

Present status and socio-cultural acceptability of traditional bamboo houses: a study in Kerala and Karnataka states of India

P. K. MURALEEDHARAN*, V. ANITHA and T. D. SIMON

*Forestry and Human Dimensions Programme Division, Kerala Forest Research Institute, Peechi,
Thrissur, 680 653 Kerala, India*

Abstract—An attempt is made in this paper to assess the present status, particularly structure, cost of construction, long-term economic benefits and socio-cultural acceptability of traditional bamboo houses in Kerala and Karnataka states of India. It also examines the major constraints and policy changes required for the promotion of bamboo houses in the study areas. This study is based on a sample survey conducted among 360 selected households dwelling in bamboo houses. Although bamboos are widely available in the study areas, the housing sector experiences severe shortage of bamboos for construction, as the pulp and paper industry purchases bamboos on a large scale by offering higher prices. In the study areas, bamboo houses are either thatched with grass or leaves or tiled using country tiles. It is reported that about 95% of the dwellers prefer tiled houses because of its durability and low maintenance cost. It is also observed that the economic benefits and socio-cultural acceptability of tiled bamboo houses are higher. Poor economic conditions of the dwellers, low availability of bamboos in the construction sector, high prices of bamboo and lack of title deeds of the land are some of the major constraints identified for the promotion of bamboo houses. It also suggests that bamboo houses in the study areas may become more popular by providing more amenities and better appearance for aesthetic satisfaction.

Key words: Bamboo thatched house; bamboo tiled house; National Housing Policy; economic benefits; socio-cultural acceptability.

INTRODUCTION

In India there is a wide gap between the demand and supply of housing stock, constituting about 31 million units [1]. In addition, the growth of slum, inadequate amenities and rising cost of shelter are some of the features of housing problems. Considering the dismal performance of the housing sector, which was totally

*To whom correspondence should be addressed. E-mail: pkmurali@kfri.org

controlled by the private sector in the country, the Central Government formulated a National Housing Policy in 1994. Following this, the State governments in the country also announced a housing policy within the broad framework of the National Policy. The long-term goals of the housing policy are to reduce houselessness, to improve the housing conditions of the inadequately housed and to provide minimum level of basic services and amenities to all. The main thrust of the housing policy is to solve the housing problems, particularly those of the poor people, by 2000 AD using cost-effective and environment friendly technologies that would create more employment opportunities and facilitate sustainable development of the society.

Bamboo assumes great significance in the context of high emphasis on cost-effective and locally available materials for construction of houses in the housing policy. Since time immemorial, various parts of the society have used bamboo, one of the traditional and cheap construction materials, for building houses. Bamboo is still a highly useful and preferred construction material in the housing sector because of its easy availability and high mechanical strength comparable to wood. Of late, it is found that the construction of bamboo houses in many places in the country has been declining and also these houses are now constructed mostly by the economically and socially weaker sections in the society [2, 3]. In the context of availability of bamboo resources in plenty in many places in the country, severe shortage of housing stock and construction materials and also policy support from the State governments, the relevant question to be addressed now is: why are more bamboo houses not being constructed? Bearing this in mind, an attempt is made in this paper to examine (1) the present status, particularly structure, cost of construction, long term economic benefits and socio-cultural acceptability of traditional bamboo houses and (2) the major constraints and policy changes required for the promotion of traditional bamboo houses.

STUDY AREAS

Kerala

The study was carried out in Kerala and Karnataka, two southern states in India (Fig. 1).

Kerala, situated in the southwestern part of India, lies between $8^{\circ} 18'$ and $12^{\circ} 48'$ North latitudes and $74^{\circ} 52'$ and $77^{\circ} 22'$ East longitudes. With a total area of $38\,863\text{ km}^2$, it supports a population of 31.8 million and density of population is estimated as 819 persons per sq km, as per the 2001 census. Natural forests in the state occupy an area of 7870 km^2 . Forests and homesteads are the two major sources of bamboos in the state. Total growing stock of bamboo resources in the forest areas in Kerala is estimated as 5.25 million tonnes [4] of which only 62 633 tonnes is collected annually by the Forest Department (estimated from various reports of the Forest Department).

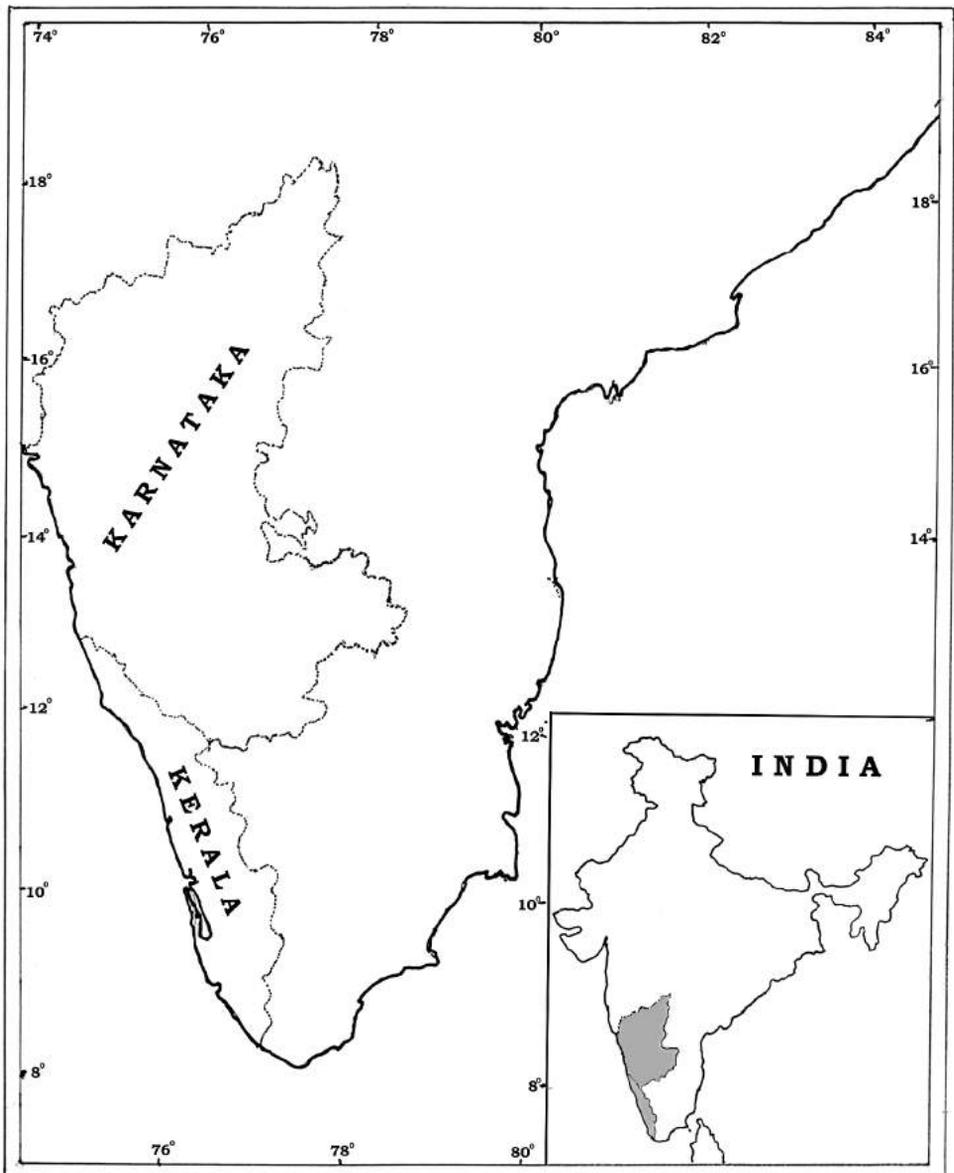


Figure 1. Study areas.

Karnataka

Karnataka, situated on the western edge of the Deccan Plateau, lies between $11^{\circ} 45'$ and $18^{\circ} 20'$ North latitudes and $74^{\circ} 00'$ and $78^{\circ} 30'$ East longitude. Karnataka covers an area of $190\,498\text{ km}^2$. The total population in Karnataka was estimated at 52.7 million and density of population was 275 persons per km^2 , as per the 2001 census. Forests in the State cover an area of $38\,284\text{ km}^2$, accounting for 20% of

the total geographical areas. In the state, forests are the main source of supply of bamboos. Total bamboo area of the state was estimated at 500 000 hectares [5] and total production at 67 834 tonnes during 1996–1997. In both states, *Bambusa bambos* and *Dendrocalamus strictus* are the two major species of bamboo.

METHODOLOGY

The study is based on both primary and secondary data. Primary data were gathered from owners/inhabitants of the bamboo houses through a sample survey and the Participatory Rural Appraisal (PRA) Method. The socially and economically weaker sections in the society, who mainly construct and live in bamboo houses, constitute the target group.

The multistage stratified random sampling method was used for the selection of sample households from the study areas and the main criteria for stratification were the availability of bamboo for house construction and income variations. Based on physiographical features, the study areas were classified as highland (more than 75 m average mean sea level (amsl)), midland (7.5 to 75 m amsl) and lowland (less than 7.5 amsl), which forms the first strata for sampling. After this classification, a representative district from each physiographical classification was selected. Of the total districts in each state, three districts, one each from high land, mid land and low land areas, were identified for sample selection. Thus, in Kerala State Wayanad (highland), Thrissur (midland) and Trivandrum (lowland) were selected and in Karnataka State the districts selected were Shimoga, Mangalore and Tumkur (Bangalore), respectively. Further, there is a three-tier system of local level administration, viz., the district level, the block-level and the grama panchayath. For the purpose of formulating the sampling frame, these areas in the selected districts were visited and a list of both types of houses was prepared. Bamboos are found abundantly in the highland areas — in natural forests, plantations and homesteads. In midland areas bamboos are grown in homesteads and bamboo culms are rarely seen in lowland areas. Houses were then randomly selected for data collection. A sample of 180 households with bamboo houses from each State, that is 60 households from each district in a state, were randomly selected, for a detailed study. The sample survey was carried out during 1999–2000 and data were collected using a questionnaire. The specific data collected include: socio-economic indicators of the sample — caste, education, age, occupation and income, features of bamboo houses, cost of construction, repair cost, socio-cultural acceptability and constraints. Simple percentages have been used to depict the data.

RESULTS AND DISCUSSION

Present status and structure of bamboo houses

Bamboo houses in Kerala and Karnataka are more or less of the same structure and pattern. Generally, these houses can be grouped into: bamboo thatched and bamboo tiled houses. Of the total sample houses in Kerala, about 92% are thatched bamboo houses and rest are tiled bamboo houses and these percentages in Karnataka are 83 and 17, respectively. It is evident that owners of tiled house belong to higher income groups (Table 1).

In both the types of houses, bamboos are invariably used for making the roof structure. In certain houses, especially thatched one, in addition to roof, bamboos are used for making walls, windows, doors and partitioning. In Kerala, the average plinth area of a thatched bamboo house was worked out to be 40 m² and plinth area per person was 8 m², while in Karnataka, they are 31 m² and 7 m², respectively. However, the plinth area (45 m²) of a thatched bamboo house in high land was slightly higher than that of an average thatched house. This is mainly due to the fact that availability of bamboo at a low price is more in high land areas in both the states. Further, the thatched bamboo houses in both the states are found to be smaller than tiled ones. For instance, in Kerala, the average plinth area of the tiled house is 58 m² and plinth area per person is 14 m². The corresponding figures in Karnataka are 62 m² and 13 m², respectively. The average plinth area of a tiled bamboo house in Karnataka varies between 82 m² in high land areas and 51 m² in low land areas.



Figure 2. Tiled bamboo house.

In older days bamboo houses were predominant in the housing sector in the study areas. Based on information gathered from elderly people in several places in the study areas using PRA, 90% of houses in the highland areas and 70% in the mid- and lowland areas were partly or fully made of bamboos about 30 years back, but its number has declined significantly. In Kerala, the total number of bamboo thatched and bamboo tiled houses were estimated as 9277 and 807, respectively, and the total demand for bamboo for new construction and maintenance was estimated as 9100 tonnes annually [3]. No such information is available from Karnataka. The decline of bamboo houses in the study areas may be due to a variety of reasons of which the most important, in the initial period, was availability of timber (there was



Figure 3. Thatched bamboo house.

Table 1.

Distribution of sample according to household income

Income (Rs.)	Kerala		Karnataka	
	Thatched	Tiled	Thatched	Tiled
Less than 10 000 (less than US\$ 222)	42	—	22	—
10 000–20 000 (US\$ 222–445)	28	—	34	—
20 000–30 000 (US\$ 445–667)	51	3	53	5
30 000–40 000 (US\$ 667–889)	35	3	28	6
40 000 and above (US\$ 889 and above)	10	8	12	20
Total	166 (92)	14 (8)	149 (83)	31 (17)

Values in parentheses represent respective percentages to total.

massive clear felling of private forests by its owners at the time of nationalization in Kerala, that was a temporary phenomenon) and later it was due to low availability of bamboo to the housing sector and high prices of bamboos.

Cost of construction: a comparison

The majority of the thatched bamboo houses are built without proper basement and mostly it is constructed with either mud or sand. On the other hand, about 66% of tiled houses have proper basement either with brick or granite. Regarding flooring, majority of the thatched bamboo houses have used clay/mud smeared with dung. About 64% of the tiled bamboo houses both in Kerala and Karnataka, have mud floor smeared with dung.

Details regarding the different items of cost involved in the construction of thatched and tiled bamboo houses in Kerala and Karnataka are given in Tables 2 and 3. On an average, number of bamboo poles used per thatched and tiled houses in Kerala was estimated as 22 and 29, respectively. The number of bamboos used by thatched bamboo houses in different areas in the state is different, varying between 14 in lowland and 31 in highland areas. The same is more or less true in the case of Karnataka also. Partly due to high availability of bamboo and partly due to low price, there is a tendency among the people in highland areas to use more bamboos for house construction (Table 4). Further, there is a tendency among people in the highland areas to cut bamboos from the forests in an unauthorized manner. The survey indicates that about 75% of the respondents in the highland areas in Karnataka cut bamboos from the forests in an unauthorized manner and use it for various purposes. Thus they incur only, for cutting, transporting and other

Table 2.

Construction cost (in US\$) of thatched bamboo houses

Particulars of houses	Kerala				Karnataka			
	State total	Highland	Midland	Lowland	State total	Highland	Midland	Lowland
No. of bamboo used	22	31	20	14	21	32	18	14
Basement	9 (6)	8 (5)	13 (10)	7 (4)	7.2 (5)	7 (5)	9 (6)	6 (4)
Cost of bamboo	31 (22)	24 (16)	42 (33)	26 (18)	25.5 (18)	6 (5)	41 (27)	30 (21)
Wall	65 (46)	70 (48)	42 (33)	83 (55)	49 (36)	46 (37)	46 (41)	41 (28)
Roof	20 (14)	23 (16)	17 (14)	20 (13)	43 (31)	55 (44)	23 (16)	51 (35)
Wages	19 (12)	22 (15)	13 (10)	15 (10)	14 (10)	11 (9)	14 (10)	18 (12)
Total cost	142 (100)	148 (100)	127 (100)	150 (100)	139 (100)	125 (100)	148 (100)	145 (100)
Cost/m ²	3.7	3.3	4.1	3.8	4.9	2.8	5.6	7.0

Values in parentheses represent respective percentages.

Table 3.

Construction cost (in US\$) of tiled bamboo houses

Particulars of houses	Kerala				Karnataka			
	State total	Highland	Midland	Lowland	State total	Highland	Midland	Lowland
No. of bamboo used	28	41	24	20	29	42	24	22
Basement	112 (26)	133 (31)	89 (24)	112 (25)	105 (22)	128 (24)	103 (21)	84 (21)
Cost of bamboo	41 (10)	33 (7)	51 (14)	39 (9)	36 (7)	8.5 (1)	54.5 (11)	46.5 (12)
Wall	113 (27)	120 (28)	96 (26)	122 (27)	110 (24)	141 (26)	103 (20)	87 (22)
Roof	92 (22)	96 (22)	70 (18)	111 (24)	200 (42)	232 (43)	207 (41)	160 (40)
Wages	62 (15)	52 (12)	67 (18)	67.2 (15)	28 (5)	27.2 (5)	35 (7)	20 (5)
Total cost	419 (100)	434 (100)	373 (100)	449 (100)	479 (100)	532 (100)	503 (100)	398 (100)
Cost/m ²	7.35	7.2	8.4	6.4	8	6.5	9.7	7.7

Values in parentheses represent respective percentages.

handling charges that work out to be Rs. 9 per culm (US\$ 0.20). In addition, these bamboos are mature and thicker. But, in other selected areas in Karnataka, people depend on traders in the market who collect bamboos from forests and homesteads. Consequently, bamboos from these sources are more expensive (Rs. 102, or US\$ 2.5 per culm in midland and Rs. 95 or US\$ 2 per culm in lowland) and also contain immature ones.

The condition is slightly different in Kerala, where only very few people in the high land areas cut bamboo from the forests. The majority of the people depend on homesteads for meeting their requirements. Probably due to this, bamboo price is found to be slightly lower in Kerala (Rs. 63/culm, or US\$ 1.5) than in lowland and midland areas of Karnataka. The average cost of thatched bamboo house is estimated at Rs. 6377 (US\$ 142) in Kerala while it is Rs. 6257 (US\$ 139) in Karnataka. In the case of a tiled house, they are Rs. 18 857 (US\$ 419) and Rs. 21 566 (US\$ 479) in Kerala and Karnataka, respectively.

Long-term economic benefits of tiled bamboo house

The longevity of a bamboo house is very difficult to calculate, particularly in the case of thatched house, as each component in the house has its own lifetime. For instance, a brick wall lasts for more than 50 years, a bamboo-reinforced mud wall lasts for 10 to 15 years and bamboo used as roof frames lasts for 2 to 15 years, depending on the quality, and coconut thatches last for 1 or 2 years. The frequency of maintenance done shows that in the case of thatched houses, 60 and 21% of the selected houses are repaired at the end of the first and second year, respectively, just before the onset of the monsoon. On the other hand, about 88% of the tiled

Table 4.
Number of bamboos used and total construction cost in Kerala and Karnataka

Physiography	State											
	Kerala						Karnataka					
	Highland	Midland	Lowland	Total	Highland	Midland	Lowland	Total	Highland	Midland	Lowland	Total
Bamboo House (type)	01	02	01	02	01	02	01	02	01	02	01	02
Average family size	5	4	5	4	5	4	5	4	4	4	5	4
Plinth area (m ²)	50	60	31	44	40	70	40	58	45	82	21	51
Plinth area/person	10	15	6	9	8	17	8	14	11	21	4	10
Numbers of bamboo used	31	41	20	24	14	20	22	29	32	42	14	22
Total cost (US\$)	148	434	127	373	151	449	142	419	125	537	144	398
Cost/m ² (US\$)	3.3	7.2	4.1	8.4	3.7	6.4	3.7	7.4	2.8	6.5	7	7.8

01: Thatched; 02: Tiled.

Table 5.

Construction and cumulative repair cost (in US\$)

	Thatched houses		Tiled houses	
	Kerala	Karnataka	Kerala	Karnataka
Construction cost	142	139	419	479
Cost of bamboo for 5 years	16	13	13	14
Cost of thatches for 5 years	67	93	—	—
Cost of other materials	61	48	76	89
Cumulative repair cost for 5 years	144	154	89	103
Amortized value	285	305	173*	199*

*For amortization, the average cost of construction of a tiled house for five years was taken as US\$ 84 in Kerala and US\$ 96 in Karnataka.

houses are repaired during or after the fifth year. Hence, the repairing cost is much less for tiled houses when compared to thatched houses. For instance, repair cost per m² is estimated to be Rs. 170 (US\$ 4) and Rs. 68 (US\$ 1.5) in Kerala and Rs. 223 (US\$ 5) and Rs. 64 (US\$ 1.5) for Karnataka for thatched and tiled houses, respectively. From the house owner's point of view, the initial investment in the thatched house is less than that of tiled house. An attempt is made here to compare cost of construction and cumulative repair charges of thatched and tiled houses for five years, assuming that the life of a tiled house is 25 years (amortized to 5 years, Table 5).

To estimate the benefits in the long run, the amortized values of both thatched and tiled houses, considering the cost of construction and cumulative cost (which includes cost of bamboos, thatches and other materials) for 5 years, were studied. For amortization, the average cost of construction of a tiled bamboo house for 5 years was Rs. 3772 (US\$ 84) in Kerala and Rs. 4314 (US\$ 96) in Karnataka. The analysis shows that the amortized value of tiled houses is less than that of thatched bamboo houses (Table 5). This result supports the fact that tiled houses are economically beneficial in the long run.

Socio-cultural acceptability

In both study areas, more than 90% of the selected households are socially and economically backward communities. In Kerala, about 39% of the sample households received an annual income less than Rs. 20 000 (US\$ 445), 30% between Rs. 20 000 and Rs. 30 000 (US\$ 667) and the rest received more than Rs. 30 000. In Karnataka, about 31% received an income less than Rs. 20 000, 33% between Rs. 20 000 and Rs. 30 000 and 25% above Rs. 30 000. The average per capita income (average family size of the sample being 4.6) was worked out to be Rs. 4800 (US\$ 107) in Kerala and Rs. 5650 (US\$ 126) in Karnataka, indicating that almost all the selected households live below the poverty line [6].

Most of the sample households in Kerala are permanent dwellers, while in Karnataka, except in highland areas, dwellers are mostly the floating type, who

settled down in their places for employment. In the absence of title deeds, they are not able to construct tiled houses that require more investment.

In highland areas of Karnataka where bamboos are widely available, most of the selected households prefer bamboo houses. Some of them are even content with thatched bamboo houses, as they feel that it is affordable and comfortable. They show some social and cultural affinity towards bamboo houses, as they were born and brought up in it and also the technology and materials required for its construction are at their disposal.

Kerala provides a different picture regarding socio-cultural acceptability of bamboo houses. The selected households gave a variety of reasons for their preference of bamboo houses of which financial stringency accounted for 50%. According to 44% of the respondents, bamboo houses are comfortable and affordable and 6% did not like other types of houses.

Another aspect relating to socio-cultural acceptability is whether the selected households are satisfied with bamboo houses? About 35% of them are satisfied with the thatched bamboo houses, while others expressed dissatisfaction. Satisfaction is regarded from the point of socio-cultural affinity, natural coolness, repair work and maintenance requiring only household labour and easy accessibility to the resource (especially in highlands, closeness to resource). Dissatisfaction is due to repeated repair, maintenance and kutchra (semi-permanent) structures that are not so strong mainly because of lack of technological know-how. In the case of tiled bamboo houses, about 70% of the respondents expressed satisfaction. Low maintenance charge and less leakage during the monsoons are two major reasons highlighted for their satisfaction regarding tiled houses. Between thatched and tiled bamboo houses, about 95% expressed higher preference and satisfaction with tiled bamboo houses due to its longevity and durability.

Traditionally, people have perfected and used most of the technology by which bamboo can be transformed and this has been passed on from one generation to another. The technology of construction of bamboo houses is very simple and labour intensive, which make them self reliant in the matter of housing. Over a period of time, there has been a significant modification in the bamboo houses in the study areas. Thatched houses were the earliest version of bamboo houses. Construction of tiled bamboo houses was one of the important developments in the history of bamboo houses. It necessitated several modifications in the roof structure (spacing of bamboo, strong lateral beams, etc.) and demanded strong basement and walls. Reinforced bamboo mud wall is another important modification in the construction of bamboo houses, which increased the longevity of the wall from 5 to 15 years [3]. Availability of thick bamboo, free from pest attack, is one of the prerequisites for the construction of good quality bamboo houses. Traditionally, people have given emphasis to this aspect and developed a variety of cost-effective and natural preservative treatments such as soaking bamboo in the water, smoking and application of diesel, waste and pesticide, etc. Further workability with simple tools and family labour is another advantage of the bamboo house and all of

which make the bamboo house socio-culturally and technologically acceptable to people.

Promotion of bamboo houses: constraints and policy changes

In the context that a good percentage of selected households are satisfied with bamboo houses, particularly tiled bamboo houses, the question now is: can we promote bamboo houses in the study areas and for which what policy changes are required? Before answering the question, major constraints for the construction of the bamboo houses are to be identified. Low economic conditions of the people, lack of availability of good quality of bamboo and lack of title deeds are some of the major detriments for promotion of bamboo houses.

Poor economic conditions of the people in the study areas are due to the fact that most of the inhabitants of bamboo houses are casual workers who do not get regular employment, resulting in low income. Data show that 69% of the sample households with tiled bamboo houses are among the 'high-income' groups (above US\$ 445). Thus, in order to improve the housing situation in the study areas, the income earning capacity of the households needs to be enhanced.

As mentioned earlier, between thatched and tiled bamboo houses, the latter is better and more acceptable. The government can implement housing schemes either to replace thatched houses with tiled one or to construct new tiled bamboo houses. In context, one scheme (Ashraya), being implemented by the Karnataka government, is to be specially mentioned. The aim of this scheme is to construct tiled bamboo houses and supply it free of cost to the socially and economically weaker classes in the society. Some of the respondents in the Shimoga region are the beneficiaries of said scheme.

Bamboo, the poor man's timber, which was widely available in forests and homesteads in the study areas, is now in low supply. Due to various reasons, such as subdivision and fragmentation of land holdings and low holding size, bamboos are being replaced with other type commercial crops in Kerala. Further, in the State, the prices of bamboo have gone up due to commercial exploitation in homesteads by the agents of pulp and paper mills [7, 8]. In Karnataka bamboo production is concentrated in certain areas from where the bamboos are collected and supplied to other areas by the traders. The survey indicates that the traders sell immature and unprocessed bamboo on a large scale at exorbitant price. Thus, the state governments can study the ways and means for rationing the bamboo for the sake of poor people who are living far away from the source of supply. Further, the State Forest Departments can manage the bamboo resources in the forests sustainably and sell bamboo at reasonable prices to the users.

The governments in the study areas implement a number of housing schemes for different income groups and also for community purposes, like schools. In most of the construction work, they prefer Casuarinas (*Casuarina litorea* L.) for roof to bamboo, as it is cheaper; the price difference being 20 to 30%. Qualitywise Casuarinas is far inferior to bamboo with a short longevity, that is, about 5 to

7 years against at least 25 years in the case of good bamboo as construction material. Bamboo is the most versatile building material because of its ready availability, low cost (compared to wood), high strength/weight ratio and capacity to absorb more energy. The tensile strength of bamboo is nearly that of mild steel, varying from 143 to 285 MPa [9].

One of the major drawbacks of the bamboo houses in the study areas is that they are only semi-permanent structures (katcha) with less amenities and poor looks. For popularising bamboo houses, more awareness regarding its quality and superiority should be created among the people. Further, the present construction should be modernized with more amenities and better appearance at a reasonable cost that will enhance the social esteem of the dwellers. As part of our study, in collaboration with COSTFORD, a non-governmental organization specializing in house construction, we prepared an estimate and plan for a small model bamboo house, with a plinth area of 25.52 m² containing one bedroom, living room, kitchen and toilet. The cost of construction of this bamboo house was estimated to be Rs. 35 000 (US\$ 778) [3], compared to Rs. 123 567 (US\$ 2745) for a RCC house with same plinth area and amenities. This indicates that bamboo houses with better amenities are more cost-effective and suitable for lower middle class people. Thus, model bamboo houses with different types of structure should be built in different parts of the study areas.

CONCLUSIONS

Bamboo houses are cost-effective and environment friendly, and thereby play an important role in reducing the housing problems, especially that of the socially and economically weaker sections in the society. They are economically beneficial and have socio-cultural acceptance among the selected households. However, there is a strong evidence to show that dwellers of bamboo houses prefer tiled bamboo houses because of its superiority to thatched bamboo houses. Low income of the dwellers is one of the major reasons for not modifying thatched houses into tiled houses. Further, people prefer to construct tiled bamboo houses, if they get bamboo at a cheaper rate. The study suggests that some policy changes are required for popularising bamboo houses in the study areas.

Acknowledgements

The work was carried out with the assistance of a grant from TRADA Technology Limited, UK. The authors wish to thank Mr. L. Jayanetti of this organization for his encouragement and support.

REFERENCES

1. C. Fox, Rural housing in Kerala. A case study of Chavakkad Taluk Rural housing co-operative society, MA Dissertation, Dr. John Mathai Centre, University of Calicut, Thrissur (1998).

2. *SUDA (State Urban Development Agency)*. Kalinga Kutira, Government of Orissa Bhubaneswar (1992).
3. P. K. Muraleedharan and V. Anitha, Assessment of economic feasibility and socio-cultural acceptability of bamboo based architecture: a study in Kerala, Karnataka and Orissa states, *KFRI Research Report* **177**, 1 (2000).
4. P. V. K. Nair, A. R. R. Menon and C. N. Krishnankutty, *Survey and Estimation of Bamboo Resources of Kerala*. KFRI Research Report, Kerala Forest Research Institute, Peechi (2000).
5. S. S. R. Bennet, Status of bamboos in India, Paper presented at the *National Seminar on Forest Produces*, Indian Institute of Genetics and Tree Breeding, Coimbatore (1993).
6. Government of India, *Mid Term Appraisal of Ninth Five Year Plan (1997–2002)*, Government of India, Planning Commission, New Delhi (2000).
7. B. Jayashankar, Economic analysis of forest resource management: a study of bamboos in Kerala, PhD Thesis, FRI Deemed University, Dehra Dun (1996).
8. C. N. Krishnankutty, Socio-economic and ecological aspects of developing bamboo resources in homesteads of Kerala. Part II. Economic and management aspects, *KFRI Research Report No. 125*. Kerala Forest Research Institute, Peechi (1998).
9. R. K. Punhani, Engineered use of bamboo for house construction — a review, Paper presented in: *International Workshop on Engineered Bamboo Housing in Earth-quake Prone areas*, Forest Research Institute, Dehra Dun (1998).

Copyright of Journal of Bamboo & Rattan is the property of VSP International Science Publishers and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.