Bamboo: Green Construction Material

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Development Alternatives

Bamboo: Green Construction Material

Key Messages

- New industrial application and modern construction design have both demonstrated bamboo's huge potential.
- Regulatory Mechanisms putting restrictions on bamboo development.
- Lack of awareness has been the bottleneck inhibiting bamboo from taking shape in construction.
- Focusing on modern technology and financial support can expand bamboo market in construction.
- Strengthening institutions and government scheme can proliferate bamboo use in construction.

EXECUTIVE SUMMARY

Bamboo belongs to grass family and has been associated with various names such as “poor man’s timber”, “Green Gold”, “Cradle to Coffin” because of its various documented applications. Bamboo is widely recognized as highly renewable, fast growing, economic raw material. Products from bamboo are grouped into industrial use, food products, construction and structural application, wood substitutes and composites, and cottage and handicraft industry.

Bamboo is most abundant in India. India has the huge potential for bamboo with 14 million hectares of bamboo forest area. India is the second largest country in terms of bamboo resources. The yield per hectare of bamboo in India is very low compared to China, Taiwan and Japan which contribute about 80% to the world’s bamboo market.

In coming years India is expected to face timber shortage in order to meet the housing needs of the increasing population. Moreover, the increased dependency on conventional materials is held responsible for degradation of environment. Both the reasons have led to give a thought on the use of bamboo as a substitute for wood and steel as it is considered as highly renewable and environment friendly material.

Bamboo products (bamboo boards, bamboo veneers, bamboo mat corrugated roofing sheets, etc) due to their physical and mechanical performance in terms of hardness, stability and strength are gaining attention with large opportunities in emerging market. Moreover, bamboo has the capability of mitigating climate change as it restores degraded land, act as carbon sequesters and protects from soil erosion.

Technology advancement and initiatives taken up by the central and state government has helped in the development of bamboo in construction and structural applications. New technologies on jointing, protection and preservation of bamboo has been developed which has increased its durability and quality and opened new areas for bamboo as wood substitute. Traditional bamboo culm used in rural housing can now be transformed into new and innovative bamboo based products with latest technology and can be used in top grade houses in roofing, flooring, doors, windows, etc.

Presently India has no export market for bamboo products except an insignificant export of handicrafts products. India has huge potential for bamboo export as it is the second largest country after China in terms of bamboo resources.

Bamboo sector has been getting support from various stakeholders that include government sector, private sector, research institutes and financial institutes. These stakeholders are promoting and regulating the use of bamboo in construction. Initiatives taken up by these stakeholders are helping in strengthening the value chain and creating the market for bamboo use in construction and structural applications.

Policies set up by central and state government for bamboo development has also been responsible in proliferating the use of bamboo in construction. National Bamboo Mission and National Mission on Bamboo application are playing major role both at central and state level. These missions are supporting

the activities taken up at state level for bamboo development in construction. State level missions have been set up in order to enhance the bamboo sector in the respective states.

Despite of these initiatives bamboo is not being utilized much in construction sector as there is a huge demand and supply gap for bamboo raw material for its industry. Majority of the bamboo is supplied to the paper and pulp industry because of increased demand after which very little is left for consumption by other industry. Moreover, the regulatory mechanisms in India impose restriction on transit and harvesting of bamboo which has a negative impact on the bamboo construction industry.

This case study will present the constraints in the growth of the industry such as regulatory restrictions, supply of raw materials, quality of bamboo, untrained labor, lack of financial support, policy support and implementation, establishment of database, etc.

Contents

1. INTRODUCTION

Bamboo which is considered as the poor man's timber is one of the most important forestry species with wide distribution throughout India. India has the largest area and second largest reserves of bamboo in the world today, yet its industries are swinging in shortage of raw material availability. The bamboo economy of the country is still in nascent stage that is 4% of the global bamboo economy (Ombir Singh, 2008). Major consumers of bamboo in the country include paper industry, construction sector, handicrafts and small and cottage industries.

1.1 Bamboo and its Uses

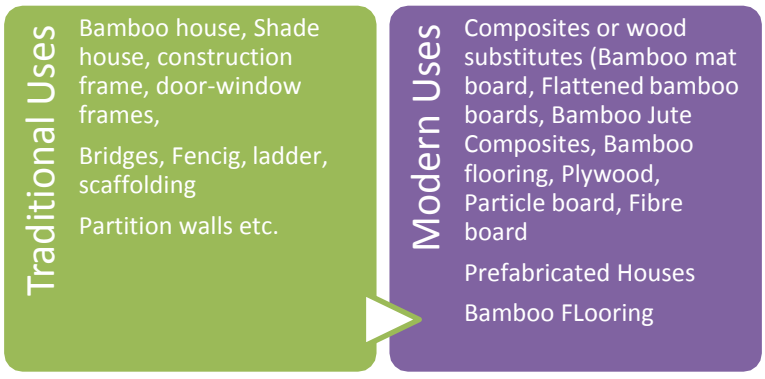
Bamboo has more than 1,500 documented uses, ranging from fuelwood to light bulbs, medicine, poison and toys to aircraft manufacturing (Forest Research Institute, 2008). The products made from bamboo can be broadly classified into:

- Industrial Use and Products, (paper and pulp, bamboo charcoal for fuel, bamboo based gasifier for electricity)
- Food Products (consumption of bamboo shoots)
- Construction and Structural Applications (Bamboo housing)
- Wood Substitutes and Composites (Bamboo based panels, Veneers, Bamboo Flooring, mat boards, fiberboards, particle boards, medium density boards, combinations of these, and combinations of these with wood and other ligno-cellulose materials and inorganic substances).
- Cottage and Handicraft Industry

This case study will focus on the bamboo uses as wood substitute and composites as well as on its construction and structural applications.

Use of Bamboo in Construction

In construction sector, bamboo is used to make all the components of building both structural and non structural. Traditionally bamboo culms were used for constructing housing in rural community, scaffolding and for constructing foot bridges. It was used in different ways for roof structure, for doors and windows, walling, ceiling, man-hole covers etc.



Traditional Bamboo Roof

Traditional BambooWindow

Traditional Wall

Modern Bamboo Roof

Modern Bamboo Window

Modern Bamboo Wall

Construction and Structure Application

Traditionally, bamboo culms[1] were used as primary building materials for constructing houses or bamboo frame was plastered with cement or clay which has now shifted to the construction of prefabricated bamboo housing. In modern times, engineered bamboo is used to make prefabricated bamboo houses with the help of bamboo based panels, veneers, and laminated boards. The technology evolved can be effectively adopted for construction of low-cost (single storied) houses with cost ranging from Rs. 300 to 500 per square feet depending upon the design of the house and nature of interior finish, and also upon the local conditions (K.Shyamasundar and Jagadish Vengala, u.d). Lot of development has taken place to improve the technology and techniques that can be used to make bamboo suitable for construction. There has been improvement in the preservation and protection technology of bamboo as well as in jointing techniques so that the use of bamboo can be proliferated as construction material. These technologies are helping in increasing the durability of bamboo as construction material. 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 with proper treatment.

[1] The woody, hollow aerial stems of bamboo grow in branching clusters from a thick underground stem (rhizome).

Figure 1 : Transformation from traditional houses to modern houses made up of bamboo through technological advancement

Modern Bamboo Based Material as wood substitute

Bamboo can be manufactured into various kinds of top-grade housing materials to meet different performances by introducing the advanced combination, restructuring technologies. Bamboo can be transformed to make products like Bamboo Veneers, Bamboo Panels, Corrugated Bamboo Roofing Sheets, Bamboo Particle Board, etc which can be used as a construction material in various applications. Lots of organizations like Indian Plywood Industry Research and Training Institute, Technology Information Forecasting and Assessment Council, Building Material and Technology Promotion Council etc are coming up with latest, innovative, cost effective and eco friendly bamboo based products that can be used in construction application.

Presently India has got no export market for bamboo products except an insignificant export of handicrafts products. India has the higher potential of export if bamboo products are produced and attempts made for export (Borah, Pathak, Deka, Neog & Borha. K, 2008)

1.2 Bamboo and its Characteristics

Bamboo is the world's fastest growing woody plant. It grows three times faster than most other species and is therefore considered as renewable material. Bamboo has certain characteristics which make it suitable for construction. It has been estimated that bamboo has ultimate tensile strength same as that of mild steel and this coupled with other merits can boost the usage of bamboo. Bamboo has a tensile strength of 28,000 lb per square inch, versus 23,000 lb per square inch for mild steel (Baksy, 2013). Bamboo fiber is longer than wood fiber, which gives bamboo some technological advantages due to its rigidity and durability and also makes its superior to wood in some physical and mechanical properties and is highly versatile for application in construction activities.

Also, bamboo possesses high strength to weight ratio compared to wood. The strength of the culms, their straightness, smoothness, lightness combined with hardness and greater hollowness; the facility and regularity with which they can be split; make them suitable for numerous end products/purposes.

Bureau of Indian standards (BIS) has given standards relevant for physical and mechanical properties of bamboo (ISO 22157: 2004). Its strength and flexibility make it a viable material for building shelters that offer protection against hurricanes and earthquakes. Also its strength-weight ratio supports its use as a highly resilient material against force created by high velocity wind and earthquakes (BMTPC, u.d). It can withstand the earthquake of magnitude ranging from 7-9. Lightness and flexibility makes the bamboo plant an excellent material for the construction of prefabricated housing and structures. It has been estimated that during processing it consumes even less energy than wood. Bamboo offers sound yet light and easily replaceable form of shelter. The methods, activities and tools are often simple, straightforward, accessible even to the young and unskilled. It also provides protection against UV rays.

Other then these characteristics bamboo also possesses characteristics that help in protecting environment. It has a high leaf surface area that makes it very efficient at removing carbon dioxide from the atmosphere and generating oxygen in its place. It generates almost 35% more oxygen than equivalent stands of trees and acts as a sequestration agent. Certain Bamboo species have been known to sequester as much as 12 T of CO2 per hectare (Baksy, 2013).

1.3 Bamboo Resources and Potential in India

Worldwide Bamboo Resources

The global bamboo coverage worldwide is 36 million hectare that is 3.2% of total forest area. Bamboo is mostly distributed in temperate, tropic and sub tropical zones of all continents naturally except Europe and North America. Recently, bamboo has been introduced into North America, Europe and Australia (Pannipa Chaowana, 2013). Asia is the richest bamboo producer with about 24 million hectares of the total world bamboo resources. Five out of six countries have large extent of bamboo forests in Asia viz. India, China, Indonesia, Myanmar, and Vietnam. Latin America occupies

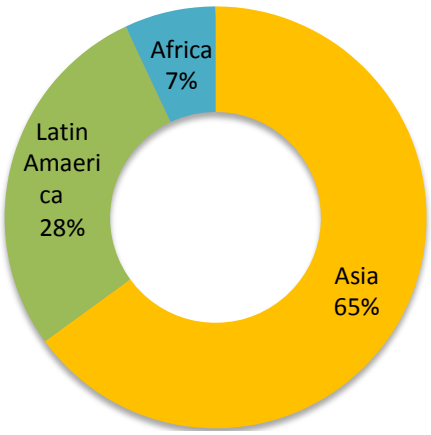


Figure 2: Worldwide Distribution of Bamboo
Source: Food and Agriculture Organization, 2005

the 10 million hectares of the total bamboo area in the world whereas Africa has the smallest bamboo area of 2.7 million hectare (FAO, 2005).

Bamboo Resources in India

India is the second largest country in the world after China in terms of bamboo resources (Forest Survey of India [FSI], 2011). Worldwide, India occupies 37.8% of the total bamboo forest area. Twenty Percent of its overall forest area is of bamboo. In India there are 125 indigenous and 11 exotic species of bamboo belonging to 23 genera (FSI, 2011). Bamboos are found in all most all parts of the country except Kashmir where bamboo does not occur naturally. Percentage of Distribution of bamboo forest area (major state wise) out of total bamboo area of the country and its growing stock (number of trees grown in that particular area) are given in table 1. This data represents bamboo resources grown on government land.

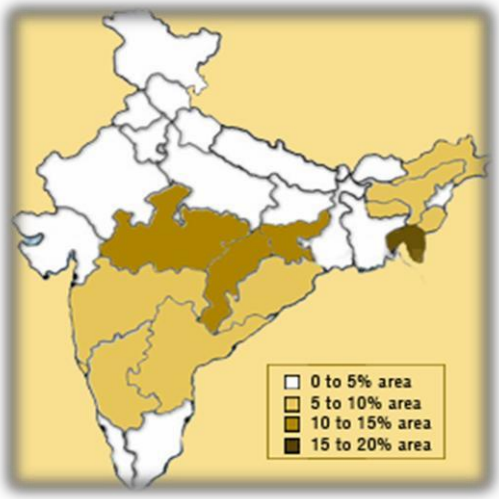


Figure 3: Bamboo growing areas in India
Source: National Bamboo Mission

Table 1: Distribution of Bamboo in India

States/Region	Area (%) (2003)	Growing Stock (%) (2003)	Area (%) (2011)
North- East	28.0	66	31
Madhya Pradesh	20.3	12	9
Maharashtra	9.9	5	8
Orissa	8.7	7	8
Andhra Pradesh	7.4	2	6
Karnataka	5.5	3	6
Others	20.2	5	32
Total	100	100	100

Source: (BMTPC)

More than 50% of principle genera are found in Eastern India that is approximately fifty-eight species of bamboo belonging to 10 genera are distributed in the northeastern states alone (Food and Agriculture Organization [FAO], 2003). The National Bamboo mission has identified bamboo species grown in India which include Bambusa balcooa, B. bambos, B. nutans, B. pallid, B. polymorpha, B. tulda, B. vulgaris, Dendrocalamus bramdissii, D. giganteus, D. Hamiltonii, D. Strictus, etc. From many researches these species have also found to be suitable for different construction applications.

Potential in India

The current demand of bamboo for various purposes is estimated at 26.69 million tones as against the supply of 13.47 million tons (Tripathi, Thakur, and Bhuyan, 2008). Of the 13.47 million tones of bamboo, 3.4 billion are currently being consumed for scaffolding alone all over India (Rain Forest Research Institute, 2008). Table 2 shows the current usage of bamboo in different sectors. Besides scaffolding, bamboo is utilized industrially in paper mills, as scaffolding, for internal consumption in bamboo growing

households for making spoons, skewer, plates, trays, containers, mat, etc., handicrafts and miscellaneous items like incense sticks, ladder, ice cream sticks, etc. Also, some of it is illegally exported to Bangladesh and Myanmar. Current market of bamboo/bamboo products in India is estimated to be Rs. 4,500 crores expected to increase to Rs. 20,000 crores by 2015. Table 3 shows the market size of bamboo (specifically for construction and housing needs) in 2003 and expected market by 2015.

Table 2 Current Usage of Bamboo

Current Usage	Quantity (MT)
Scaffolding	3.4
Paper	2.5
Handicrafts	2.5
Miscellaneous	1.97
Illegal Exports to Bangladesh Myanmar	1.7
Internal Consumption	1.35

Table 3: Current Market and Expected Market of Bamboo (*Source: Planning Commission, 2003*)

Product/Application	Market Size 2003 (Rs. in Crores)	Expected Market by 2015 (Rs.in Crores)
Bamboo Shoots	4.8	300
Bamboo as wood substitutes	10,000 (import Value)	30,000 (in 20 years)
Bamboo Plywood	200	500
Bamboo Ply board (for trucks and railways)	1000	3400
Bamboo Flooring	100 (domestics) 100 (Export)	1950
Bamboo Pulp	100	2088
Bamboo Furniture	380	3265
Building Construction Material		
Scaffolding	340	861
Housing	NA	1163
Roads	NA	274
Bamboo grids for tiny cottage sector	NA	1000
Tiny and cottage industry Agarbatti, Industry **Miscellaneous**	394	600

The yield per hectare of bamboo in India is very low as compared to other countries like China, Japan, and Taiwan. As compared to China and Taiwan, India's productivity is one fourth to one fifth (Samir Jamatia, u.d). The annual yield of bamboo per hectare varies around 2 tons per hectare per annum against China, Taiwan and Japan which contribute about 80% to the world's bamboo market. The reasons behind the low per hectare yield are the poor management, unscientific exploitation and low investment in raising preferred bamboo species (Arnab Hazra, u.d).

Very little attention has been paid to ensure sustained supply of this raw material that result in constraining and reducing the potential benefits and value of bamboo applications. It could be increased to 4-5 times in rain fed area by ensuring proper grazing and management practices. It is estimated that only about 15.4% of the total Bamboo resources of India lie on private lands; as a result, 84.6% of the resources are unavailable for utilization in industrial purposes without excessive regulation getting in the way (FAO, 2005).

1.4 Need for Bamboo

The biggest anthropocentric reason to build with bamboo is its low cost that will easily shelter millions who could not normally afford a roof over their heads. India has a 60 million unit housing deficit which is one of the reasons that India is likely to face serious shortage of timber. It has been seen that with the increase in consumption and population the demand for timber as a raw material is set to increase while supply diminishes. According to the Planning Commission, the demand for timber is estimated to increase from 58 million cubic meters in 2005 to 153 million cubic meters in 2020 whereas its supply is projected to increase from 29 million cubic meters in 2000 to 60 million cubic meters in 2020 (T.R Manoharan, 2011). This gap has led to rising timber prices, which thus presents an opportunity for bamboo products, widely seen as more eco-friendly due to the quick regeneration of bamboo as compared to timber.

Moreover, the increased dependency on conventional energy intensive materials like cement, steel, bricks and timber, etc for construction have led to several environmental consequences including release of green-house gases during their production. With rising concern about climate change and sustainable development, bamboo has emerged as a highly promising building material as it consumes less energy in its production than cement, steel and brick. Bamboo is highly renewable and fastest growing material and has properties which make it suitable for construction.

Bamboo is widely used in many forms of construction, particularly in rural housing. These buildings are often simple and construction relying on a living tradition of local skills and methods. India has the huge potential of raising the market for bamboo based products if proper cultivating, management and marketing schemes with proper regulatory mechanisms are adopted while technology advancement and market driven changes have led to an increase in the use of bamboo based materials much still needs to be done.

2. MAJOR STAKEHOLDERS

Various stakeholders are involved in the lifecycle of bamboo. These include the government sector, private sector, research institutes, financial institutes as well as consumers. These actors play different roles in promoting the use of bamboo based materials in construction application through various advancement in technologies. The government has a major role in promoting and regulating use and the market. However, the support of research, financial and civil society organizations is essential to build and strengthen the value chain for bamboo. The role of various organizations is described below.

2.1 Government

Many organizations are working at national level in order to increase the use of bamboo.

National Level

Ministries: Various central ministries are taking initiatives for the development of bamboo sector in India.

- The Ministry of Agriculture: It has a centrally sponsored scheme (CSS) called Mission for Integrated Development of Horticulture (MIDH) in which National Bamboo Mission (NBM) is implemented as sub scheme in order to promote the growth of bamboo sector by increasing the area under bamboo cultivation and marketing of bamboo based products.
- Ministry of Environment and Forest: The Ministry under its National Afforestation Programme has an objective to improve and conserve the non timber forest produce including bamboo. The Ministry is involved in promoting bamboo plantation outside forest areas under the Social Forestry Programme. It has also undertaken bamboo development over degraded forest lands through Joint Forest Management (JFM) initiatives.
- The Ministry of Urban Development is promoting the bamboo based housing development projects to increase the usage of bamboo as construction material with the help of Housing and Urban Development Corporation Limited (HUDCO) and BMTPC.
- **Department of Science and Technology (DST):** The department has launched National Mission on Bamboo Application (NMBA) which is working on to improve the bamboo sector through technology promotion and dissemination for product, machine and tools and standards with the help of Bureau of Indian Standards. It is mainly looking after the application oriented research and development activity in bamboo sector and supporting the demonstration and entrepreneurial projects with a focus on value addition and commercialization. It has supported various bamboo board manufacturing units.
- **North East Centre for Technology Application and Reach (NECTAR):** It is an autonomous society, set up under the DST. The Centre looks at harnessing and leveraging niche frontier technologies available with central scientific departments and institutions. NECTAR has taken several initiatives to support bamboo sector in North Eastern region in terms of marketing their various products in major markets in India (Delhi NCR, Bangalore, and Hyderabad). It is involved in sensitizing major dealers/architects /interior- designers within these cities

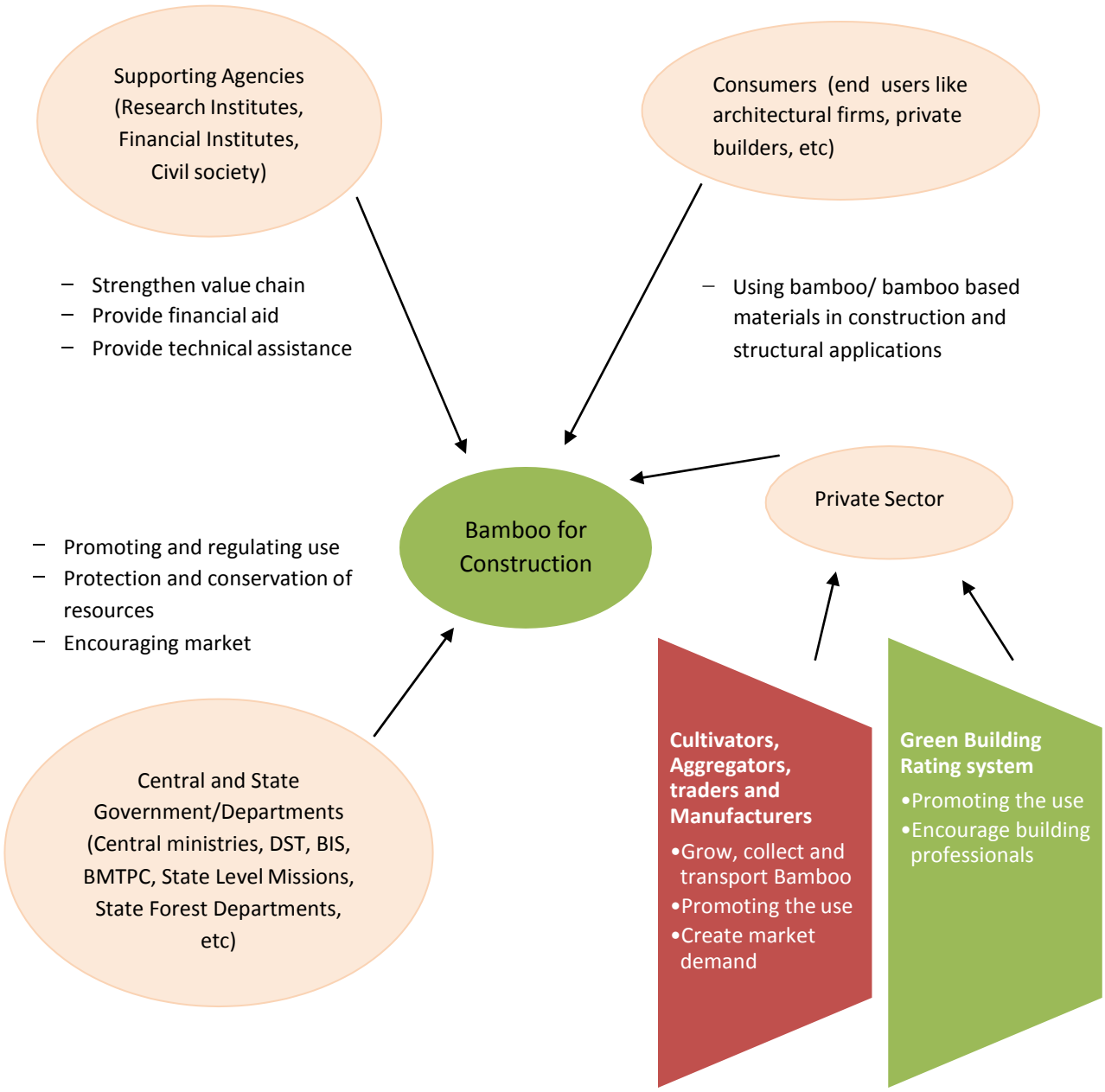


Figure 4: Key Stakeholders in Bamboo Sector

- Bureau of Indian Standards: It has come out with the standards relevant for utilization of bamboo and bamboo composite material in structural application like IS 13958: 1994 Specification for bamboo mat board for general purposes, IS 14588: 1999 Specification for bamboo mat veneer composites for general purposes, IS-15476: 2004 Bamboo mat corrugated sheets, IS 8242:1976 Methods of tests for split bamboos, IS 8295 (Part 1): 1976 Specification for bamboo chicks: Part 1 Fine, IS 8295 (Part 2): 1976 Specification for bamboo chicks: Part 2 Coarse, IS 6874:1973 Methods of

test for round bamboos, IS7344:1974 Specification for bamboo tent bamboos, IS 9096: 1979 Code of practice for preservation of bamboo for structural purposes.

- Building Materials & Technology Promotion Council (BMTPC): It is under the Ministry of Housing and Urban Poverty Alleviation. The Council strives to package proven innovative technologies for the benefit of entrepreneurs and is structured to undertake the task of extension and application of technologies and materials developed by research institutions on the ground with the backing of financial institutions and enabling regulatory environment. The council is actively involved in developing bamboo based technologies and promoting these technologies in the North-Eastern Region and other bamboo growing areas, by setting up Bamboo Mat Production Centers for processing of bamboo, encouraging commercial production of bamboo based products, construction of demonstration houses etc. It is also engaged in providing training to the local artisans in processing of bamboo. BMTPC has developed the technology for making Bamboo /mat Corrugated Roofing Sheets in Collaboration with Indian Plywood Industries Research & Training Institute, Bangalore.

State Level

- State Level Bamboo Missions: The National Bamboo Mission runs its programme through the State Bamboo Mission. The State Bamboo Mission is the nodal agency for carrying out all the activities mandated to the bamboo mission. Various states have come up with state level missions for bamboo development with different objectives in order to promote bamboo industry in India. States like Madhya Pradesh, Kerala, and Tripura have set up their own State Bamboo Missions in order to provide livelihood and economic security through various initiatives taken up under these state level missions and are playing very important role.
- Bamboo Development Agencies (BDA): At state level, both programmes of National Bamboo Mission & National Mission for Bamboo Application are implemented through Bamboo Development Agency and it is also responsible for disbursement of funds to the beneficiaries in non forest areas. BDAs are set up in order to encourage, start, organize, carry on, assist, lease, develop and regulate resources, plantation, utilization, research and development of bamboo. Orissa, Nagaland, and Mizoram have their own bamboo development agencies, set up by their respective government. Bamboo Development Agencies are under formation in Assam, Arunachal Pradesh, Sikkim, Meghalaya, and Manipur (National Bamboo Mission, u.d).
- State Forest Departments: These departments play an important role in providing the database on bamboo resources available, its potential and its utilization in their respective states for proper management of its resources.

2.2 Supporting Institutes

Research Institutes

Many research institutes have taken up the researches on bamboo sector.

- Indian Institute of Technology (IIT): The institute has number of ongoing research projects related to bamboo as building material including structural aspects of bamboo, its characterization, bamboo as

a green alternative to concrete and steel. The institute is involved in researches that can provide more information regarding the use of bamboo as a construction material which can further help in proliferating its use and bringing new and innovative bamboo based materials for construction purposes. The institute has been involved in the research projects such as testing of human load, dead load testing on small bamboo structures like bamboo arch, bamcrete arch, etc. IIT, Delhi has also signed a memorandum of understanding (MoU) wit HUDCO, in 2008 for establishing a Bamboo Centre of Excellence (BCE). This centre is exclusively for bamboo; it would show case technologies, display products, train people, hold workshops. It would be fully equipped with machinery and equipment by HUDCO, and utilise structures made of bamboo and bamboo composite material.

- Cane & Bamboo Technology Centre (CBTC), Guwahati: CBTC has carried out a NMBA supported project for development and demonstration of structural applications involving the use of bamboo and based material. This project adapts traditional techniques of construction, to build well designed, architecturally innovative and comfortable structures, with bamboo and bamboo composite material as the dominant structural elements.

Figure 5: Demonstration House by IPIRTI-Bangalore, March, 2001

- The Timber Research and Development Association (TRADA): TRADA has been involved in bamboo development projects since 1994, funded by the UK department for International Development (DFID). It is working with partners in India for developing bamboo based building systems that are affordable, strong, and sustainable. It also helping in dissemination of knowledge, skills and training to the target group through various media.
- Indian Plywood Industries Research and Training Institutes (IPIRTI): IPIRTI is an autonomous body under the Ministry of Environment & Forest Government of India. It is a creative organization dedicated to developing new environment friendly technologies for the wood based industry. One of its areas of applied research is evolving technologies for manufacturing wood alternates from natural/renewable fibers. It has also come up with new and innovative bamboo based products such as Bamboo Mat Corrugated Roofing Sheets, Bamboo Mat board, Bamboo Mat Veneer Composites. IPIRTI has been involved in the construction of affordable housing and earthquake resistant housing systems using bamboo and its composites.
- International Network on Bamboo and Rattan (INBAAR): It is an intergovernmental organization set up by Canada's International Development Research Centre. INBAR membership has grown to include 38 countries, with regional offices across Asia, Africa and Latin America. It is dedicated to promote sustainable development with bamboo by consolidating, coordinating and supporting strategic and adaptive research and development. Under its sustainable construction work they are promoting the use of sustainable bamboo buildings. They are focusing on three key themes under Sustainable construction with bamboo:

- Sharing and adapting traditional bamboo construction technologies.
- Innovation of new bamboo construction technologies and design
- Providing policy support for bamboo-based construction.

INBAAR is also involved in bamboo related research focusing on bamboo and climate change, Trade development of bamboo, etc.

Institutes like Centre for Indian Bamboo Resource and Technology (CIBART), Tripura Bamboo and Cane Development Centre (TRIBAC) , Konkan Bamboo and Cane Development are also making efforts to increase the use of bamboo in construction. Efforts of all these research institutes have led to the development and promotion of new and advanced bamboo products with latest technology.

Financial Institutes

There are institutions that are financially supporting various projects related to bamboo in order to develop this sector.

- National Bank for Agriculture and Rural Development (NABARD): NABARD has accorded special status for development of bamboo farming in consonance with the action plan prepared by National Bamboo Mission for upgrading the bamboo economy. NABARD aims at developing bamboo farming, processing and marketing as a mainstream activity by changing 'forestry mindset' into 'farm mindset'. It is envisaged to provide credit support for development of bamboo.
- Small Industries Development Bank of India (SIDBI): It was set up under an Act of Indian Parliament, is the Principal Financial Institution for the Promotion, Financing and Development of the Micro, Small and Medium Enterprise (MSME) sector. The institution is providing various schemes for Micro, Small and Medium Enterprises. It is also providing financing schemes for sustainable development-cleaner production. It support bamboo based units specially the tiny and small industry making utility items or mass consumption through its schemes.
- Export Import Bank of India (EXIM): Export-Import Bank of India is the premier export finance institution of the country under the Export-Import Bank of India Act 1981. Its role is to enhance the export from India. It is promoting bamboo and bamboo products for export and providing finance for commissioning market surveys and studies.

Bamboo House India (BHI)

It is a social enterprise, striving to create chain of bamboo showrooms across the country which shall promote & market all bamboo based products under one roof starting from Bamboo pen to Bamboo Housing Structures. BHI works through a hybrid model, a 'for-profit' component and a 'non-profit' component. "For profit" activities "Bamboo House India" involves sourcing, designing, retailing, exhibiting and developing markets and "not-for-profit" activities are handled by "Bamboo Artisan Welfare Society" involving skill training & upgradation, design development & capacity building. The organization is taking initiative of opening showrooms for bamboo products, artifacts, materials etc. BHI is also encouraging the artisans to come up with bamboo based materials by providing them with interest free- cash in advance for their orders which allows artisan to purchase equipment and raw materials without going into debt by taking out loans with high interest rates.

Civil Society

There are enterprises and NGOs that are promoting the use of bamboo and are taking initiatives to bring bamboo in the mainstreaming of construction. These organizations are helping in building networks and partnerships for bamboo sector as well as in innovating new bamboo based materials with their market establishment. Bamboo House India is an example of such an enterprise.

2.3 Private Sector

Market-driven changes in the bamboo sector have encouraged communities previously not involved with the resource to enter a bamboo-based economy. Now, additional applications of bamboo have propelled it into new markets, increasing profits and income for most participants in the sector.

Collectors and Aggregators

Collectors have an important role to play as they are generally responsible for growing and harvesting bamboo and carrying out primary processing (cleaning, drying, scraping and splitting). The Cultivator then provides the Bamboo produced to the Aggregator.

Aggregators or Middlemen are responsible for the collection of Bamboo and sorting of this Bamboo depending on its grade in terms of quality. These aggregators supply bamboo to traders who are involved in transportation of Bamboo.

Manufactures

Manufacturers are coming up with new and innovative bamboo based materials which can be used for construction purposes. Advancement in technologies related to bamboo in constructions has encouraged the manufacturers to come up with different bamboo based materials in the market. Manufacturers like AB Composites Pvt. Ltd., Sampoorna Bamboo Kendra, Arunachal Plywood Industries, UNIFAB Bamboo Tech Pvt. Ltd. have come up with bamboo based products such as bamboo panels, bamboo boards, bamboo prefabricated houses, bamboo cottage, bamboo flooring etc. Box-2 Shows the role of a manufacturer (Wonder Grass) in proliferating the use of bamboo based construction materials. Manufacturers are helping in creating a niche for these products by promoting their materials either through online portals (indiabambooallinall.com, indiamart.com, tradeindia.com, etc) or by promoting their bamboo based products through trade shows and exhibition at national and state level.

Wonder Grass: Wonder Grass is an enterprise offering end-to-end solution for bamboo based building systems. The vision is to bring bamboo and bamboo based building system into the mainstream of Building Industry. Wonder Grass is working on building bamboo habitat through Design-innovation and development Collaborate with Building-material research establishments and other technical institutions to undertake assignments for development of innovative building systems. The enterprise is attempting to develop building systems for large span structure and making efforts for standardizing them so that these can be put in market for commercial application.

Rating Systems

Green rating systems in India (LEED/GRIHA) help in promoting the use of bamboo as construction material by encouraging the building professionals to use bamboo related buildings. IGBC Green Home provides four points for the use of rapidly renewable building material in the building. In GRIHA under its Criterion 16 (Reduce volume, weight, and construction time by adopting efficient technologies such as pre-cast systems) and Criterion 17 (Use low-energy material in interiors) professionals can gain 4 points in each by using low-energy materials/efficient technologies in structural and non structural applications or in interiors in each of the three categories of interiors (internal partitions, paneling/false ceiling/interior wood finishes/in-built furniture door/window frames, flooring).

2.4 Consumers

With increase in awareness about bamboo uses in construction, architects are taking up bamboo based materials to be used in the construction of houses. Many architectural firms are specialized in bamboo buildings and seek to promote bamboo as a renewable, sustainable and strong building material.

3. POLICY INITIATIVES: GOVERNMENT MISSION AND POLICIES

There is the need for market establishment of bamboo products, with product testing for quality being a necessity which will ultimately lead to market acceptability. In this regard, various missions at national and state level have been mooted by the Planning Commission, Ministries and several other organizations to accord bamboo development a strategic role in rural economy, poverty alleviation, and bamboo based handicrafts and industrial development. The Government of India has several policies to support the bamboo sector in India. These policies include promoting bamboo plantation, strengthening bamboo based handicrafts, and developing bamboo based technology applications.

3.1 National Level

- National Mission Bamboo Application (NMBA) : NMBA, an autonomous organization under Department of Science and Technology supports:
    - Application oriented research and development activity,
    - Utilizing bamboo for constructional application
    - Innovation with different construction techniques
    - Sets benchmarks of quality of construction functionality, strength, and safety and aesthetics.
    - Combining bamboo with locally available appropriate, newly developed, and non conventional materials.

  NMBA has developed and commercialized technology and applications in the segments of developing bamboo based wood substitutes, conversion of closed plywood units to bamboo ply, development of pre-fabricated bamboo based housing structures and other technological applications of bamboo. National Mission on Bamboo Application had launched a web portal – www.indiabambooallinall.org for the marketing of all Indian bamboo products made by enterprises, organizations, cooperatives or communities anywhere in the country. The objective of the project is to provide a web based

platform for enterprises engaged in production of bamboo goods and bamboo applications to showcase their products to the worldwide markets so that they are able to expand their business opportunities.

There have been several other initiatives taken up by NMBA in order to increase the bamboo development including activities like product promotion for creating awareness, taking up of projects for cluster housing. The mission is taking up entrepreneurial projects like establishment of units for bamboo mat, bamboo boards, bamboo ply and bamboo mat composite sheets. National Mission on Bamboo Application has supported activities for bamboo sector in North-East State (Assam, Mizoram, Tripura, Etc), Andhra Pradesh, Jharkhand, Gujarat, Kerala, Uttaranchal and Orissa.

- National Bamboo Mission: The Ministry of Agriculture, Government of India has launched the National Bamboo Mission with 100% central assistance with a total budget of Rs 568 Crores for a duration of 5 years (Last year of 10th plan 2002-2007 and first four years of 11th Plan 2007-2012). The mission targets 176,000 hectares of fresh plantation with 88,000 hectares each in forest and non-forest areas. It has been recommended to integrate this schemes and other central scheme of horticulture development and the same may be named as "Integrated National Horticultural Development Programme" for the 12th year plan 2012-2017 (Planning Commission, 2011).

Table 4 Cumulative achievements of National Bamboo Mission till 2013-14 (*Source: National Bamboo Mission)*

S.No.	Description	Targets	Achievements
1.	Plantation in Forest Area (in ha.)	2,36,463	2,10,863
2.	Plantation in Non Forest Area (in ha.)	1,32,690	1,06,729
3.	Improvement of Existing Stock (in ha.)	92,447	73,886
4.	Training of Farmers (in No.)	48285	37,935
5.	Training of field functionaries	9,947	6,909
6.	Nurseries (in no.s)	1,647	1,424
7.	Micro-irrigation	6,359	5,032
8.	Post Harvest Storage and Treatment Facilities	59	24
9.	Pest and disease management (ha.)	1,04,061	83,249

- National Building Code (NBC): It is a comprehensive building Code, a national instrument providing guidelines for regulating the building construction activities across the country. It has recently included the information related to the various bamboo species available in India and their physical and mechanical properties, grading for structural purposes, its durability and treatability and also design considerations in its Section 3B, Part-6 of National Building Code (2005). The section relates the use of bamboo for constructional purposes and ensures quality and effectiveness of design and construction using bamboo. It also covers the preservative treatment, design and jointing techniques with bamboo which would facilitate scientific application and long-term performance of structures. It covers guidelines so as to ensure proper procurement, storage, precautions and design limitations on bamboo.

3.2 State Level

Many initiatives have been taken by the State Governments in order to proliferate the use of bamboo and for the development of its industry. National Bamboo Mission and National Mission on Bamboo

Application also plays major role in supporting the activities at state level for bamboo sector development.

Name of the Policy	Objectives	Approach	Achievements
Tripura Bamboo Policy, 2001	To develop bamboo sector in the State. Provide an impetus to conservation; Develop the resource, both in forest and farm areas Improve the utilization of bamboo and Develop effective marketing for the bamboo-based products.	Adopting scientific means (tissue culture) Practicing improved cultivation and management using community based initiatives Establishing small and large enterprises	Inauguration of bamboo tiles factory Increase in turnover to Rs. 115 crores Setting up of bamboo park Online B2B[2] & B2C[3] marketing through Indiamart.com and eBay.com 40,591 persons trained
Tripura Bamboo Mission, 2007	Sustain growth in bamboo sector Increase turnover from Rs. 95 crores to 200 crores Provide production and commercial infrastructure, technology, marketing support, capacity building and product diversification Provide livelihood and employment opportunities	Develop institutional structure Building enterprises on commercially sustainable models Mobilization of private investment in bamboo sector Promoting Plantation	
Kerala Bamboo Policy	Protect and conserve biodiversity Enhance resources Improve bamboo productivity Improve and promote traditional bamboo houses and establishment of modern bamboo houses Promote bamboo sector development	Database Development Protection and Conservation of Biodiversity Sustainable Management of Resources Resource Enhancement Development of bamboo based industries Livelihood Security of the Bamboo Dependents Enactment of Grower Friendly Rules and Regulation Environmental protection Skill development Scientific Input and Research Activities Publication and Awareness	Approval to conduct Kerala bamboo fest every year. Treatment facilities being inducted Preparation of a data base in the form of an annotated bibliography of bamboo literature.

[2] Business-to-business (B2B) describes commerce transactions between businesses, such as between a manufacturer and a wholesaler, or between a wholesaler and a retailer.

[3] Business to consumer is a transaction that occurs between a company and a consumer,

Kerala Bamboo Mission,2003	Promote cultivation of bamboo Promote development of new products and innovative designs and usages Promote research in the bamboo sector	livelihood and economic security through broad-based association linking Government, NGOs, SHGs, and Local bodies	
Madhya Pradesh Bamboo Mission, 2013	develop a new line of bamboo products by bamboo artisans for national and international marketing (market) promote and facilitate traditional and non - traditional bamboo based artisans	Skill development Increasing supply of quality bamboo Availability of advanced tools and equipments	Road map has been made Organized bamboo fest Organized bamboo workshop Organized Bamboo Utsav
Nagaland Bamboo Policy, 2004	Protect & conserve rich bio-diversity Sustainable development and utilization of bamboo resources Promote bamboo plantation Promote bamboo as an essential wood substitute Promote awareness and understanding of bamboo	Development of bamboo as resource: Development of bamboo forest area. Bamboo Plantation Development Development of Bamboo as an Enterprise: Promote bamboo based Industries Create awareness of the uses and value of Bamboo Promote and Develop traditional usage of Bamboo	Marketing channels established for bamboo products Demonstrated high end and architecturally complex structures involving use of bamboo and bamboo composite material at village Kisama

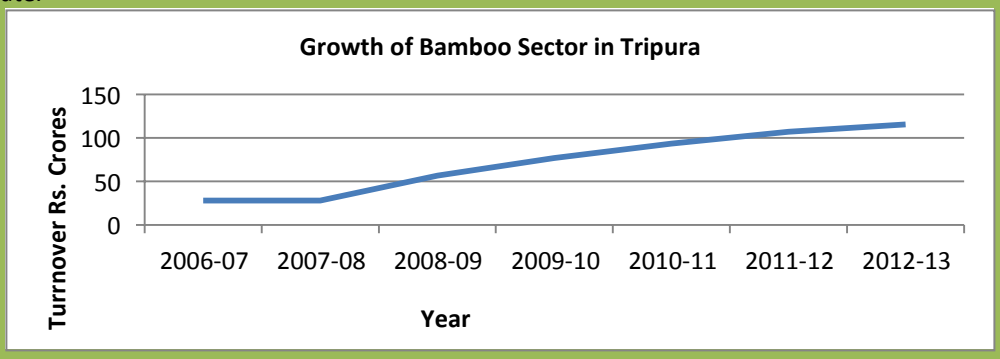
Other states like Chhattisgarh, Orissa, Mizoram, Jharkhand etc, are also taking different initiatives in order to promote the use of bamboo. Sates have their own policies/plans/missions which are working for the development of bamboo industry. Many of these states have developed bamboo development agencies (Odisha Bamboo Development Agency, Mizoram Bamboo Development Agency, etc) which have been implementing the scheme of National Bamboo Mission and National Mission on Bamboo Applications. Box 3 depicts the growth of bamboo sector in Tripura.

State Bamboo Fest: These fests are organized in Madhya Pradesh and Kerala as a part of marketing the bamboo products made in States. Exhibition stalls are set up to display products such as handicrafts, building construction and structural applications, industrial products, etc. Artisans, Master craftsman, NGOs, Micro & Small enterprises, Government controlled institutions etc. participate in the Fest

Growth of Bamboo Sector in Tripura (Policy Initiative)

Tripura has vast bamboo resources in its forests. It is a major producer of bamboo based craft products in India. The state has a long tradition of bamboo providing livelihood to large number of its inhabitants. The State Government had launched the Tripura Bamboo Mission in the year 2007 under a PPP framework, for integrated development of the sector. The State has formulated a state bamboo policy and also signed a MoU with the International Network for Bamboo and Rattan (INBAR) for effective implementation of the Bamboo policy. As a result of these initiatives:

- Tripura has registered a 240% absolute growth rate and 35.8% compound annual growth rate in the production of bamboo-based products
- Target to be achieved by 2017 for bamboo sector turnover is of Rs. 200 Crores where as the target achieved in 2012-13 is of Rs.115.56 crores.
- Government has organized at least 500 training programmes (in which 22,000 beneficiaries participated and 10,000 incremental livelihoods created).
- State is setting up a Tripura Bamboo Park for value adding technology intensive bamboo industries in the state.



The State has been able to achieve these targets by taking up different initiatives like launching of Tripura Bamboo Plantation programme, establishing of skill training centers, making and publicizing short film on model plantation & its best practice

4. CATALYSTS AND CONSTRAINTS IN BAMBOO DEVELOPMENT

The bamboo sector in India is still a part of the informal and backward rural economy. There has been an inability to grab the large potential. Bamboo is available in different forms or products, with improved technology of preservation or protection and jointing. Despite technology advancements, bamboo is not used much in construction. These catalysts and constraints are faced at all the stages of value chain. The value chain usually follows the following structure discussed below:

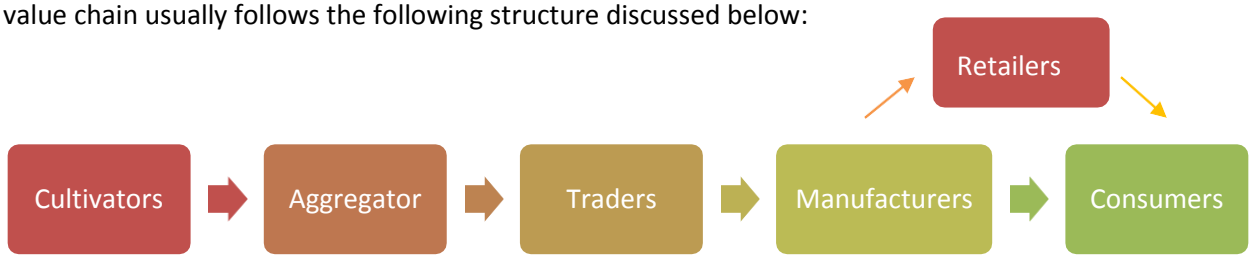


Figure 6: Value Chain in Bamboo sector

Bamboo collectors are defined as those who grow bamboo and collect it from forests. They are also involved in the primary processing of bamboo and supply it to aggregators or middlemen who are responsible for the collection of Bamboo and sorting of this Bamboo depending on its grade in terms of quality. The bamboo is than supplied to traders who take them to the urban market or manufacturers who transfer bamboo into several utility products that can be sold to the consumers.

The factors behind the poor development of bamboo are found to be at policy level and due to lack of awareness among the stakeholders. Both the law and lack of awareness about its application are inhibiting the bamboo based construction from taking shape.

China's Success in Bamboo Development

China has the largest bamboo resources in the world, with between 300 to 500 species. Timber shortage in China led to bamboo development by government and recognition of bamboo as an ideal substitute for timber. With changes in reforms and market liberation the bamboo sector has undergone great changes and become increasingly important. Changes in the land tenure and adoption of the household responsibility system in which farmers were encouraged to lease collectively owned bamboo forests under contract. 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. According to the contract, farmers were entitled to 15-year user rights to bamboo forests (later modified to 30 years) and were allowed to keep or sell the bamboo products after paying 5-10% of the lease fee. Local government provides the technical assistance to farmers in order to improve productivity. Along with this, changes in the market reforms have been carried out abolishing the state's monopoly in purchase and sale of bamboo products. The introduction of free market has contributed to the growth of bamboo based enterprises in China.

4.1 Regulatory mechanisms putting restrictions on Bamboo Development

The initiatives both at national and state level which include National Bamboo Mission, National Mission on Bamboo Application, State Bamboo Missions, etc has proliferated the growth of bamboo leading to the increase in the forest area from 12.8% in 2003 to 20% in 2011. However, there are some policy barriers that hinder in the path of bamboo sector to flourish. These include Indian Forest Act 1927, The Forest Conservation Act 1980, Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006, govern forest & forest produce and bamboo falls within the purview of all the three acts thus posing trade and transit restriction on bamboo.

Trade and Transit Restriction: Indian Forest Act (IFA) 1927, considers bamboo as a tree and therefore felled bamboo is considered as timber. This act prohibits harvesting of bamboo in reserved forests except by the Forest Department whereas harvesting of bamboo from protected forest is done with written permission of the forest department as per the guidelines. It also spells out the transit rule for bamboo where control of forest produce (bamboo) is vested with the state government.

Forest Conservation Act 1980, is another act which is responsible for the trade restriction of bamboo as it empowers the central government in directly managing country's forest and restricts the allotment of forest land for non forest purpose (breaking up or clearing of any forest land for cultivation of crops including bamboo).

Recognition of Forest Rights Act 2006, vests the right of ownership and the right to collect, use and dispose of bamboo in the forest-dwelling communities, as a part of their traditional rights. The FRA restricts the development of bamboo industry by attempting to vest the right to trade in bamboo in the tribals. All these acts lead to restriction on both transit and trade of bamboo as the transportation of bamboo requires transit permit (Centre of Civil Society, u.d).

Under IFA, 1927 bamboo is also subjected to harvesting permissions in many parts of the country if grown on private lands. The felling and transportation of Bamboo grown on private land requires a Certificate of Origin and a transit pass, which must be obtained for each individual shipment and obtaining which may take up to 6 months. This has discouraged private plantation.

In states like Kerala, Madhya Pradesh, Tripura, etc bamboo grown in captive plantations is not a forest produce and therefore harvesting permission or permit of transporting bamboos thus grown is not required, due to which the states have been able to develop its bamboo sector well.

Lack of Quality Control: Even though there are standards given by BIS and NBC for bamboo, it is not being utilized that much as there is no control system in place to check whether these standards are being followed or not.

Lack of Prioritization: There has been no prioritization done for the distribution of bamboo in its various industries. Majority of the bamboo is supplied to paper and pulp industry and scaffolding after which very little is left for the consumption of other industries this is due to the more market demand for these materials in which bamboo is used as the raw material. Therefore, bamboo industries also have to deal with the irregular supply of bamboo to different industries.

4.2 Lack of awareness has been the bottleneck inhibiting bamboo from taking shape in construction

Various government and private organizations are involved in organizing awareness, capacity building and training programmes for cultivators, field functionaries, entrepreneurs, etc in order to generate awareness about the various technologies available for making bamboo more durable, to help increase entrepreneurs in developing market linkages through various promotional strategies but these initiatives are growing steadily. However certain knowledge gaps still plague the sector.

Perceptions about Bamboo: There is lack of awareness among the important stakeholders and a widespread stigma of bamboo as poor man's timber. People in India perceive that bamboo available is of low quality if to be used as construction material or in modern bamboo housing. This is because consumers are unaware about Bamboo properties which make it reluctant to use as a construction material instead of traditional wood, steel, etc.

Lack of Management and conservation: Less importance is given (in case of bamboo) to the application of bio-technology, genetic engineering, identification of genotypes and gene bank and in-situ and ex-situ conservation in order to increase the productivity. There is insufficient data regarding resource and usage pattern. The data is usually not available or is outdated which leads to difficulties in adopting concrete plans for management and planning for resource allocation. Due to improper management and conservation practices India's bamboo sector has to face the problem of poor yield. India, despite having

the largest area under bamboo has low yields. The average yield for bamboo in India is 2-3 metric tons per hectare. As compared to China and Taiwan, India's productivity is one fourth to one fifth**.**

Poor Quality: The people harvesting bamboo has less knowledge related to quality and quantity of bamboo they sell to the trader. Aggregator/middle men perform the function of grading and sorting. Due to their lack of expertise in processing and treating, manufacturers still receive unsorted bamboo.

Moreover, despite of having new and improved technologies for treatment of bamboo these are not being utilized properly by the aggregators due to lack of awareness and technology transfer that again leads to the supply of poor quality bamboo to the manufacturers.

Lack of access to inputs in Production and trained labors: The majority of region with high potential of bamboo lack access to basic inputs or better technology for example Bamboo production requires intensive electricity and water as well as several chemicals for primary and secondary processing of culms. Moreover, Indian artisans are naturally trained for handicrafts product but lack in the efficiency and skills required for construction purposes like jointing techniques for bamboo.

4.3 Focusing on modern technology and financial support can expand bamboo market in construction

Technology advancement in bamboo sector is steadily increasing the involvement of manufacturers. Lots of manufacturers are coming up with new and innovative bamboo based materials in the market to create a demand for these materials. They are promoting and selling bamboo based materials through trades, exhibition, online portals and by directly contacting customers. Urban phenomenon like Green ratings have also helped in creating a demand for bamboo based materials among the building professionals. There are enterprises that are coming up with showrooms that can promote and sell bamboo based materials. Beside these drivers market of bamboo is facing the following barriers:

Volatility in Market Prices: The prices in this sector are highly volatile and fluctuating quiet frequently. This has discouraged private forestry in the sector and contributed to the proliferation of middlemen, contributing little value and reducing remuneration to the grower. This can be seen through the example of Agarbattis in Tripura, where the cultivator/grower sells the raw bamboo at the rate of Rs. 4-5 per kg and by the time it reaches the retailer and traders in the form of Agarbattis or finished good it is sold at the price of Rs. 250-400 per kg (Center for Civil Society, 2013). No pricing method has been adopted by the government or institution and therefore the price of bamboo products vary from trader to trader. Bamboo farmers are usually unaware of prevailing market prices and rely upon the traders to determine their prices for them (Rao et al, 2009.) This is in contrast to farmers for many other crops including rice and wheat, whose prices are available continuously and are continually updated.

Market Competition: Bamboo retailers do not generally want to stock bamboo based materials like composites, boards, veneers, etc due to their deficient demand. Many bamboo manufacturers choose to advertise and find Buyers through online portals to prevent loses that may occur from stocking the bamboo material.

Bamboo has to face stiff competition from other products in the market. Products like wood composites, wood and plastic composite, etc are preferred more than bamboo based materials as people are not aware about the properties of bamboo as a wood substitute.

For finances, ministries and banks provide funds for supporting bamboo based projects through organizations like HUDCO, NABARD, etc but still there is lack of financial access to people for setting up production units. These organizations do not provide financial support to individual private firms. Mainly the financial support is provided for increasing the plantation of bamboo, training of farmers and in development of the nurseries.

Lack of Financial Support: Bamboo industry lacks the access to finance as there are very few financial institutions providing support for setting up the bamboo industry. Poorer farmers face higher risks and uncertainties in undertaking investments, and need more information to evaluate these opportunities Due to lack of financial support the person who wants to set up an industry has to undergo through the barrier discussed below:

Lack of capital intensity in Production: This is primarily due to the high costs of machinery required for processing and treating bamboo so that it can be used in construction or in developing bamboo based materials, as a result of which starting a small-scale Bamboo industry faces significant hurdles.

4.4 Strengthening institutions and Government scheme can proliferate bamboo use in construction

Various social enterprises (Bamboo House India, Wonder Grass, etc) support the bamboo sector through technological innovations in order to bring new and innovative technologies that can be used to develop bamboo based constructional materials. These enterprises help in skill training & up-gradation, design development & capacity building of field functionaries and farmers to enhance the use of bamboo in construction sector. Beside the efforts of these enterprises bamboo is facing the barriers related to partnerships and institutions.

Lack of Promotional Schemes and Support: Unlike, other sectors such as tea, coffee, etc bamboo is not well supported by the government, for example; refer Government support to Tea sector. Due to lack of institutional set up bamboo funds and financial support can't be utilized efficiently by the beneficiaries most of the fund goes into the plantation, protection and conservation of bamboo resources. There has been limited effort to transfer technology, enhance local capacity and ensure long-term access to the raw material.

Lack of institutes for technological innovation is also acting as a hindrance for bamboo sector. Since, improvement in

Government Support to Tea Sector

Tea sector has grown tremendously in India. Since 1850 Initiatives have been taken from formation of Indian tea Association in 1881 and Tea Board in 1954 to the action plan in five year plans. Government of India has taken steps from time to time for developing the tea sector which has also encouraged the emergence of private entrepreneurs in this sector. Schemes like Plantation Development Scheme, Quality up gradation and Product diversification, Market Promotion Scheme, research and development scheme, etc have led to the growth of tea sector in India. Initiatives for tea sector development:

- Tea Board is regularly coming up with new schemes for development of tea sector through which it is providing promotional support to Tea Association, brand support for packaged teas of Indian origin, etc.
- It is involved in conducting tea researches in India covering the basic, applied and regulatory aspects such as plant improvement, production and protection; tea quality, tasting, processing etc.
- The Board is also promoting the tea sector by market development activities such as market surveys, analysis, tracking consumer behavior, etc.

technology and more value addition will increase the use of bamboo among the developers/architects. More institutes should be encouraged to come with new and latest technological innovations in bamboo sector so that more value added bamboo based products can be brought out that can be used for construction purposes as a substitute to wood, steel, etc

The above challenges are seen at different stages of value chain from production to consumption which results in minimal level of value addition, capital intensive production and a generally low level of quality. In order to proliferate the use of bamboo in construction all these constraints need to be taken care off.

5. CONCLUSION

India having the largest reserves of bamboo in the world is dealing with the shortage of bamboo as a raw material in its industries. Presently it is underutilized and found in abundance. If bamboo sector has to be grown beyond the certain level the regulatory restrictions on trade and transits need to be taken care off. India can have 4-5 times better productivity then now and is expected to have an increase in the market size by 2015 if proper management, cultivation and plantation practices are followed with proper market linkages. Thus, bamboo can play an important role in meeting the future human needs of timber used as input for housing and construction. In the light of increasing demand of raw materials for housing and construction, including timber and decreasing forest area, bamboo based materials can serve as an alternative in bridging the gap of demand and supply.

Changes in Regulatory Mechanism: The restrictions on trade and transit of bamboo are the biggest impediment to the bamboo based industry and applications. Irregular supply of bamboo is affecting the development of bamboo in India. Promotion of private plantation can deal with this problem but until and unless the transit and harvesting restrictions are tackled the delay and cost escalation will continue to throttle the sector. Amendments in the laws can help in the growth of bamboo sector. Certain States like Tripura, Kerala, Madhya Pradesh, etc have been doing so.

Governmental organization can play a strong promotional role which would help generate awareness on bamboo products, run a nationalized campaign and help develop product-market linkages. Government can help in establishing more number of bamboo product promotion showrooms such as PURBASHA in the case of Tripura. It can also encourage private entrepreneurs to enter bamboo sector as the increase in promotion will help in increasing the awareness among the people about the bamboo use in construction. Further, this will help in increasing the demand of bamboo in construction sector.

Innovation, New Technology and Product Options: Advancement in technology and innovation can encourage more number of manufacturers or manufacturing units to come up. Further, there is a need for market establishment with product testing for quality being a necessity which will ultimately lead to market acceptability. There is a need to set up technology institute in order to train people about new and advanced bamboo technology.

Strengthening of Research Institute: It can tremendously help in the development of bamboo sector in order to develop better High Yield Variety (HYV) bamboo yield, conservation of existing genetic material in bamboo industry. These institutes can help in developing new and better technology for primary,

secondary processing of bamboos. Institutes can help in promoting researches in bamboo sector regarding data on the usage pattern, bamboo resources, species, etc. Bamboo sector lacks the data base; regular surveys could be conducted in order to have adequate baseline information for proper planning, management and allocation of bamboo resources.

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