



# Bamboo Resource Utilization, Household Dependency and Livelihood Dynamics in Karbi-Anglong District, Assam

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## Abstract:

Bamboo is one of the most indispensable biological resources in Northeast India, supporting a diverse range of applications, sustainable livelihoods, traditional practices, and daily household requirements. The present study assessed the utilization, household dependency, and livelihood dynamics associated with bamboo resources in Karbi-Anglong district, Assam. A stratified mixed multi-stage sampling approach was adopted, wherein 2 forest ranges, 11 forested regions and 16 villages were covered across Karbi-Anglong East and West. A total of 450 respondents were surveyed for primary data collection, using Participatory Rural Appraisal (PRA) tools, such as focus-group discussions, key-informant interviews, semi-structured questionnaire surveys, and field observations. The findings revealed that bamboo was cultivated by all households within their homestead gardens. The area under bamboo in the homestead gardens of Karbi Anglong East was observed to be higher than that of Karbi Anglong West. Five major bamboo species were documented, of which *Bambusa tulda* and *Dendrocalamus hamiltonii* were identified as the most socio-economically important species. The former was prioritized for construction purposes, while the latter was preferred by the households for handicrafts and bamboo shoot consumption. Bamboo utilization was predominantly household-oriented, with 93% of households cultivating bamboo to meet their daily subsistence requirements, highlighting limited commercialisation. Forest dependency was relatively low, although specific species continued to be traditionally procured from forests. The bamboo market structure was largely informal, fragmented, small-scale, characterised by weak market linkages and irregular demand. The study highlights the crucial role of bamboo in sustaining rural livelihoods and focus on strengthening resource management, market linkages, value addition, and capacity-building initiatives for overall development of the bamboo sector in the study area.

**Keywords:** Livelihood dynamics, Homestead gardens, Participatory Rural Appraisal, Subsistence, Karbi-Anglong, Household dependency

## 1. Introduction:

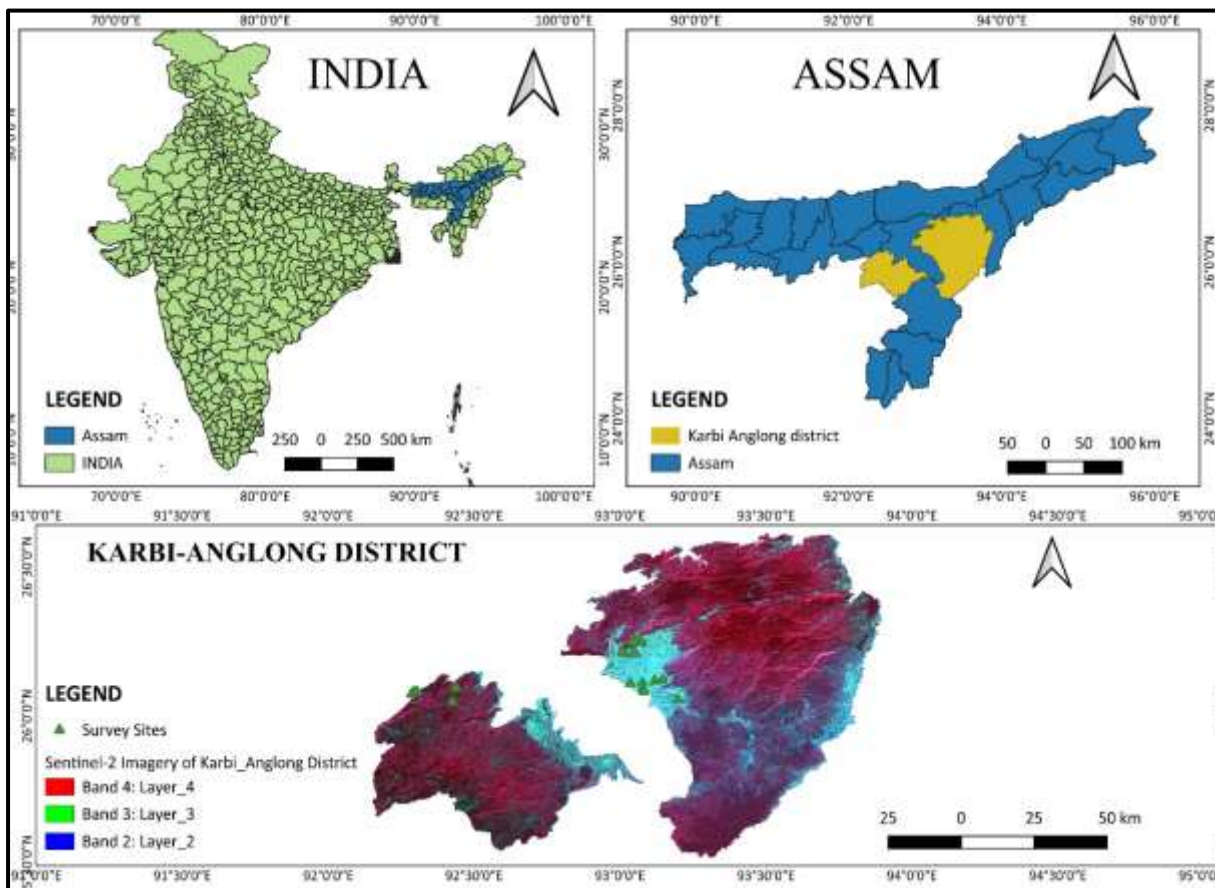
Bamboo is considered as one of the critical biological resources, integral towards human civilization since antiquity and evident in its role towards sustaining the livelihoods of approximately 2 billion people throughout the tropical and sub-tropical parts of Asia, Africa, & Latin America (Kiruba et al., 2007). Traditionally, bamboo has been used for fuel, food, rural housing, fencing, shelter, and tools, while in recent times, it has emerged as a vital raw material for the paper and pulp industry, construction and engineering applications, and panel products (Hussain, 2022). Bamboo shoots serve as a vital source of income for rural residents during the lean rainy period, when the cultivation of major agricultural crops is constrained (Acharya et al., 2015). Bamboo contributes substantially to the rural economy (Gogoi, 2020) and offers considerable scope for local communities to achieve financial independence and long-term self-reliance (Nadkarni & Puneekar, 2020). Bamboo-based products require low production costs and energy inputs, making them economically viable for both small-scale and large-scale industrial enterprises (Tripathi and Hazarika, 2003). The existing body of literature on ecosystem services associated with bamboo forests remains notably limited (Paudyal et al., 2019).

Nath and Das (2008) inventoried bamboo diversity in the homegardens of Irongmara and Dargakona villages in Barak Valley, Northeast India, identifying seven species, with *Bambusa cacharensis*, *Bambusa vulgaris*, and *Bambusa balcooa* as dominant, and highlighting their significance in fulfilling ecological, social, and economic needs, while emphasizing the need for sustainable management. The tea tribe communities of Assam have been reported to be highly dependent on bamboo resources for a wide range of uses, including house construction, farming and fishing implements, as well as various household items such as hen coops, flower pots, hats, carrying baskets, hand fans, and stools (Nath et al., 2011). Das et al., (2012) documented traditional bamboo-based housing patterns in Assam and Mizoram through field-based observations, highlighting its significance in sustainable living practices and its predominant use in wall panels and flooring, with designs adapted to local climatic and topographic conditions. Teron and Borthakur (2012) documented the traditional uses of bamboo among the Karbi tribe of Karbi-Anglong district, Assam, underscoring its pivotal role in socio-cultural and religious practices as well as its contribution to local livelihoods and rural economies. Singha and Timung (2015) documented the role of bamboo in Karbi culture in the Lumbajong block of Karbi-Anglong district, Assam, emphasizing its extensive use in Karbi rituals, household applications, food systems, and subsistence practices, thereby highlighting its significance in tribal life and the rural economy. Borthakur et al., (2021) assessed the status of bamboo resources in the northeastern part of Karbi-Anglong district, Assam, through field-based surveys and participatory

approaches, highlighting its diverse utilization in daily needs, rural livelihoods, and cultural practices, while also identifying challenges related to resource overexploitation, limited market access, and the need for sustainable management. Hussain (2022) analyzed the socio-economic importance of bamboo in Assam, highlighting its multifunctional use in housing, food, handicrafts, and industrial sectors, and emphasizing its potential for livelihood generation and sustainable economic development. Existing studies indicate that techniques and methodologies for the assessment and valuation of bamboo ecosystem service remain underdeveloped, and the lack of comprehensive databases constrains informed decision-making and effective management planning (Paudyal et al., 2022). The objective of the present study is to assess the utilization, household dependency, and livelihood dynamics associated with bamboo resources in Karbi-Anglong district, Assam.

## 2. Materials and Methods

### 2.1 Study Area:



*Fig. 1: Location Map.*

The present investigation was conducted in Karbi-Anglong district, Assam, Northeast India. It is the largest district of the state encompassing an area of 10,434 km<sup>2</sup> (Kramsapi et al., 2025) and forms part of the Central Assam administrative division (Basumatary et al., 2025; Borah et al., 2025). The climate is of predominantly sub-tropical monsoon type, with an average annual rainfall measuring 2416 mm (Government of Assam, n.d.). Approximately, 85% of the district is dominated by hills (NBSAP, 2002). The district is situated between 25°20'00" N to 26°40'00" N latitudes and 92°50'00" E to 94°00'00" E longitudes (Basumatary et al., 2025), with elevation ranging from 47 – 1370 m (Kramsapi et al., 2025). Temperature ranges from 6-12° C during winter and 23-32°C during summer (Government of Assam, n.d.). The natural vegetation of the district is primarily composed of Moist Semi-Evergreen Forests, Moist Mixed Deciduous Forests, Riverain Forests and Miscellaneous types with scattered pure or mixed patches of Bamboo (Champions and Seth, 1968). The Karbi tribe is the predominant community in the entire district (Borah et al., 2025), and the community is primarily dependent on agriculture and traditionally practices shifting cultivation (Teron and Borthakur, 2016). Karbi-Anglong is recognized as one of the major bamboo-rich areas of Assam, with bamboo distributed across natural forests as well as homestead gardens (Borthakur et al., 2021).

**2.2 Study approach & sampling strategy:** The study employed a stratified mixed multi-stage sampling approach. In the first stage, the study area was stratified into two administrative units, namely Karbi-Anglong and West Karbi-Anglong districts. For the purpose of this study, Karbi-Anglong district is hereafter referred to as East Karbi-Anglong. From each district, one forest range was purposively selected based on the following pre-defined criteria: a) availability and abundance of natural bamboo forests, b) ease of accessibility and field research feasibility, considering the hilly terrain and logistical constraints, and c) the availability of local contacts and institutional support to facilitate efficient and reliable field data collection. In the second stage, a total of 11 forested regions and 16 villages were randomly sampled to capture variation within the chosen forest ranges. From these sampled areas, a total of 450 respondents were randomly selected and interviewed, accounting for

approximately 10% of the total population across the 16 villages. The respondents included the households from various communities as well as key-informants, local stakeholders, forest officials, bamboo traders and bamboo growers. The age of the respondents varied from 25 to 58 years.

**2.3 Survey design:** Field surveys were conducted between August, 2023 and February, 2024 across the sampled sites under the jurisdiction of Ouguri and Dokmoka forest ranges of West and East Karbi Anglong, Assam for primary data collection. Participatory Rural Appraisal (PRA) model was adopted to study bamboo utilization patterns, dependency, and management practices through active community involvement. A semi-structured questionnaire was prepared, pilot-tested through a reconnaissance survey, and finalized prior to field survey. Multiple PRA tools, including key-informant interviews, focus-group discussions, field observations, community interactions, and semi-structured questionnaire surveys were employed for comprehensive data collection. These methods were used to understand bamboo resource availability, utilization patterns, household dependency, species preference, traditional community practices, market dynamics, and challenges associated with bamboo use and trade in the study area. The questionnaire primarily focused on a) bamboo resource availability and area under bamboo in homestead gardens; b) utilisation patterns, species preference, community practices, provisioning services, and household dependency; and c) commercial utilization, market dynamics, and challenges associated with bamboo cultivation and trade. The coordinates of the surveyed areas were recorded using a Garmin etrex 10 handheld GPS device. The study area and survey location maps were prepared using ArcMap version 10.8.1.

**2.4 Statistical analysis:** Field data were entered, systematically compiled and coded prior to data analysis. Both descriptive and inferential statistical techniques were applied for data analysis. Descriptive statistics included frequency, percentage, mean, median, standard deviation, range, and inter-quartile range (IQR). Inferential statistical techniques included the Mann-Whitney U test, Pearson's Chi-square test, Spearman's rank correlation, and Fisher-Freeman-Halton exact test. Normality of the variables was assessed using the Kolmogorov–Smirnov and Shapiro Wilk tests. Microsoft Excel and SPSS (version 21) were used for data entry, data management, visual representations and advanced statistical analysis.

### 3. Results

#### 3.1 Division-wise comparison of area under bamboo in the homestead gardens:

Table 1 presents the division-wise descriptive statistics of area under bamboo in homestead gardens across Karbi-Anglong East and West. The mean area under bamboo was comparatively higher in Karbi-Anglong East ( $0.131 \pm 0.173$  ha) than in Karbi-Anglong West ( $0.043 \pm 0.016$  ha). The median values also followed a similar pattern, with  $0.050$  ha in Karbi-Anglong East and  $0.036$  ha in the West. The mean ranks further exhibited a similar trend.



*Fig. 2: Workflow of Research Methodology.*

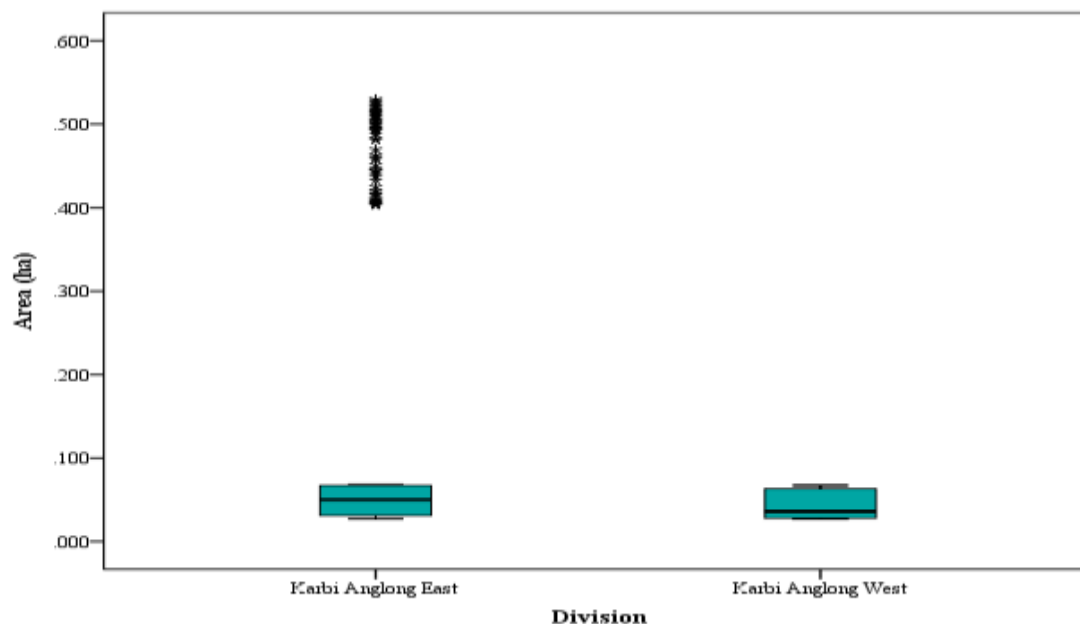
A wider range was observed in the East ( $0.027 - 0.530$  ha) than in the West ( $0.027 - 0.067$  ha), indicating greater variability among the households in the East, which is further supported by the higher standard deviation. The inter-quartile range (IQR) remained similar ( $0.036$  ha) across both divisions.

Area under bamboo in homestead gardens (ha)	Divisions	
	Karbi – Anglong East	Karbi-Anglong West
N (Sample)	283	117
Mean	0.131	0.043
Median	0.050	0.036
Variance	0.030	0.000
Standard Deviation	0.173	0.016
Range	0.503	0.040
Maximum	0.530	0.067

<b>Minimum</b>	0.027	0.027
<b>Inter-Quartile Range (IQR)</b>	0.036	0.036
<b>Mean rank</b>	213.83	168.26

**Table 1:** Division-wise descriptive statistics of area under bamboo in homestead gardens (ha) (n = 400 households).

Figure 3 represents the distribution of area under bamboo in homestead gardens across Karbi-Anglong East and West. The median area was observed to be higher in the East than in the West. The distribution in Karbi-Anglong East demonstrated greater variability, with several extreme values indicating households with relatively larger bamboo areas. In contrast, the western households exhibited a more compact distribution, suggesting relatively uniform bamboo holdings.



**Fig. 3** Distribution of area under bamboo in homestead gardens.

The normality of area under bamboo (ha) in homestead gardens across Karbi-Anglong East and West was assessed using the Kolmogorov-Smirnov's test. The results revealed that the data for both divisions significantly deviated from normality ( $p < 0.001$ ). Therefore, non-parametric statistical tests, such as the Mann-Whitney U test, were considered appropriate for further analysis.

The Mann-Whitney U test (Table 2) revealed a significant difference in the area under bamboo (ha) in homestead gardens between Karbi-Anglong East and West ( $U = 12784$ ,  $Z = -3.591$ ,  $p < 0.001$ ). The effect size ( $r = 0.18$ ) indicated a small difference between the two divisions.

Test	U-value	p-value	Z-value	Effect size (r)
Mann-Whitney U	12784	<0.001	-3.591	0.18

### 3.2 Utility and priority of bamboo species:

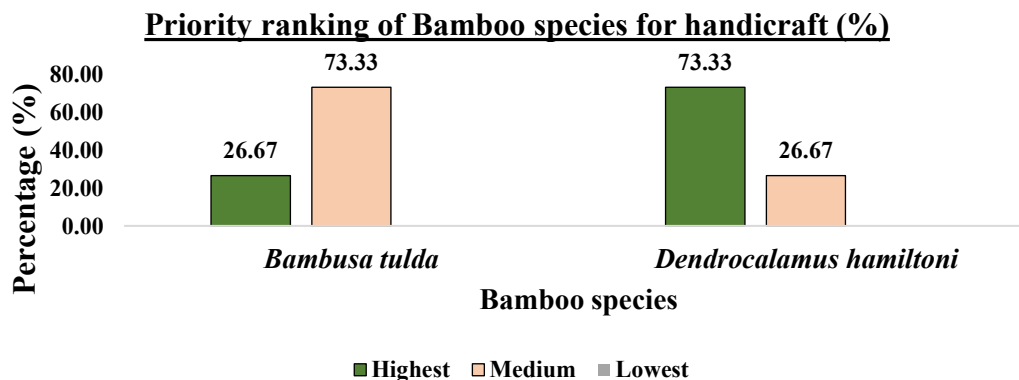
Table 3 presents the species-wise habitat distribution and traditional use patterns of bamboo in Karbi-Anglong district, Assam. A total of five bamboo species, namely *Bambusa tulda*, *Dendrocalamus hamiltonii*, *Bambusa pallida*, *Melocanna baccifera*, and *Bambusa balcooa*, were reported to be utilized by the surveyed households, although additional species were recorded in the study area but were not associated with any reported uses. The listed species were distributed across both forests and homestead systems, with *Bambusa balcooa* being restricted to homestead gardens. The documented use patterns indicate that these species are utilized for a range of purposes, including house construction, agricultural tools, fishing gear, handicrafts, furniture, and edible shoots. Among the species, *Bambusa tulda* was associated with a wider range of applications, indicating its relative importance in household utilization as compared to the other species.

Scientific Name	Local name	Growth location	Use pattern
<b>Bambusa tulda</b>	Jati banh	Forests and homestead gardens	House construction, agricultural tools (Jintaak*) and (Phanki*), fishing gear (Soklet*), fencing, floor, roofing and walling.
<b>Dendrocalamus hamiltonii</b>	Kako/Kaipho banh	Forests and homestead gardens	Handicrafts, paper production, furniture, edible shoots.
<b>Bambusa pallida</b>	Bijuli banh	Forests and homestead gardens	Musical instruments (flute), bamboo sticks, ropes, baskets, wall hangers.
<b>Melocanna baccifera</b>	Muli banh	Forests and Homestead gardens	Handicrafts (baskets, trays, sieves), fishing rods, mats.

<b>Bambusa balcooa</b>	Bhaluka banh	Homestead gardens	Construction and scaffolding.
Jintaak: rope prepared from bamboo for bundling harvested crops.			
Phanki: bamboo-based shoulder pole for transporting crops.			
Soklet: bamboo-based handicraft used for fishing.			

**Table 3:** Diversity of bamboo species, their local nomenclature, habitat distribution, and traditional use patterns in Karbi-Anglong district, Assam.

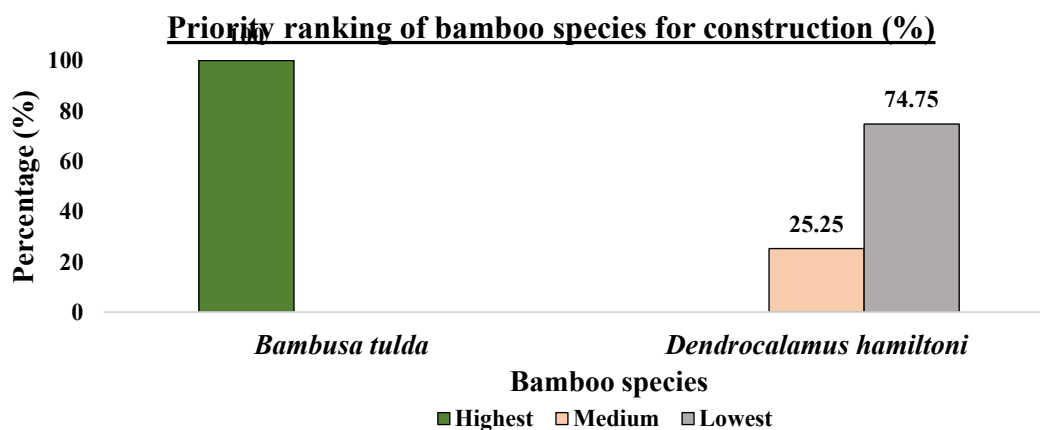
Figure 4 shows the priority ranking of bamboo species for handicraft purposes. *Dendrocalamus hamiltonii* was predominantly ranked as the highest priority species by 73.33% of the surveyed households, whereas *Bambusa tulda* was assigned the highest priority by 26.67% of respondents. Conversely, *Bambusa tulda* was more frequently assigned as a medium priority species (73.33%), while *Dendrocalamus hamiltonii* was assigned medium priority by 26.67% of households. Neither of the species was reported under the lowest priority category.



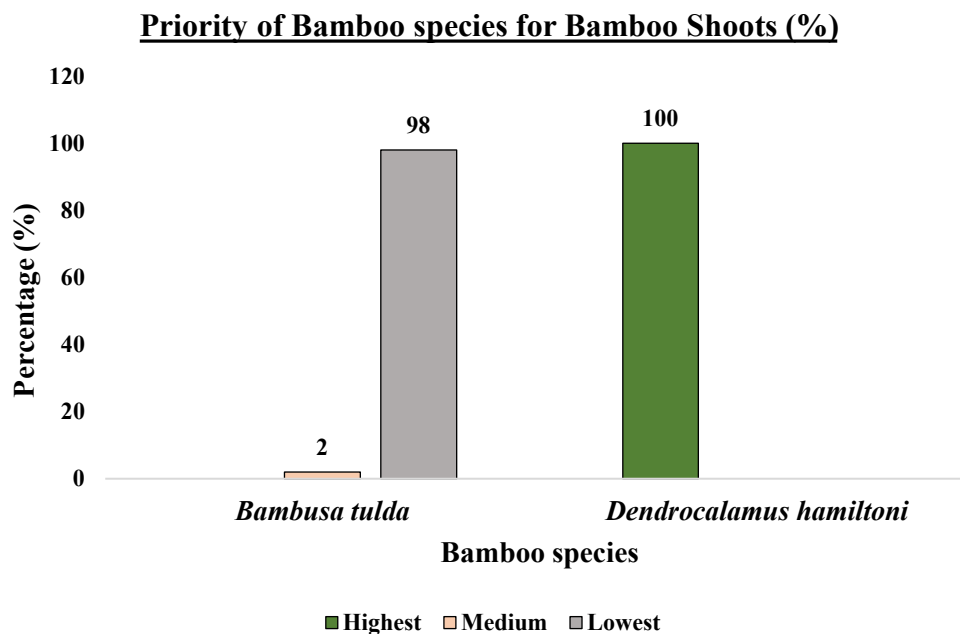
**Fig. 4:** Priority ranking of bamboo species for handicraft purpose (%).

Figure 5 shows the priority ranking of bamboo species for construction purposes. *Bambusa tulda*, was ranked as the highest priority species by all surveyed households (100%), whereas *Dendrocalamus hamiltonii*, was assigned medium and lowest priority ranks by 25.25% and 74.75% of respondents, respectively.

Figure 6 shows the priority ranking of bamboo species for bamboo shoot consumption. *Dendrocalamus hamiltonii* was exclusively ranked as the highest priority species by all respondents (100%). In contrast, *Bambusa tulda* was assigned the lowest priority by majority of the responses (98%), with only 2% of the households assigning it a medium priority. None of the respondents ranked *Bambusa tulda* as the highest priority species.

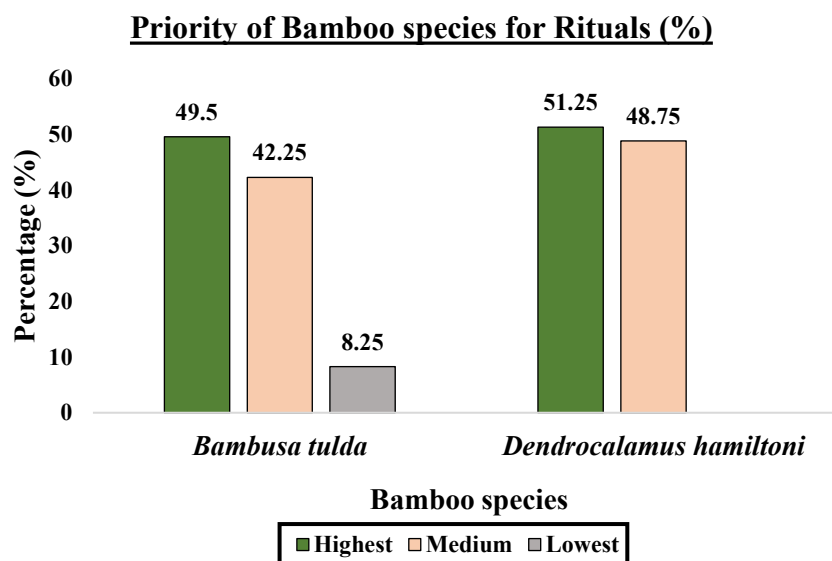


**Fig. 5:** Priority ranking of bamboo species for construction purpose (%).



*Fig. 6: Priority ranking of bamboo species for bamboo shoot consumption (%).*

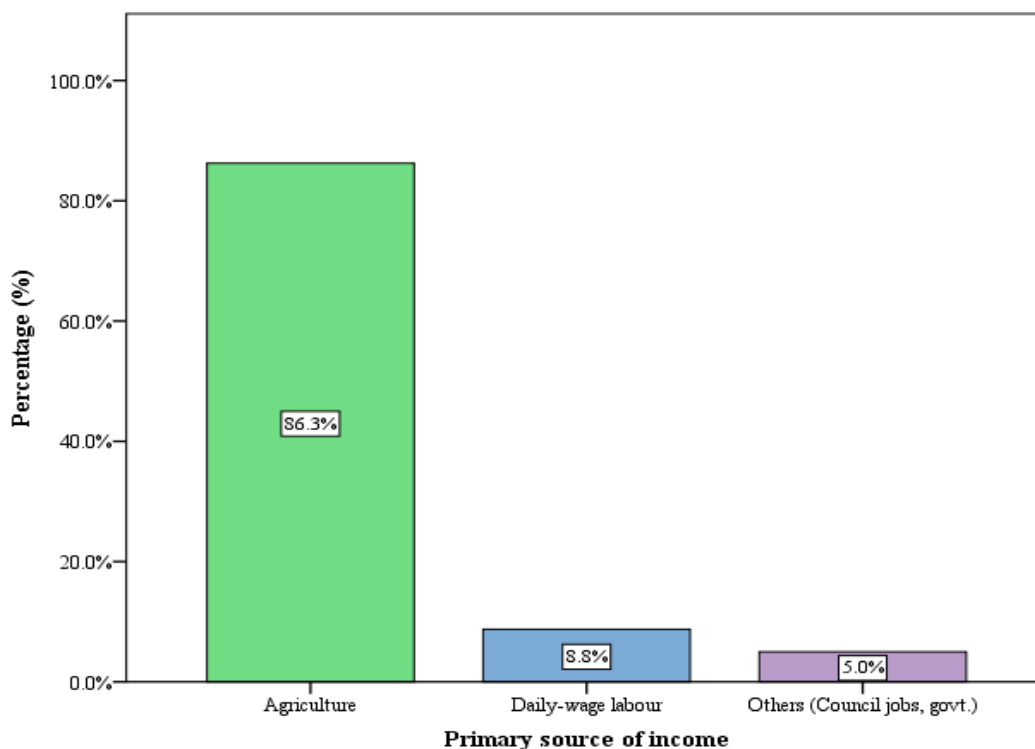
Figure 7 shows the priority ranking of bamboo species for ritualistic and cultural purposes, revealing the socio-cultural prominence of both *Bambusa tulda* and *Dendrocalamus hamiltonii* within the Karbi community. Approximately 49.5% of respondents assigned the highest priority to *Bambusa tulda*, while 42.5% assigned it medium priority and 8.25% assigned it the lowest priority category. Similarly, *Dendrocalamus hamiltonii* received the highest priority from 51.25% of respondents, whereas 48.75% assigned it medium priority. No respondents assigned the lowest priority category to *Dendrocalamus hamiltonii*.



*Fig. 7: Priority ranking of bamboo species for various rituals (%).*

### 3.3 Bamboo Resource Utilization and Household Dependency Patterns:

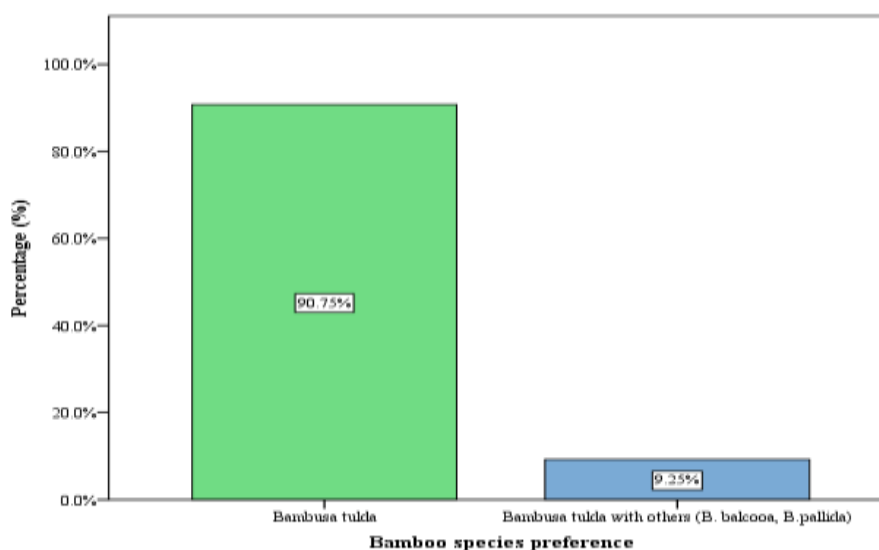
Figure 8 shows the distribution of primary sources of income among surveyed households in the study area.



**Fig. 8: Distribution of primary sources of income among surveyed households (n = 400).**

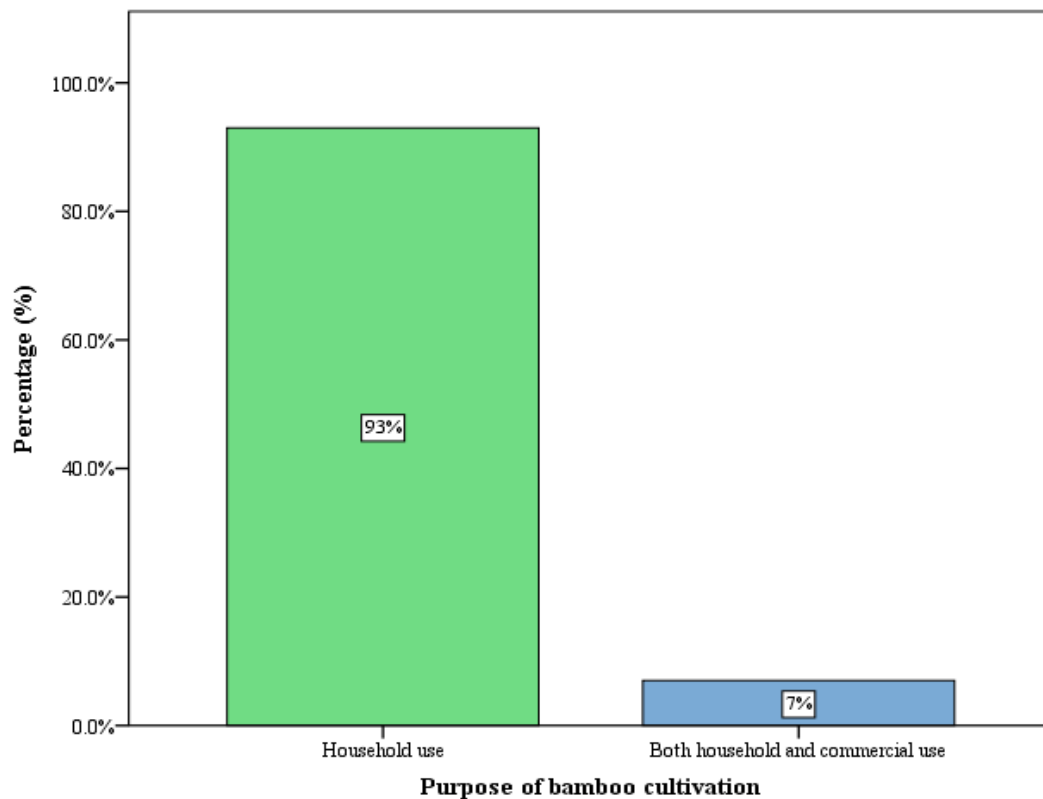
Agriculture was the predominant source of livelihood, accounting for 86.3% of households, followed by daily-wage labour (8.8%). A small proportion (5.5%) of households was engaged in other occupations, including council-related jobs and government services. Bamboo plays a vital role in the socio-economic lives of households in the Karbi-Anglong district, being extensively utilized for construction, traditional handicrafts, and the preparation of agricultural and fishing implements. Notably, all surveyed households reported cultivating bamboo within their homestead gardens. The production of bamboo-based items was largely a small-scale household activity, typically involving 1 or 2 members per household, with 68.5% of households engaging one member and 31.5% engaging two members, indicating limited but efficient labour utilization.

The preference for bamboo species cultivation was strongly dominated by *Bambusa tulda*, commonly (locally known as Jati bamboo) (Figure 9). A majority of households (90.8%) prominently preferred cultivating *Bambusa tulda*, due to its durability, strength, and robustness. In contrast, a smaller proportion of households (9.3%) preferred cultivating *Bambusa tulda* along with other species such as *Bambusa pallida*, *Bambusa balcooa*, and *Dendrocalamus hamiltonii*. This pattern underscores the dominant role of *Bambusa tulda* in local agroforestry systems, highlighting its significance in supporting household-level provisioning services.



**Fig. 9: Preference of bamboo species for cultivation among surveyed households (n = 400).**

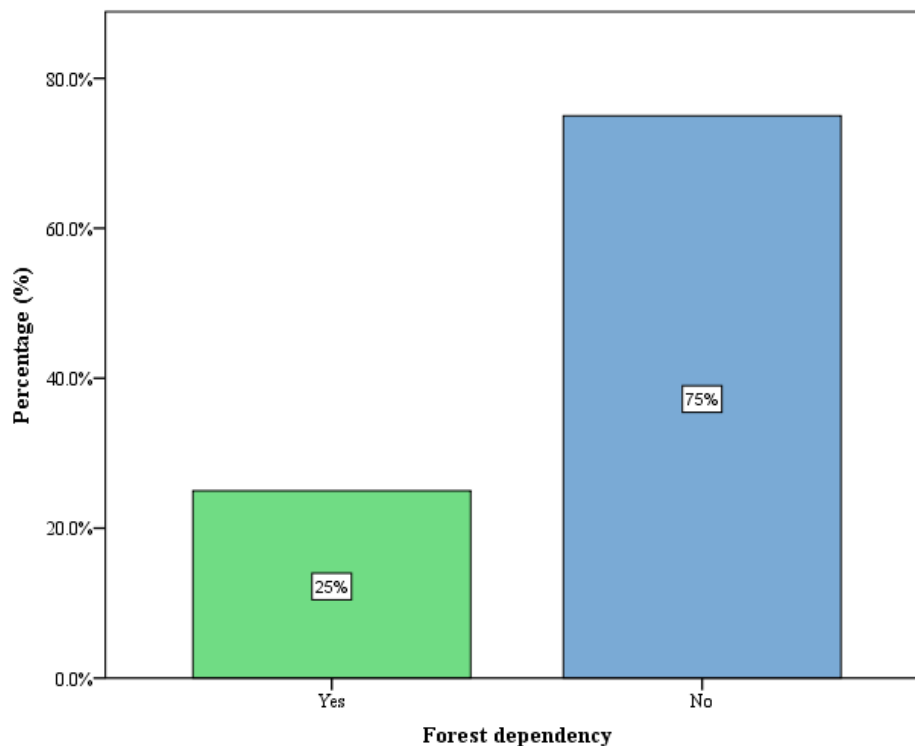
The purpose of bamboo cultivation and use among the surveyed households was predominantly oriented towards household use (Figure 10). A majority of households (93%) reported cultivating and utilising bamboo primarily to fulfil household requirements, highlighting its pivotal role in meeting daily subsistence needs. In contrast, only a small proportion of households (7%) reported using bamboo for both domestic and commercial purposes. This pattern indicates the subsistence-oriented nature of bamboo cultivation in the respective study area, with limited participation in market-oriented production.



**Fig. 10: Purpose of bamboo cultivation among surveyed households ( $n = 400$ ).**

The majority of households in the study area were not dependent on forest resources (Figure 11), with approximately 75% reporting no dependency, while 25% reported some level of reliance. Field survey responses revealed that the villagers depend on forests for the procurement of specific bamboo species such as *Dendrocalamus hamiltonii* (locally referred to as Kako/Kaipho bamboo). Notably, Kaipho is not exclusively cultivated by the Karbi community in the homestead gardens owing to prevailing cultural and religious taboos, making forested regions the primary source for its collection.

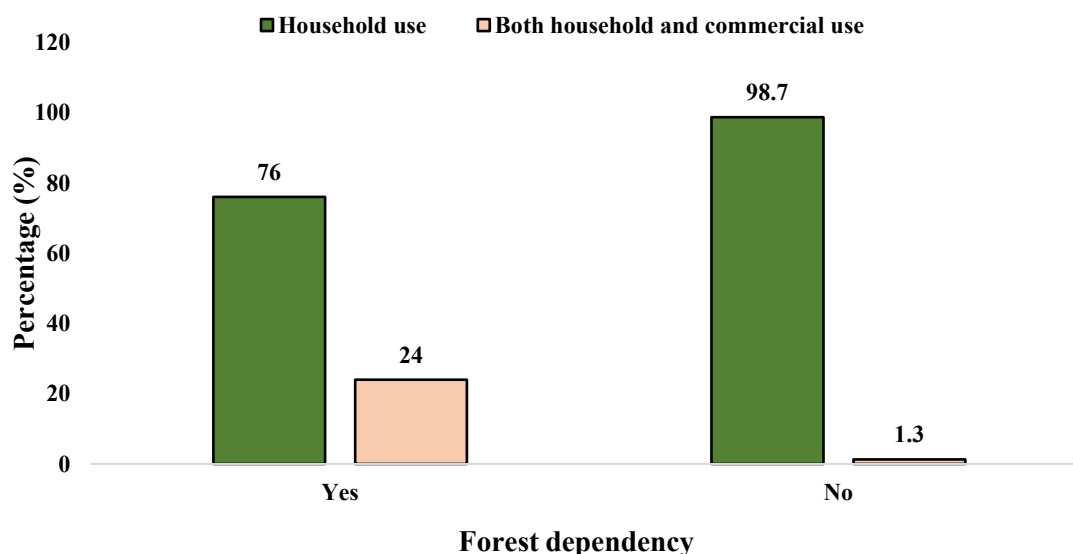
The relationship between forest dependency status and the primary purpose for bamboo cultivation and use revealed distinct patterns among households (Figure 12). Among the forest-dependent households, a majority (76%) cultivated and utilized bamboo for household purposes, while a relatively higher proportion (24%) engaged in both household and commercial use. In contrast, among the non-dependent households, an overwhelming majority (98.7%) cultivated and used bamboo solely for fulfilling household requirements, while a negligible proportion (1.3%) were involved in both household and commercial activities.



*Fig. 11: Percentage distribution of households based on forest dependency.*

The association between forest dependency status and primary reason for bamboo cultivation and use was found to be statistically significant (Pearson's  $\chi^2 = 59.400$ ,  $df = 1$ ,  $p < 0.001$ ), indicating that forest dependency significantly influences the bamboo utilization pattern among households. All expected cell counts exceeded 5, confirming that the assumptions of the Chi-square test were satisfied.

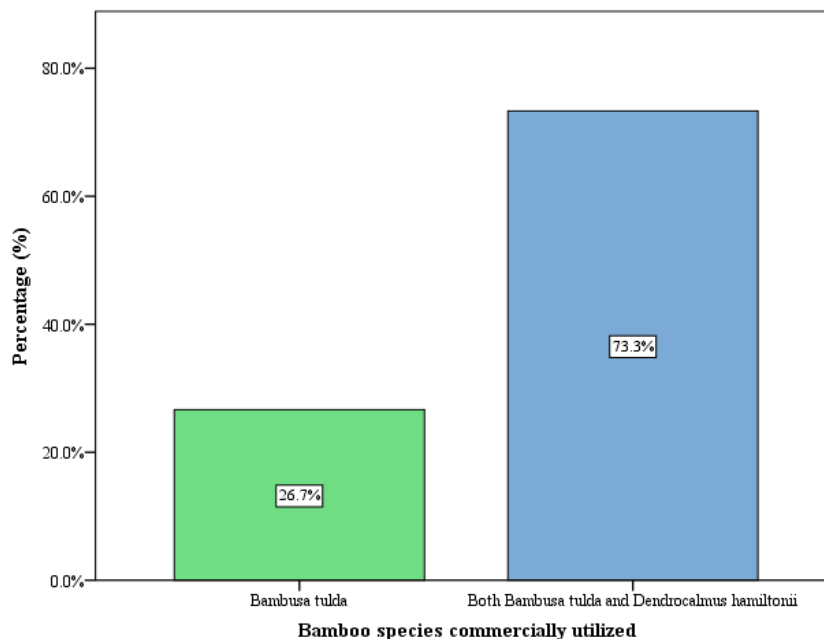
#### Primary reasons for bamboo cultivation and use across forest dependency statuses (%)



*Fig. 12: Distribution of primary reasons for bamboo cultivation and use among households across forest dependency statuses.*

Dependency on local bamboo markets was observed to be relatively low among the surveyed rural households. A majority of households (92.8%) reported no dependency on local bamboo markets, whereas only a small proportion (7.3%) indicated some level of dependence. Field survey responses indicated that such dependency was largely seasonal and primarily associated with the procurement of agricultural and fishing implements, as well as bamboo shoots during specific periods of demand or limited household availability. Among the households reporting market dependency, a majority (82.8%) indicated a low frequency of dependence, while only 17.2% reported an intermediate level of dependency, further underscoring the limited and occasional reliance on local bamboo markets in the study area.

*Bambusa tulda* and *Dendrocalamus hamiltonii* were the primary bamboo species utilized by traders and shopkeepers for commercial purposes (Figure 13). A majority of respondents (73.3%) reported the commercial utilization of both species, whereas 26.7% reported utilizing only *Bambusa tulda*. These findings suggest that the two species constitute the principal commercially valuable resources in the study area, owing to their suitability for construction, handicrafts, and other market-oriented applications.



**Fig. 13:** Bamboo species commercially utilized in the study area.

Table 4 presents the market price and profit margin of commercially utilised bamboo species in the study area. *Bambusa tulda* had a comparatively higher selling price (Rs. 120/culm) than *Dendrocalamus hamiltonii* (Rs. 80/culm). Field survey responses revealed that profit margins were generally estimated at approximately 10% per product or around Rs. 500/cart, depending on the quantity and nature of bamboo products sold in the market. However, bamboo traders reported that the quantity of bamboo sold per month varied substantially due to low and irregular demand, seasonal fluctuations, and the absence of formal sales records.

Bamboo species	Average selling price (Rs. /culm)	Estimated profit margin
<b>Bambusa tulda</b>	120	10% per product or Rs. 500 per cart
<b>Dendrocalamus hamiltonii</b>	80	10% per product or Rs. 500 per cart

**Table 4:** Market price and profit margin of commercially utilised bamboo species.

The mean age of bamboo traders and shopkeepers interviewed in the study area was  $40.97 \pm 7.92$  years, with a median age of 42 years. The age of respondents ranged from 26 to 54 years, with an interquartile range (IQR) of 12.75. The respondents had an average business experience of  $11 \pm 8.04$  years, with a median of 7.5 years. Years of involvement in bamboo-related business activities ranged from 1 to 25 years, with an IQR of 14.75. The Shapiro-Wilk's test was conducted to assess the normality of age and years in business among bamboo traders and shopkeepers. Age did not significantly deviate from normality ( $W = 0.966$ ,  $p = 0.429$ ), indicating an approximately normal distribution. In contrast, years in business significantly deviated from normality ( $W = 0.870$ ,  $p = 0.002$ ), suggesting that the data were not normally distributed.

The box-plot showing the distribution of years in business among business traders and shopkeepers (Figure 14) indicated an uneven distribution with greater spread towards higher values, further supporting the non-normal distribution identified through the Shapiro-Wilk test.

The relationship between age and no. of years in business was assessed using Spearman's rank correlation due to significant deviation from normality in one of the variables (years in business). The correlation was observed to be very weak and statistically non-significant (Spearman's  $\rho = 0.049$ ,  $p > 0.05$ ), revealing no meaningful association between the two variables. Hence, age could not be considered a reliable indicator of business tenure within the studied sample. For comparison, Pearson's correlation was also calculated and yielded a similar result ( $r = 0.068$ ,  $p > 0.05$ ).

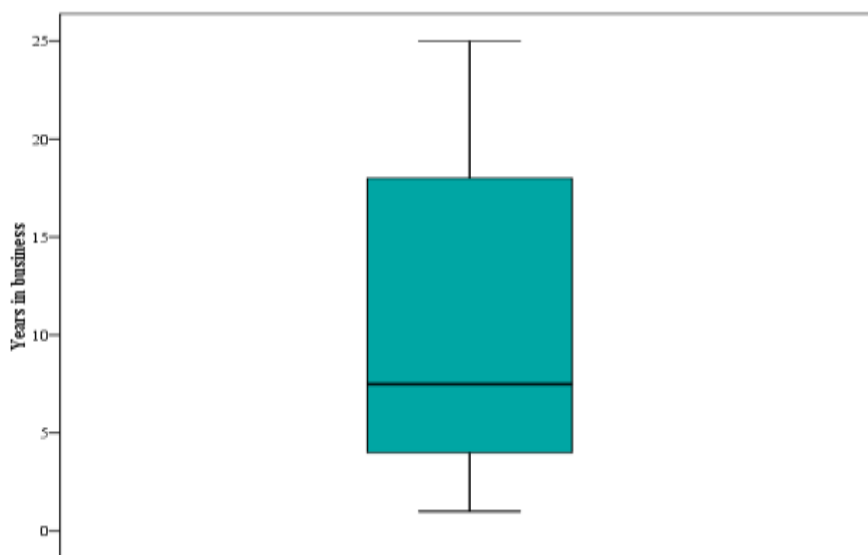


Fig. 14: Distribution of years in business among bamboo traders and shopkeepers.

Figure 14 illustrates the distribution of business satisfaction levels across different types of bamboo markets prevalent in the study area. Among the respondents associated with bamboo handicraft stores, the majority reported a good level of business satisfaction (63.6%), followed by satisfactory (31.8%) and fair (4.5%) levels. In contrast, respondents engaged in raw bamboo stores exhibited relatively lower levels of satisfaction, with an equal number of respondents reporting good and fair satisfaction levels ( $n = 3$  each), while only a few respondents reported satisfactory levels. Overall, respondents associated with bamboo handicraft stores reported comparatively higher satisfaction levels than those involved in raw bamboo trade. The association between the nature of bamboo markets and business satisfaction levels was initially assessed using Pearson's Chi-square test ( $\chi^2 = 5.577$ ,  $df = 2$ ,  $p = 0.083$ ) (Table 5). However, owing to the small sample size ( $n = 30$ ) and low expected cell frequencies, Fisher-Freeman-Halton exact test was subsequently employed. The exact test revealed no statistically significant association between the type of bamboo market and business satisfaction levels (Value = 4.754,  $p = 0.109$ ), indicating that business satisfaction levels did not vary significantly across the different market types in the study area.

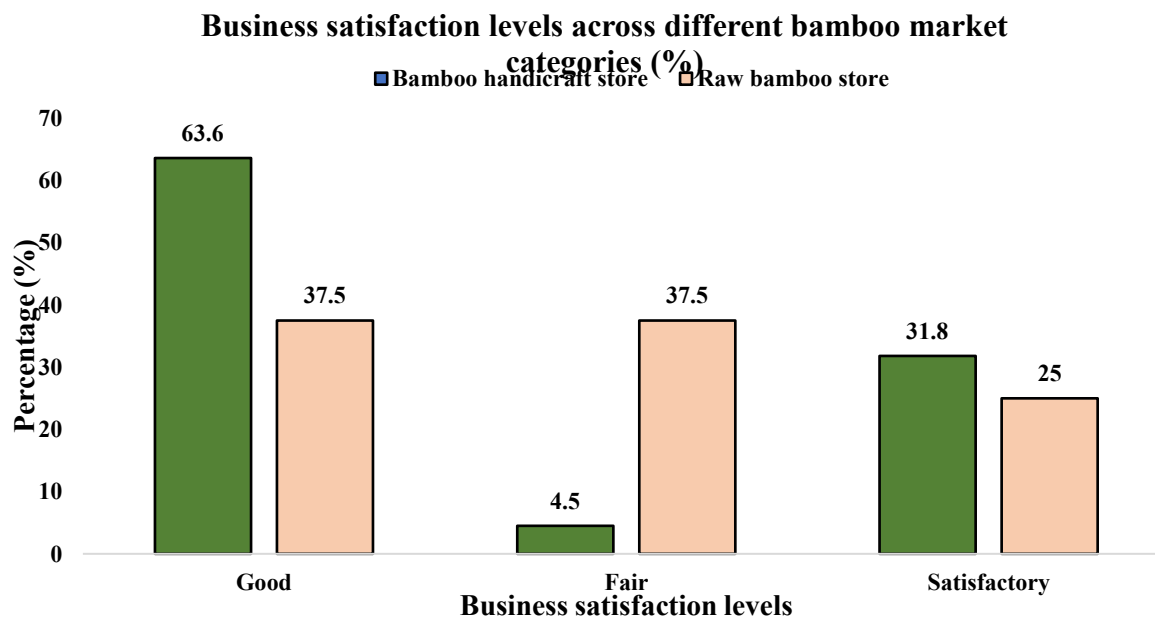


Fig. 15: Distribution of business satisfaction levels across different bamboo market categories.

Statistical Tests	Value	df	p-value
Pearson's Chi-Square	5.577	2	0.083 (>0.05)
Fisher's Exact Test	4.754		0.109 (>0.05)

Table 5: Results of Pearson's Chi-square test and Fisher-Freeman-Halton exact test examining the association between business satisfaction levels and the type of bamboo market among bamboo traders and shopkeepers.

#### 4. Discussion

A higher area under bamboo in the homestead gardens of Karbi Anglong East was observed compared to Karbi Anglong West, possibly indicating a relatively greater dependency on bamboo resources within the eastern household land-use systems. The wider range and higher variability observed in Karbi Anglong East further

suggest that certain households maintain comparatively larger bamboo holdings, reflecting stronger integration of bamboo resources for domestic utilization, subsistence requirements, and supplementary livelihood support. In contrast, a more compact distribution was observed in Karbi Anglong West, indicating relatively uniform bamboo holdings among the households. However, despite the observed heterogeneity, the significant Mann-Whitney U test results, together with the relatively small effect size, suggest that bamboo cultivation remains an integral component of homestead gardens across both Karbi-Anglong East and West.

Similar observations were reported by Das et al., (2015), who documented that bamboo forms an indispensable component of traditional agroforestry systems in Barak Valley, Assam, and is commonly maintained in separate management zones locally referred to as Bansh tilla or bamboo groves. The authors further reported the widespread occurrence of bamboo within homestead systems irrespective of landholding size, thereby emphasizing the socio-economic and functional dependency on bamboo resources among rural households. Nath and Das (2008) additionally highlighted the importance of bamboo within the homegarden systems of Barak Valley, Assam as it provides rural households with a wide variety of goods and services for fulfilling their varied day-to-day requirements.

The present study documented the utilization patterns associated with five major bamboo species across the homestead gardens and forested landscapes of Karbi-Anglong district, Assam. These species are widely utilized for house construction, agricultural implements, fishing gear, handicrafts, furniture, musical instruments, and edible shoots, thereby underscoring their multifaceted significance in fulfilling a wide range of rural household requirements. *Bambusa tulda* exhibited the widest range of applications among the reported species and was ranked as the highest priority species for construction purpose by all the surveyed households. The suitability and higher preference for *Bambusa tulda* in structural and household applications may be attributed to its favorable mechanical and physical properties, including comparatively higher tensile strength, durability, density, and stiffness, as reported in earlier studies demonstrating its considerable potential for construction-related applications (Singh et al., 2019; Reddy et al., 2025).

*Dendrocalamus hamiltonii* was highly prioritized by the rural households for handicraft applications, whereas *Bambusa tulda* was assigned comparatively lower priority. The observed utilization pattern may be associated with the extensive traditional usage of Kaipho bamboo (*Dendrocalamus hamiltonii*) in household utility items and indigenous bamboo-based crafts. Teron and Borthakur (2012) reported similar observations, documenting Kaipho bamboo (*Dendrocalamus hamiltonii*) as one of the most frequently utilized species within the hilly landscapes of Karbi-Anglong district, and further highlighting its utility for fulfilling day-to-day household requirements.

Furthermore, the present research revealed that *Dendrocalamus hamiltonii* was predominantly preferred for edible shoot consumption by all surveyed households, whereas *Bambusa tulda* was assigned comparatively lower priority. The observed preference may be attributed to the favorable nutritional value of *Dendrocalamus hamiltonii* shoots. Similar findings were reported by Bhatt et al., (2003), who documented *Dendrocalamus hamiltonii* among the major commercially important edible bamboo species across several states of Northeast India and further reported that its tender shoots were extensively harvested for consumption throughout the region, thereby highlighting their nutritional significance among the tribal communities. *Bambusa tulda* possessed comparatively higher food energy and protein content and were extensively harvested for consumption throughout the region, thereby highlighting their nutritional significance among the tribal communities. Similar nutritional characteristics of *Dendrocalamus hamiltonii* shoots were further reported by Choudhury et al., (2012).

Agriculture was the predominant source of livelihood among the surveyed rural households of Karbi-Anglong district, reflecting the largely agrarian nature of the rural economy. Here, agriculture represents a broad umbrella category encompassing horticultural practices, vegetable cultivation, and other agro-forestry based production systems such as broom grass and arecanut cultivation. Bamboo-based activities required the involvement of only 1 or 2 household members, as reported by the surveyed households, indicating the small-scale and household-oriented nature of bamboo utilization practices within the study area.

The findings of the present study indicated that bamboo is largely cultivated and managed for fulfillment of household requirements and day-to-day needs rather than for commercial purposes, thereby highlighting the subsistence-oriented nature of bamboo resource management among the rural communities of the study area. Similar observations were reported by Nath and Das (2008) in Barak Valley, Assam, where rural households maintained the bamboo resources within homestead systems primarily for fulfilling their household necessities. Sailo et al., (2025) further reported that provisioning services of bamboo were the most frequently utilized services in the daily lives of the rural communities of Arunachal Pradesh, India, thereby highlighting the substantial dependency of rural households on bamboo resources for fulfilling their varying household needs.

The forest dependency results indicate that, although overall forest dependency remains limited, forests continue to serve as an important and regulated source for specific bamboo species, that are not commonly managed within homestead systems, particularly among the Karbi community. In addition, forest dependent households were comparatively more engaged in partial commercialization, whereas non-dependent households primarily relied on bamboo for subsistence needs. Most households of the study area remained self-reliant in fulfilling their bamboo-related requirements, with local market dependency restricted to occasional or specialised needs, thereby highlighting the supremacy of household-level production and limited reliance on market-based procurement.

The market survey conducted during the present study indicated that culms of *Bambusa tulda* had a comparatively higher market price than *Dendrocalamus hamiltonii* within the study area. This could be associated with its diverse range of applications in construction and household-related uses. However, bamboo trade in the region was observed to be largely informal and small-scale in nature, with considerable fluctuations in sales influenced by seasonal variations, irregular demand, and the absence of systematic market records. Furthermore, a non-significant statistical relationship was observed between age and number of years in business, indicating that

bamboo trade or business within the study area is not necessarily influenced by the age of the traders and may possibly depend on household-level involvement and local market dynamics.

Comparatively higher satisfaction levels were observed among respondents associated with bamboo handicraft stores than those involved in raw bamboo stores, possibly due to the greater market demand and value addition associated with processed bamboo products. In contrast, raw bamboo traders reported relatively lower levels of satisfaction, potentially driven by fluctuations in local market demand and seasonal market dynamics.

## 5. Conclusion

The present study demonstrated that bamboo resources remain an integral component of rural communities inhabiting Karbi-Anglong district, Assam. They provide substantial household benefits by supporting daily subsistence, indigenous practices, and supplementary livelihood activities. The findings further emphasized the vital provisioning services of bamboo in sustaining the rural economy of the study area. Bamboo utilization patterns were observed to be largely species-specific, depending upon their traditional and functional suitability as well as household requirements. Despite its socio-culture significance and economic potential, bamboo utilisation within the study-area remains primarily household-oriented, with limited commercialisation and informal market systems. Sustainable bamboo resource management, formal market linkages, value addition, and capacity-building initiatives could play a crucial role in enhancing rural livelihoods and ensuring long-term socio-economic development in the region.

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## 7. References

1. Acharya, S. K., Gupta, M., Biswas, A., & Mishra, G. C. (2015). *Bamboo in North-East India: The ecology, economy and culture*. Krishi Sanskriti Publications.
2. Basumatary, L., Borthakur, P., & Simhachalam, A. (2025). Land use land cover (LULC) change detection analysis between 2013 and 2023 in Karbi Anglong district, Assam, using geo-informatics. *Indian Journal of Science and Technology*, 18(27), 2227–2234. <https://doi.org/10.17485/IJST/v18i27.772>
3. Bhatt, B. P., Singha, L. B., Singh, K., & Sachan, M. S. (2003). Some commercial edible bamboo species of northeast India: Production, indigenous uses, cost-benefit and management strategies. *Bamboo Science and Culture*, 17(1), 4–20.
4. Borah, S. N., Sarma, K., & Sarma, A. K. (2025). Role and functional aspects of bamboo amongst the ethnic communities of Northeast India: A case study of the Karbi tribe in the district of Karbi-Anglong, Assam. *Explore*, 2(3), 17–29. <https://doi.org/10.62823/exre/2025/02/03.80>
5. Borthakur, R.D., Kalita R.K., Bora S.J., Das N.C. (2021). Bamboo Resource Scenario in the North - Eastern Part of Karbi Anglong District, Assam: A Case Study. *Journal of Bamboo & Rattan*. Vol. 20, p.p. 9-14. <https://cabidigitallibrary.org>
6. Champion, H.G. and Seth, S.K., 1968. *A Revised Survey of the Forest Types of India*. New Delhi: Government of India Press.
7. Choudhury, D., Sahu, J. K., & Sharma, G. D. (2012). Bamboo shoot: Microbiology, biochemistry and technology of fermentation—A review. *Indian Journal of Traditional Knowledge*, 11(2), 242–249.
8. Das, P., Chaaruchandra, K., Sudhakar, P., & Satya, S. (2012). Traditional bamboo houses of North-Eastern Region: A field study of Assam and Mizoram. *Key Engineering Materials*, 517, 197–202. <https://doi.org/10.4028/www.scientific.net/KEM.517.197>
9. Das, M. K., Nath, A. J., & Das, A. K. (2015). Village bamboos of Barak Valley: Opportunities of utilization through small scale industries. In *Problems and prospects of village industries in India* (pp. 39–47).
10. Gogoi, M. (2020). Market analysis of bamboo products in Assam. *Agro-Economic Research Centre for North-East India*, Assam Agricultural University.
11. Government of Assam. (n.d.). District profile: Karbi Anglong. Karbi Anglong District Administration. <https://karbianglong.gov.in/information-services/district-profile>
12. Hossain, M. A., Tripura, S., Hossain, M. M., & Hasnat, G. N. T. (2022). Allometric models for estimating above ground biomass of *Bambusa tulda* Roxb. and *Melocanna baccifera* (Roxb.) Kurz. XV World Forestry Congress Proceedings.
13. Kiruba, S., Jeeva, S., Sam Manohar Das, S., & Kannan, D. (2007). Bamboo seeds as a means to sustenance of the indigenous community. *Indian Journal of Traditional Knowledge*, 6(1), 199–203.
14. Kramsapi, R., Cajee, L., & Sarma, K. K. (2025). Land use transitions and bamboo based livelihood diversification in Karbi Anglong, Northeast India. *Asian Journal of Geographical Research*, 8(4), 61–73. <https://doi.org/10.9734/ajgr/2025/v8i4318>
15. Nadkarni, S., & Punekar, R. M. (2020). Agoli Bah: Bamboo furniture for rural school and primary health centre. Department of Design, Indian Institute of Technology Guwahati.

16. Nath, A. J., & Das, A. K. (2008). Bamboo resources in the homegardens of Assam: A case study from Barak Valley. *Journal of Tropical Agriculture*, 46(1–2), 58–61.
17. Nath, A. J., Bhattacharjee, P., Nandy, S., & Das, A. K. (2011). Traditional utilization of village bamboos among the tea tribes of Barak Valley, northeast India. *Bamboo Science and Culture*, 24(1), 35–44.
18. National Biodiversity Strategy and Action Plan (NBSAP). (2002). Biodiversity strategy and action plan for Karbi-Anglong.
19. Paudyal, K., Yanxia, L., Long, T. T., Adhikari, S., Lama, S., & Bhatta, K. P. (2022). Ecosystem services from bamboo forests: Key findings, lessons learnt and call for actions from global synthesis. *International Bamboo and Rattan Organisation (INBAR)*. <https://doi.org/10.13140/RG.2.2.26017.07526>
20. Reddy, P. M., Sen, T., & Pal, J. (2025). Comprehensive characterization of Bengal bamboo (*Bambusa tulda* Roxb.) for advanced material applications: Physical, mechanical, thermal and microstructural insights. *Advances in Bamboo Science*, 13, 100214. <https://doi.org/10.1016/j.bamboo.2025.100214>
21. Singha, K. N., & Timung, L. (2015). Significance of bamboo in Karbi culture: A case study among the Karbi tribes of Assam (India). *International Journal of Advanced Research in Biology and BioTechnology*, 1(1), 1–9.
22. Singh, K., Garg, H., & Pabla, B. S. (2019). Evaluation of mechanical properties of different bamboo species for structural applications. *International Journal of Innovative Technology and Exploring Engineering*, 8(11), 2927–2935. <https://doi.org/10.35940/ijitee.K2218.0981119>
23. Sailo, R. L., Sarkar, B. C., Apshahana, K., Dabral, A., Jilen, A., Marak, A. D., Shukla, G., Suresh, C. P., & Chakravarthy, S. (2025). Perceptions of ecosystem services and disservices of bamboo by indigenous communities in Northeast India. *Advances in Bamboo Science*, 10, 100135. <https://doi.org/10.1016/j.bamboo.2025.100135>
24. Teron, R., & Borthakur, S. K. (2012). Traditional uses of bamboos among the Karbis, a hill tribe of India. *Bamboo Science and Culture: The Journal of the American Bamboo Society*, 25(1), 1–8.
25. Tripathi, Y. C., Singh, S., & Hazarika, P. (2003). Bamboo—The green gold of northeastern India. In G. Tripathi & A. Kumar (Eds.), *Potentials of living resources* (pp. 352–383). Discovery Publishing House.