General Article Chapter- 11

BAMBOO: THE GREEN GOLD

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ABSTRACT

The world has over exploited its natural resources. The urge to conserve the biodiversity has resulted in implementation of various laws and sustainable development ideas in people. The restrictions in felling of trees in forest resulted in limited source of raw wood. This in turn drew the world's attention in identification of suitable alternative. Bamboo has emerged as a forerunner in this field due to its easy availability, fast growing nature and good mechanical properties. A change in legislation in the Indian Forest (Amendment) Act, 2017 allowed free movement of bamboo from farmers to industries. This is going to boost the industry production and its utilization. Bamboo has been used in various sectors and mainly as handicrafts. This general article aims to discuss the sectors where bamboo is in use and aims to give an idea where it can be improved.

Keywords: Bamboo, sustainable development, mechanical properties, handicrafts, sectors

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Introduction

Bamboo has traversed a long path with a change in perception from it being termed as 'Poor Man's Timber' to being acknowledged as 'Green Gold' (Vyawahare, 2009). Importance of bamboo has been understood and its demand has increased since last decade when the search for an alternative source of wood accelerated. This increase in the demand of bamboo over the last decade could be attributed to the growing awareness about the concept of "sustainable development" (Carlos, 2004). Sustainability calls for balancing short term business interest and long term development of both the society and company itself (Gupta and Kumar, 2008). Bamboo is an abundantly available renewable material (Mohamed et al., 2007) wood resource that creates an opportunity for the struggling wood based industry with its excellent strength (Limaye, 1952; Sekhar et al., 1962). The lead towards the development of rural folks and thereby creating a chance to strengthen the economy depends largely on bamboo resource as it provides job opportunity and an income source for people (Gowri and Saxena, 2003; Moktan, 2007).

According to a report by Grand View .Research, Inc., the bamboos market size is projected to reach USD 98.3 billion by 2025 globally and is expected to grow at a Compound Annual Growth Rate (CAGR) of 5.0% over the forecast period. Moreover, it is predicted to show swift growth because of the growing infrastructural development and increasing dependency on sustainable resources for the furniture industry globally (Bamboos Market Size & Share, Global Industry Report, 2019). India has bamboo forest of around 90-lakh hectare, which is approximately 30% of the world's bamboo resources, but India captures just 4.5 percent of the world market in bamboo, but China with just 40-lakh hectare holds about 50 percent of the world market.

Bamboo Industry in India

There are more than 1,500-documented utilities of bamboo (Khan and Hazra, 2007) and all this is set to contribute in the value addition of bamboo in India. From utilizing bamboo as a wood substitute and composites for structural purpose to food products, fibers and fabrics, the bamboo shows potential growth. The Planning Commission's 2003 report, which detailed the creation of the National Mission on Bamboo Technology and Trade Development, focuses on harnessing the potential of Bamboo as a crop in a multi-disciplinary fashion (NBM Operational Guidelines, 2003).

Bamboo is a traditional material with multidimensional uses, having its main market with bulk demand in paper industry, infrastructure and horticulture (Tambe et al., 2020). In spite of its versatility, the bamboo has failed to mark its presence in the furniture industry of India. In recent years, bamboo has been in demand because of increased production of round and laminated furniture, parquet and pulp (Tang, 2009). With the advancement in the adhesive bonding and processing technology, strand woven outdoor flooring has drove attention in China and their products have been popularized in United States, Europe and in the Southeast Asian countries (Nugroho and Ando, 2001; Van der Lugt et al., 2006; Sun et al., 2012).

Bamboo has become bread owners for millions of poor traditional artisans as well as small scale industries (Bonilla et al., 2010; Sawarkar et al., 2020). Bamboo has been chief raw material in big industries like paper making, house scaffolding, bamboo boards,

fiber boards, charcoal (Chung et al., 2002; Awoyera and Ede, 2017; Nguyen et al., 2018). Of the 1,500-documented utilization of bamboo (Khan and Hazra, 2007), top sectors are pulp and paper, rural building materials, agricultural implements, packaging, handicrafts, ladders and such other (Li and Kobayashi, 2004; Sosola-Banda and Johnsen, 2005; Boruah et al., 2019). Other field involves fiberboard making, cellulose acetate making and mitrocellulose making (Tang, 1997; Yang, 1997; Liu and Liu, 2011).

Bamboo Furniture and Handicrafts

Bamboo craft and traditional woven products have been in use in South East Asian countries like Malaysia, Philippines and Thailand over a long period of time. Of these, bamboo mats, plaiting material and basketworks top the international market (Tyagi et al., 2011; Porras and Maranon, 2012). Industrial scale utility of bamboo furniture is still new in India. The consumer in India has not been much aware of the potential of the application of bamboo in furniture. Traditionally bamboo furniture were made of round or split bamboo but with the advent of technology and new machineries, a new type of furniture known as "pack-flat' or 'knockdown' furniture emerged which uses glue-laminated bamboo panels (Gupta and Kumar, 2008).

The world market has a combined import trade value of 170 million USD with USA, EU and Japan being in the top tier. India imports these products at an estimated value of USD 1.47 million (INBAR, 2019a).

Table 1: Comparing the Efficiency of Materials for Strength and Stiffness (Janssen, 1981)

Material	Strength (N/mm^2)	Weight by Volume	Ratio*	Stiffness (N/mm^2)	Weight by Volume	Ratio*
Concrete	8	2400	0.003	25000	24000	10
Steel	160	7800	0.02	210000	7800	27
Wood	7.5	600	0.013	11000	600	18
Bamboo	10	600	0.017	20000	600	33

**Ratio=strength or stiffness/ weight by volume*

Bamboo exhibits an excellent strength property, especially in tensile parallel to the grain. Most mechanical properties of bamboo are closely correlated with specific gravity and density. The strength, as well as the stiffness increases with specific gravity (Janssen, 1981). The study of 1981 by Janssen showed that the properties of bamboo are comparable to that of wood and can hence be acknowledged as "an alternative to wood".

Laminated bamboo timber is an excellent engineering material of great extents, high strength and stiffness with small deformation and relatively stable when used in dry conditions. A comparative study by Sattar in 1995 showed that bamboo can be as good as some commonly available wood in terms of mechanical properties like Modulus of Elasticity and Modulus of Rupture. The study was done on species commonly found in the South East Asian countries.

Fig 1: Furniture and Handicrafts made out of bamboo.

Fig 2: Hut constructed of bamboo

Table 2: Mechanical Properties of Bamboo Culms and Timber from Different Countries (Sattar, 1995)

Species	Country	Specific Gravity	Moisture Content	Modulus of Rupture(N/mm^2)	Modulus of Elasticity(N/mm^2)
Bamboo					
Bambusa bambos	India	0.65	15.5	67.4	6500
B. blumeane	Philippines	0.50	Green	30.8	8640
B. nutans	Bangladesh	0.68	12.8	81.8	12900
B. tulda	India	0.71	14.9	50.6	8265
B. vulgaris	Indonesia	-	17.0	86.0	-
B. balcooa	Bangladesh	0.74	12.5	80.3	10900
Dendrocalamus asper	Indonesia	-	15.0	105	-
D. Strictus	India	0.72	10.7	118.4	15949
Timber					
Tectona grandis	India	.60	12.0	95.9	11960
Shorea robusta	India	.71	12.0	131.8	16204
Melocanna bacifera	Bangladesh	.66	12.0	72.3	23200
Koompasia malaccensis	Malaysia	-	12.0	122	18600
Intsia palembanica	Malaysia	-	12.0	116	15400
Hevea brasiliensis	Malaysia	-	12.0	66	9240

Building Materials

Bamboo has been used in construction since ages with bamboo culm being the predominant material. The culms or poles have tensional and compression strengths comparable to that of steel (Archila et al., 2018; Mali and Datta, 2020). Another significant feature of bamboo is its light weight that increases its suitability as building material (Leake et al., 2010).Most of the bamboo species available in India like *Bambusa balcooa, Bambusa tulda, Bambusa nutans, Bambusa pallida, Bambusa polymorpha, Dendrocalamus hamiltonii,* and *Melocannabaccifera* are suitable for construction (Borah et al., 2008).Traditionally, bamboo huts are made in combination of mud and clay in the Eastern and North-Eastern part of the country (Laha, 2000). This can be of two types:

(i) bamboo culm as the primary building material
(ii) *bahareque* houses with walls of bamboo frames plastered with cement or clay.

Scaffold structures are necessary for construction buildings; bamboo is used as scaffolding material due to its low costs (Chung and Yu, 2002; Bambhava et al., 2013). Bamboo bridges can often be seen in the North-Eastern part of the country due to its high mechanical strength and sustainability of the material. Electrical poles made out of bamboo and bamboo grids for road construction is still in practice (Sharma and Saikia, 2016).

Fig 3: Hut made out of bamboo and bamboo laminates

Modern uses as building material involves the use of bamboo laminated boards, veneers and panels. Bamboo can also be used to design functional and attractive doors and windows frames. Bamboo panel flooring is in demand in Western Countries and in Japan due to its soft natural luster and long lasting natural gloss (Gupta and Kumar, 2008). Bamboo based panels provides exclusive insulation against sounds due to their ability to absorb sound waves and impacts (Sawarkar et al., 2020). INBAR report of 2019b estimates the international trade value of bamboo panels at 135 million USD with top importers being USA, EU and Singapore.

Pulp and Paper Industry

Wood was used traditionally for making paper. The shift from wood to bamboo for production of paper not only increased consumption of bamboo but also reduced usage of wood and rapid deforestation. The higher cellulose content along with the long fibers of bamboo favors high quality papers. Paper made of bamboo has marked improved properties in terms of brightness, optical quality, permeability, water absorption, tensile and biotic and abiotic stress resistance even though the morphological characteristics and tear index is comparable to that of hardwood and softwood papers. However, even with these remarkable features, bamboo paper production fails to mark its presence in the India. A report of 2010 suggested that a mere 26 of total 759 paper mills in India are wood based but still they share about 31% of the total production of 10.11 million tonnes (Tambe et al., 2020).

Food and Health Benefits

Introduction of bamboo shoots in the food brought a new dimension in utility of the grass. Young bamboo shoots with two weeks old or less than one foot tall are only edible (Gupta and Kumar, 2008). Shoots are low in fat and calories, good source of fiber, and contains potassium, lignins, and phenolic acids. Bamboo leaves provide fodder for the cattle, and other livestock. Bamboo has many nutrients, especially nitrogen (N), phosphorus (P), and potassium (K) in content orders as N > P > K. Its' shoots are helpful

for weight loss, balanced cholesterol level, and boosts immune system. It also has cancer-fighting and anti-inflammatory properties. Modern research on bamboo shoot revealed that consuming shoots increase appetite and helps in better digestion, controls obesity, diabetes, and also useful in treatment of heart disease and cancer.

Fuel and Charcoal

Bamboo can be converted into fuel when worked under various parameters including temperature and pressure and hence be an alternative to the non-renewable petroleum fuels, charcoal, bio-oil and biogas. Bamboo has low ash content and low alkali index which makes more desirable for use as fuel wood. Bamboo has almost 50% carbon and thus often used as charcoal. Activated charcoal serve as antibacterial agent, capable of absorbing foul odor and toxic elements from substances. Heavy machinery or high technology is not required for the production of the bamboo charcoal and thus, provides an opportunity of MSME to run one. The process of converting bamboo into bamboo mats or fiberboards produces saw dust and this can further be used to prepare charcoals, creating value addition in the process. According to INBAR 2019b, India imported bamboo charcoal worth 115 thousand USD. The leading charcoal consumer in world however is USA, EU, and Japan with an import worth of 20.6 million USD.

Agricultural and Aquacultural Implements

About 40% of the total bamboo usage in India is limited to the rural parts where it is used as building materials, for fencing, bridges and even for rafters. According to a survey by Krishna (pers. comm.), 49% of the total usage is strictly in making tool handles. The most preferred species by farmers is *Bambusa bambos* followed by *Dendrocalamus strictus* and *Bambusa vulgaris.* While *D. strictus* is preferred for hoe making, B. bambos is used for seed drills. No scientific explanation or specific reason can be attributed to the choice of the species (Rao et al., 2008).

Bamboo also plays an important role in the field of aquaculture. The fishing community uses a variety of bamboo items like fishing nets, fishing baskets, fishing poles, rafts and flag poles. Fishing trap basket known as 'mavulu' in Telugu consumes around 6 lakh bamboos per annum (Rao et al., 1992). Bamboo screens, known as 'dadikattus' is a type of bamboo fence that runs from 100m to 10km at stretch is often used to demarcate boundaries of villages and communities. Apart from this, bamboos are used to make baskets that transports fishes from one destination to the other (Rao et al., 2008).

Other Application Areas of Bamboo

Bamboo has been a major contributor to the incense stick industry. The bamboo is the primary raw material in the industry as all other ingredients like fragrance, binding material, and charcoal powder are stuck on to the bamboo to make the agarbathi (Rao et al., 2008). National Council of Applied Economic Research (NCAER) market survey showed that India produced around 147 billion sticks generating a revenue of around 7 billion INR. Another area where bamboo is extensively used is the sericulture sector in South India. Bamboo woven baskets called 'thatte' has been in use for collecting mulberry leaves, mounts for production of cocoons and trays for cocoon storage, and stiffing baskets for cocoon and woven mats (Rao et al., 2008). The statistical data available at the Ministry of

Statistics and Programme Implementation reveals that the annual turnover was around 2500 crore INR in 2017.

Bamboo poles have been in use in the horticultural sector as poles, fence and overhead covering structures. With the rise in growth of horticulture (Horticulture Statistics Division, 2015) by almost two fold from 43 million tonnes in 2001 to 86 million tonnes in 2014, the demand of bamboo has risen since then (Tambe et al., 2020). Bamboo plantation has remarkable impact on the environmental and ecological aspects (Akwada and Akinlabi, 2018). Being a fast growing species, bamboo plantation does not require any fertilizers and thereby the soil quality is retained. Bamboo provides resilience for a high number of people on a global basis. About 1 billion people rely on bamboo in one form or the other.

Conclusion

National Mission on Bamboo Application (NMBA) under Technology, Information, Forecasting and Assessment Council (TIFAC), Department of Science and Technology (DST) was established in 2002 following the Planning Commissions' recommendations to strengthen the bamboo sector and commercialize the applications of bamboo sector. Central government and state government have been working hand in hand and taking good initiatives to promote cultural and social growth of the bamboo plantations. These initiatives will in turn cater the national and international markets through technology and development of science. With international trade increasing, bamboo industry is bound to flourish accordingly. Being a sustainable material, with certain specific properties and extraordinary performances, the bamboo industry may boost the Indian rural economy.

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