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Bamboo Housing Structures for Livelihood Support and Enhancing Agro-Tourism in Konkan Region

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World Tourism Organisation (WTO) predicts that international tourist arrivals will increase from year to year, from 1 billion in 2010 to 1.6 billion tourists in 2020. The motivations of tourists to visit destinations have changed dramatically and now tourists are more interested in specific things, enthusiastic activities and, most importantly, in the quality experience of touristic products and services. As a corollary, one of the emerging areas in tourism is agrotourism. In the past agro touristic attractions were natural sights and plantations but the new agro-tourism concept involves a system of bringing together the tourism sector and the agricultural sector as a model of regional development. There is great potential for agrotourism in the Konkan region of Maharashtra. Maharashtra Tourism Policy 2016 stated that the Maharashtra state offers a unique tourism proposition through its rural landscape (approx. 55% of the state area). This strategy aims to promote rural tourism as the primary tourism product to spread tourism and its socio-economic benefits to rural and the surrounding regions. This will lead to a balanced and far-reaching growth in the state, thus improving the economic situation at the village level (Anon. 2016).

One of the experiences sought after by agro-tourists is stay in low-cost, eco-friendly housing. The bamboo house is one of the components of agrotourism which is made by local material and hence cost effective. The adoption of bamboo for house construction helps to preserve the environment. Moreover, shifting bamboo from short life cycle to long life cycle through housing is going to be a major carbon sequestration strategy (Patil *et al* 2016). Traditionally, bamboo was an important material used in construction of houses in India under the wattle and daub method. It still features in that form many rural and tribal areas. Konkan region presents an opportunity to enhance this enterprise. On the other hand, the heavy rainfall of Konkan region and associated preservation problems pose a challenge. The undulating topography and associated architectural hurdles in Konkan also add up to the problems.

Bamboo is an important resources in India. There are 125 indigenous and exotic species of bamboo growing in the country. Over an area of more than 10 million ha or 12.8 per cent of the total forest area. (Anon. 1999). The annual production of bamboo in India is 3.2 million tons against the potential availability of about 4.6 million tons, with an average production of 0.33 ton per hectare. The yield varies considerably, depending upon the intensity of stock and biotic interference, from 0.2 to 4 tons per hectare (Anon. 1998). Most of this bamboo is used for its short-life utilities like scaffolding in construction, basketry and in agriculture. Use of engineered bamboo as a building material is still to acquire commercial scales in India. But it should be focused upon because there is a growing demand and industry for sustainable building material (Sharma *et al* 2015).

The attack of fungus and beetles harms the bamboo, hence chemical treatment is absolutely necessary when bamboo is used as a structural member and where safety is of major concern. Bamboo used without chemical treatment needs frequent replacement which would be time-consuming and involves costly labour. Life of bamboo house is increased by treatment, thus it is more economical in the long run.

Agro tourism is very important for rural communities as well as urban areas. It can provide several advantages like income, employment, natural resource conservation, recreation and education. Agro-tourism intends to obtain higher standards of living for rural communities especially through increased income for people who work in agriculture. More and more, bamboo houses are becoming the next trend in homebuilding to replace traditional building materials with renewable sources that can do the job as well or better. Humans have been utilizing bamboo as a construction material

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for millennia as it is light but very strong, extremely resilient to shear forces like those of earthquakes and hurricanes, and grows back very rapidly once harvested. The construction materials for building a bamboo house should be readily available and accessible. The bamboo based house has a very low weight therefore foundations can be minimised. For wall construction bamboo mat boards are used assembled from hot pressed bamboo sleeves mats. Bamboo can tolerate high values of deformations in the elastic range i.e. possesses high elasticity. Therefore bamboo houses when properly constructed are ductile i.e. being able to sway back and forth during an earthquake, without any damage to the bamboo poles.

The farmer along with crop produce can generate handsome income by erecting bamboo houses in farm. The techniques of chemical treatment of Bamboo and erection of bamboo house could be easily learned by local artisans.

To fetch the benefits from agro-tourism the farmers should erect low cost structural facilities like Bamboo House for tourists. Besides farming, concepts of agro tourism shall be implemented by farmers for sustainable livelihood. The various benefits of Agro-Tourism are village community development, increased income of the local community, intensifying and diversifying the economic activities, employment opportunities, poverty alleviation, sustainable development and environment sustainability.

Generally agro-tourism features include separate accommodation at the farmers' homes, activities related to maintained family traditions and customs; it allows visitors to have a comfortable stay away from noise, experiencing the people's friendship and the tranquillity of nature. The following are the salient points of using bamboo housing in agro tourism:

- Different feel of stay to urban population visiting villages as agro tourists
- Concrete houses are costly to be built up by farmer
- Comfort levels are better in bamboo houses
- The energy required in processing bamboo is less than for concrete, wood, and steel
- Resistant to earthquake damage and practical on steep slopes
- Good tensile strength
- Good compressive strength
- Bamboo structures can be built very quickly, at low cost, durable, and environmentally friendly
- Most of the bamboo house construction material is available locally
- Farmer himself can do many works like erection of columns, preparation of trusses, fixing walls that will reduce labour cost drastically

Also farmer can give traditional look to bamboo houses using traditional warli paintings etc.

Due to abundant availability of raw material, least cost of construction and as technology available bamboo houses can be conveniently constructed in Konkan region so that it can boost agro tourism. Secondly bamboo house construction and selling can come up as a new enterprise in Konkan region. It can help for the economic upliftment of farmers. The technology can be adopted by farmers, hoteliers, extension workers, researchers and bamboo growers.

The varieties most suitable for construction are available

Table 1. Structural properties of dfferent local species of Bamboo in Konkan region.

Sr. No.	Species (local name)	Physical property	Mechanical property
1	*Bambusa bambos* (Kalak)	Up to 30 m tall 15-18 cm diameter	Modulus of rupture – 35 to 39.3 N mm^{-2} Modulus of elasticity – 1.5 to 4.4 kN mm^{-2} Maximum crushing stress – 39.1 to 47.0 N mm^{-2}
2	*Dendrocalamus strictus* (Mes)	8 to 16 m tall 2.5 to 8.0 cm diameter	Modulus of rupture – 118.4 N mm^{-2} Modulus of elasticity – 1.59 kN mm^{-2} Maximum crushing stress – 64.5 N mm^{-2}
3	*Dendrocalamus stocksii* (Manga)	Up to 9 m tall 2.5 to 4.0 cm diameter	Modulus of rupture – 62.0 N mm^{-2} Maximum crushing stress – 38.6 N mm^{-2}

in Konkan. These are *Bambusa bambos, Dendrocalamus strictus* and *Dendrocalamus stocksii*. The salient features of these varieties are tabulated in Table 1.

Bamboo has very little natural toxicity and therefore, is easily prone to fungi and insect attack. The objective of treatment is to remove the starch and other carbohydrates (soluble sugars) that attract fungi and insects and replace it with chemicals in the cells of the bamboo thereby increasing the life of the bamboo. Well treated bamboo has a life expectancy of 50 years without losing its structural properties. The efficiency of the chemical treatment is influenced by anatomical structure of the bamboo culm. There are no radial pathways in the culm tissue, like the ray cells in wood, and lateral cell-to-cell movement of preservative depends on a slow diffusion process. Freshly cut culms are easier to treat due to the water-filled cells providing a continuous transportation channel. Both ends of the culms should be cut up to the next node in order to remove the blockage of vessels.

Whereas there are several indigenous treatment systems like lime wash and smoking of bamboo, chemical treatments are known to have longer effect against fungi and insects. The use of water as a solvent to carry the preservatives into the cells of the bamboo. Water-soluble salts are dissolved in water, on treatment the water evaporates leaving the salts inside the bamboo. The recommended salts are boric acid, borax and copper sulphate. Boron salts are effective against borers, termites and fungi (except soft rot fungi). (Kumar *et al.* 1994)

The attack of fungus and beetles harms the Bamboo, hence chemical treatment is absolutely necessary when bamboo is used as a structural member and where safety is of major concern. Bamboo used without chemical treatment needs frequent replacement which would be time-consuming and involves costly labour. Life of bamboo house is increased by treatment thus it is more economical in the long run.

Table 2. List of chemicals for bamboo treatment

Sr. No.	Chemicals	Ratio	Applied
1	Coal tar creosote : fuel oil	3:7	Fencing poles
2	Copper: Chrome: Arsenic	3:1:4	Green - Furniture Dry - Bridge, ladders
3	Boric acid : Borax	1:1.5	Carrying food stuff
4	Copper: Chrome: Boron	1.5:3:4	Furniture, trusses

The details of chemicals used for Bamboo treatment as per IS: 9096: 2006 and IS: 1902: 2006 are listed in Table 2.

The popular species Manga, Mes and Kalak are useful for bamboo house. Bamboo is used for construction of bamboo house as columns, purlins, rafters, trusses, Bamboo mat boards. Bamboo has good tensile and compression strength. While using bamboo as structural materials avoid nails for fixing joints. Instead, drill the holes and use nuts and bolts with the help of mild steel strips. All the joinery in the structure is based on clamps made from M. S. strip of 50 mm width and 5 mm thick. The strip bent in proper angle as per requirement. Holes of 9 mm drilled at the ends of strip for using nut and

Fig. 1 Preparation of M. S. clamps: (a) cutting of M. S. strips (b) making of angles for joints (Photos@ Jain S.K.)

Fig. 2 Bamboo trusses (Photo @ Jain S.K.)

bolts and joining the members of bamboo. Figure 1a and 1b illustrate the preparation of clamps. The joints for trusses are shown in Figure 2 can be prepared by farmers.

Roofs and Walls

In the high rainfall areas like Konkan, Gable roofs are necessary with slope of more than 22.5°. Two way slopes or four way slopes can be given to the roofs. In two steps also roofs can be given to improve the architectural beauty. Some of the related points are listed below:

- Houses with bamboo mat board walls can have CGI Sheets. These sheets shall be fitted to purlins with J – hooks and bitumen washers to make it waterproof.
- The understructure or false ceiling for roofs can be made with bamboo mat boards of 3 mm thickness.
- The spacing between principal rafters shall not be more than 60 cm in case of CGI sheet roofs.
- The bottom most purlins at the end of roof overhang shall be tied to the eave level beam.
- The slope of the roof shall be as per relevant IS codes. Sloping CGI roofs can range from 22.5^{o} to 35^{o} to avoid suction (negative pressure) on roof covering during high speed winds.
- The roof shall have a overhang of minimum 45 cm on all four sides
- The end of the cantilever portion of the rafter shall be lashed to the posts.
- Nails shall not be used in any part of Bamboo Kutir. If required screws of proper size may be used.

The walls could be made up of bamboo mat boards. These are available in market in size 2.4 m x 1.2 m. The bamboo mat boards could be fitted at eave height with nut and bolts. The base of bamboo mat board shall be made water tight by layering silicon gel. The doors shall be made up of bamboo mat board by local carpenter. The glass window frames could be made up in aluminium square pipe fittings.

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