up-gradation of skill formation,
- Waste utilisation, and

- Competition from Chinese products.

The regulatory restrictions on transit and harvest of bamboo are the biggest impediment to the growth of bamboo based industries and applications. This happens because bamboo is defined to be a tree, when it is a grass and therefore it is treated at par with timber and other forest produces. The transit pass requirement adds to delay and increases the cost due to red tapism. For example, the cost of one pole of *Dendrocalamus Strictus* is rupees ten but by the time the pole is available for further processing in Hyderabad city, the price increases to rupees forty per pole. This arises from the severe restrictions on movement of bamboo. Failure to get movement licenses forces people to move to other plantation trees like eucalyptus.

Even if the added costs can be factored in, the irregular and delayed supplies holds up production and sometimes indefinitely. Promoting private plantations in bamboo can ease out the problem of irregular supply but until and unless the transit and harvesting restrictions (along with trade restrictions in certain states like Orissa) are tackled the delays and cost escalation will continue to throttle the sector. Bamboos from private plantations also are subjected to these restrictions in most states (West Bengal, Andhra Pradesh and Nagaland being exceptions).

Of the other barriers to realizing the potential of bamboo is the poor market linkage and technology application. New technology and product options need to be developed. Only when this happens will it encourage manufacturing units to be established. A public interest awareness campaign was felt to be essential for promoting the sector by most of the industry representatives throughout the country. The sector cannot thrive by making handicraft items like baskets anymore. There has to be a movement towards lifestyle products and utility products (not just show pieces). Further therefore, there is the need for market establishment of these products, with product testing for quality being a necessity which will ultimately lead to market acceptability. In this regard, the National Mission on Bamboo Technology & Trade Development was mooted by Planning Commission to accord Bamboo development a strategic role in rural economy, poverty alleviation and bamboo based handicrafts & industrial development. However, presently more need to be done and in a concerted way.

Bamboo technology is not taught in India per se. So it was felt that there is a need for a bamboo technology institute, which can also impart the desired training. It needs to be located where the bamboo industry shows potential. The institute can also provide immediate solutions to local

problems and help disseminate the information after research is carried out for further development. There was the need for a credible certifying organisation that would be accountable on quality issues. This can help the grower grows appropriate varieties that have industrial applications and the institute can spread awareness among states that will promote the use of bamboo. Presently, Central Institute of Plastics Engineering and Technology (CIPET), an autonomous Institute under the Department of Chemicals and Petrochemicals, Government of India, is the only agency authorised to do some kind of certification and they certify the tsunami related structures. However, CIPET's core competency is in plastics and not in Bamboo.

Several other constraints also stand in the way of development of this sector in India, like lack of application of known scientific methods in plantation, poor post-harvest treatment, product development and up-gradation of skill formation. Low yield per hectare reveals poor management of extant bamboo forests. Inadequate trained manpower and inadequate infrastructure for large scale harvesting in the event of gregarious flowering was also identified as a potential constraint. The bamboo cutters are usually exploited in the present system, especially by the Paper Mills, with no welfare schemes to benefit them and they work at abysmally low daily wage rates. As a result, many migrate in search of jobs. Bamboo Plantation activities over the next 5 years could generate about 50.4 million man days of work according to the Planning Commission. In the nursery sector, total estimated employment to be generated every year is to be around 9.7 lakh man days. Besides this, there will be employment generation in both skilled and unskilled segments in the handicraft sector.

1.7 Regulating the bamboo sector

The Central laws pertain to forestland which is the property of the government. In other words, the central laws do not apply to private forests or private plantations. There are three central Acts that govern forest and forest produce. These are *the Indian Forest Act 1927*, the *Forest Conservation Act 1980* and the *Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006*. Before proceeding to understand how these laws affect bamboo plantation, harvesting and transportation, it is imperative to outline the objectives that all these three laws purports to achieve.

The *Indian Forest Act* 1927 is the single most important piece of legislation on forests. This Act has only minor differences with the 1878 forest Act with the philosophy remaining the same.[10] Two fundamental issues can clearly be identified in the Act. The first pertains to the establishment of absolute state property rights over forests. Towards this end, the classification of forests – into reserved forests, protected forests and village forests – and the legal separation of customary rights as well as the procedure for forest settlement in these was an administrative feature characterizing this Act. The second pertained to the control of timber and other forest produce in transit, the duty leviable on them and the collection of drift and stranded timber. The commercial motive and revenue generation remained the guiding principle. Of relevance to this study are the definitional aspects contained in Section 2 and chapter VII of the Act, which contains detailed and wide encompassing provisions empowering the government (more specifically the state governments) in the control of timber and other forest produce in transit by land or by water. The link between Section 2 and chapter VII lies in the fact that whatever got defined as a 'forest produce' could be controlled by the state governments through the rules framed by these various state governments in their respective states.

The *Forest Conservation Act*, 1980, deals with restriction on allotment of 'forestland' for non-forest purposes and de-reservation of reserved forests. The Act is a two-page document, consisting of only five sections. The Act clarifies that the term "non-forest purpose" means the breaking up of or clearing of any forest land for the cultivation of tea, coffee, spices, rubber, palms, oil-bearing plants, horticultural crops or medicinal plants, or nay purpose other than reforestation. The Act was a crisis driven response. The objective of enacting this Act was to empower the Central Government in directly managing India's forests. The Act, is not really a substantive law, it is a delegated legislation, which empowers the Union Minister to make the decisions about how to use the forestlands. Further, this Act only forbids "reserve forests" from being de-notified by the states. The need to promulgate this Act was felt as remote sensing data of the 1970s showed the adverse consequences of large-scale diversion of forestlands to non-forestry purposes (which hit an astounding rate of 150,000 hectares per year prior to the 1980s). Again, after forests were transferred to the concurrent list by the Forty-Second Amendment Act of 1976 and the Ministry of Environment and Forests (MoEF) was set up as a nodal central authority in 1980; the Union Government could now directly intervene.

[10] The 1927 Act was promulgated to "consolidate the law relating to forests, the transit of forest produce and the duty leviable on timber and other forest produce". A brief genesis of the Act is in Supplementary Note 1.

In particular there is no aspect of the Forest Conservation Act, 1980 that is of relevance to this study. However, the Supreme Court case - *T. N. Godavarman Thirumulkpad vs. Union of India and others* (Writ Petition No 202 of 1995) – was filed in contravention to this Act and this case has turned out to be a landmark one that has perhaps altered the way bamboo ought to be regulated in future. The other central law is the *Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act*, 2006, which was notified in the Gazette of India only on January 2, 2007. The rules under this Act are not yet notified. The Act seeks to undo the historical injustice done to forest dwelling communities and vests property rights on forestland in forest dwelling communities thereby addressing their long standing insecurity of tenure and access rights. The Act gives them access to minor forest produce (including rights to sell), and a stake in the preservation of open spaces. The Act provides heritable but non-transferable tenures if they have occupied the lands (up to a maximum of four hectares per family) for three generations from 1930, with December 13, 2005 as the cut-off date. The Act gives the right of jurisdiction of gram sabhas to settle tribal claims. Of relevance to this study is only the definition of bamboo.

There are two kinds of relevance vis-à-vis bamboo that the Central Acts deal with. The first is definitional, which defines bamboo as a forest produce by its origin. The second pertains specifically to the harvest and transit rules applicable to bamboo. The issue of trade regulation is contained in some of the State laws. The issue of harvest of bamboo from private lands or private cultivation is also contained in the State laws. Beginning with the second issue first, that is the harvest and transit in bamboo; it is primarily the provisions of the *Indian Forest Act*, 1927, that is of relevance.[11] Specifically, by Section 26, removal of any forest produce (harvesting of bamboo) is prohibited in reserved forests, except by the forest department (usually in accordance with working plans). In protected forests, (Chapter IV) removal of timber or any other forest produce (including bamboo) is to be done with the written permission of the Forest Officer or in accordance with the rules framed by the State Governments. The rules so framed by the State governments can include among others, granting of licenses to persons felling or removing trees or timber or other forest-produce from such forests for the purposes of trade, and the examination of forest-produce passing out of such forests.

[11] According to the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, the forest dwellers have the right to "collect, use and dispose of minor forest produce" and which includes bamboo, but there is no explicit mention of trade or transit of either timber or any other forest produce. The word "dispose" is not assumed to mean either trade or transit.

The provisions particularly related to transit are contained in Sections 41 and 42 of Chapters VII.[12] Under clause (1) of Section 41, "the control of all timber and other forest-produce in transit by land or water is vested in the State Government, and it may make rules to regulate the transit of all timber and other forest-produce". The section is fairly detailed in its ambit, and gives the State Governments ample powers including the authority to frame rules for transit, control all river banks (as regards floating timber) and to make rules to prescribe the routes for import, export and other movements of timber or other forest produce from the State or within the State. Thus the State rules regarding prohibition of such movements without pass, issuing of pass and prescribing fees in respect thereof becomes important and almost all states have laws/rules that guide movement of timber and other forest produce.

As mentioned before, the central laws on forests governed forestlands that were the property of the government. As regards the private forests or private plantations, the state laws, if any, governed the harvesting of bamboo. However, the transit rules applied to bamboo irrespective of its origin as the definition of trees in the Indian Forest Act 1927 makes bamboo a forest produce. Prior to the harvesting or felling of any tree from private lands, a certificate of origin is required from the state forest department, which is issued after due inspection and according to procedures laid out in the State laws that govern private forests for the respective states. Although the procedures vary the methodology follows this pattern. As seen in the following section, bamboo if included under the definition of a tree, and thus if treated as a forest produce even if its harvesting is from private lands would require a certificate of origin, and which would then form the basis of the issuance of the transit permit. So, section 41 and 42 of the I*ndian Forest Act* 1927, and thereby all Rules framed on transit of forest produce by the States, will be applicable to bamboo as long as it is a forest produce.

Conclusion

Despite having fairly detailed estimates on the size and potential of the various market segments of the bamboo based industries or where bamboo is used, and despite they being estimates of a Planning Commission Document, the appropriateness and reliability of the market potential, along with its availability and method of estimation is circumspect. As a result these estimates,

[12] Chapter VIII also contains certain related provisions. Chapter VII is titled "of the control of timber and other forest-produce in transit", while Chapter VIII of the Act deals with the "collection of drift and stranded timber". There was no particular need to have two different chapters on very similar aspects, and the former chapter was quite sufficient.

duly quoted, are nevertheless questioned here. The process of consultation with the stakeholders - people associated with the resource use, including government officials and representatives from various bamboo based industry, along with the site visits to get a primary view of the process and the practical difficulties encountered helped us formulate the difficulties encountered.

The most important bottleneck was identified as the regulatory bottleneck, and as long as this was not meaningfully addressed, the sector cannot grow beyond a certain threshold level. In general, there seemed to be a strong promotional role of a governmental organisation, which would help generate awareness on bamboo products, run a nationalized campaign and help develop product-market linkages, apart from handholding the sector in the initial stages. The government initiatives and agencies created for the development of the sector was described and although there seems to be overlapping of jurisdictions, the sector is presently at such a nascent stage of development that there cannot be shortages of initiatives. What perhaps is lacking is a more concerted effort and better planning, and we are of the opinion that either of the Missions, NMBTTD or NMBA, and perhaps the latter, should be converted into a permanent 'Board' for the development of the Bamboo sector in India, in lines of the 'Coffee Board' or the 'Tea Board'. This is especially called for because the report argues for bamboo cultivated in private plantations and it is hoped for that in future bamboo will be treated at par with other plantation crops once the viability of private plantations is demonstrated in different parts of the country.

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