ESTIMATION OF SPECIES WISE BAMBOO RESOURCES USING REMOTE SENSING AND GIS AND ASSESSMENT OF UTILIZATION PATTERN IN MOKOKCHUNG DISTRICT, NAGALAND

GBPNI/NMHS-2017-18/HSF-03/606
NMHS-Himalayan Institute Fellowship Grant

Final Technical Report

Submitted

To

National Mission on Himalayan Studies, GBP NIHE, Almora, Uttarakhand

(Ministry of Environment, Forest & Climate Change (MoEF&CC), New Delhi)

By
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Scientist- F

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NMHS-Himalayan Institutional Fellowship Grant

FINAL TECHNICAL REPORT (FTR)

NMHS Reference No.:	GBPNI/NMHS-2017-18/HSF-03/606

Date of Submission:	0	9	1	1	2	0	2	2
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ESTIMATION OF SPECIES WISE BAMBOO RESOURCES USING REMOTE SENSING AND GIS AND ASSESSMENT OF UTILIZATION PATTERN IN MOKOKCHUNG DISTRICT, NAGALAND.

Sanctioned Fellowship Duration:*from* (30.03.2018) *to* (30.03.2021)

***Submitted to*:**

Er. Kireet Kumar
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National Mission on Himalayan Studies, GBP NIHE HQs
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***Submitted by*:**
[Dr. Dhruba Jyoti Das, Scientist-F]
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DSL: *Date of Sanction Letter*

3	0	0	3	**2**	**0**	**1**	**8**
d	d	m	m	y	y	y	y

DFC: *Date of Fellowship Completion*

3	**0**	**0**	**3**	**2**	**0**	**2**	**1**
d	d	m	m	y	y	y	y

Part A: CUMULATIVE SUMMARY REPORT

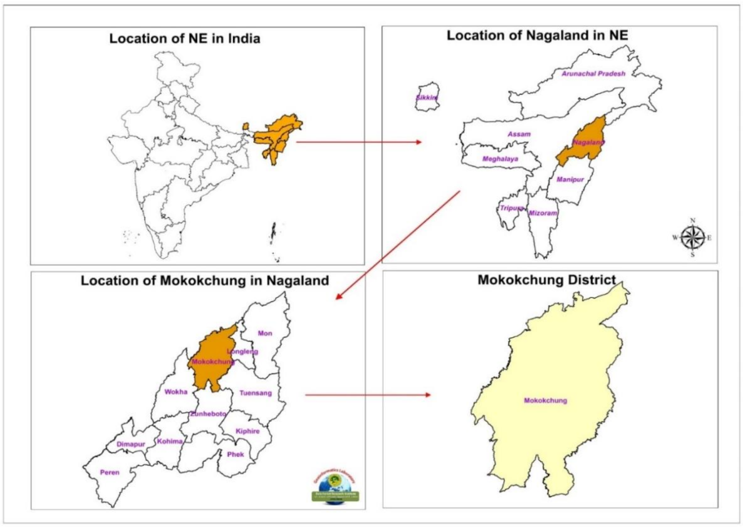
1. Details Associateship/Fellowships

1.1 Contact Details of Institution/University

NMHS Fellowship Grant ID/ Ref. No.:	**GBPNI/NMHS-2017-18/HSF-03/606**
Name of the Institution/ University:	**Rain Forest Research Institute, Jorhat-Assam.**
Name of the Coordinating PI:	**Dr. Dhruba Jyoti Das (Scientist-F)**
Point of Contacts (Contact Details, Ph. No., E-mail):	Contact Details: Rain Forest Research Institute, Jorhat-Assam, India E-mail: dhrubajyoti.india@gmail.com Ph. No.: 9435742252/ 8638285136

1.2 Research Title and Area Details

i.	Institutional Fellowship Title:	**Estimation of Species Wise Bamboo Resources and Assessment of their Utilization Pattern in Mokokchung District of Nagaland, India**					
ii.	IHR State(s) in which Fellowship was implemented:	Nagaland, India					
iv.	Scale of Fellowship Operation	Local:	-	Regional:	Yes	Pan-Himalayan:	-

iii.	Study Sites covered (*site/location maps to be attached*)	 **Fig 1: Map showing the district of Mokokchung**
v.	Total Budget Outlay (Lakhs):	INR 11.73 lakhs

1.3 Details Himalayan Research /Project Associates/Fellows inducted

Type of Fellowship	Nos.	Work Duration	
		From	To
Research Associates	Nil	Nil	Nil
Sr. Research Fellow	Nil	Nil	Nil
Jr. Research Fellows	Nil	Nil	Nil
Project Fellows	01	04/07/2018	30/03/2021

2. Research Outcomes

2.1. Abstract

Background: Bamboo, a fastest growing, multi-purpose woody plant that has been closely knitted especially with the lives of the rural communities. Northeast-India is blessed with abundance of bamboo species with almost 60% of the species found in this region. The state harbors diverse species of bamboo which differs in structure and habitat ranging from the lower elevation to higher elevation gradient. According to Nagaland Bamboo Development Authority (NBDA, 2009) a total of forty-six (46) species have been reported so far which is 31.08% against 148 species reported from India (Sharma and Nirmala, 2015). It is one of the important minor forests produces that play an important role in the tribal community as it has a vast range of potential from being taken as a food to various ethno-religious purposes. There is a scarce availability of information on bamboo in the state of Nagaland, therefore looking into all the scenario the study has been taken up.

***Aim and Objectives*:**

1. To assess the species wise growing stock of bamboo and quantify harvestable bamboo resources in the district.
2. To generate species wise distribution map of bamboo resources.
3. To document various utilization pattern of bamboo resources.

Methodology(ies) & Approach: Reconnaissance survey was conducted in the study site and the encountered bamboo species during the survey was recorded. Taking into consideration of the recorded bamboo species, literatures for biomass equations were reviewed. Destructive and non-destructive method was followed to estimate the growing stock. For quantifying the harvestable bamboo, data recorded in the clump enumeration form was used. A detailed LULC map was prepared following hybrid approach which was helpful to generate the dominant species- distribution map of bamboo. Village level questionnaire survey was conducted to get an information on utilization pattern of various bamboo species.

***Results*:** A total of 22 bamboo species were recorded from Mokokchung district. The average culm density of the stand was found to be more for *Gigantochloa parvifolia* (7255 No.s/ha) followed by *Bambusa tulda* (6193 No.s/ha), *S. dullooa* (4575 No.s/ha) *Dendrocalamus hamitonii* (2943 No.s/ha), *B. pallida* (1828 No.s/ha), *D. longispathus* (1533 No.s/ha), *D. sikkimensis* (1024 No.s/ha), *B. balcooa* (843 No.s/ha) and others. Their corresponding biomass was also estimated, species wise *B. tulda* was estimated to be 107925.5 kg/ha followed by *G. parvifolia* (73852.6 kg/ha), *D. hamiltonii* (27977.9 kg/ha), *D. sikkimensis* (24928.9 kg/ha), *S. dullooa* (19636.7 kg/ha), *D. longispathus* (15990.8 kg/ha), *B. pallida* (8951.4 kg/ha), *B. balcooa* (3507.8 Kg/ha) and others. The total estimated culm of 'green sound' was 218.08 million along with its corresponding biomass of 2.28 Tg. A total of 334 rural households were surveyed to know their dependency and utility on bamboo. It was seen that many people of the district were considerably dependent on bamboo for their day-to-day activities. As far as utilization pattern is concerned, People were found more inclined towards *B. tulda* and *D. hamiltonii*. *B. tulda* was predominantly used for construction and household activities whereas *D. hamiltonii* was found to be preferred more as food items, made in different form for consumption from fresh, dried to fermented. A total of 90 articles were documented.

Conclusion: In the study area, *B. tulda, G. parvifolia* and *D. hamiltonii* had higher AGB as compared to other species. The diameter (D) and Height (H) of a culm was found to be the best fitted predictor variable to estimate the biomass. On the other hand, though the numbers of culms were more for *G. parvifolia* as compared to *B. tulda*, the AGB was higher for *B. tulda*. This phenomenon may be attributed to the morphological characteristics of *B. tulda*, which include a larger culm diameter and greater height compared to *G. parvifolia*. The total growing stock estimation in this study was important for evaluating the amount of resources available in the region.

Recommendations: Considering the importance of bamboo being recognized these days, the predictive biomass equation of *B. tulda* developed in this present study could be very useful for forestry professionals, potential bamboo growers and other interested parties to derive aboveground biomass directly. Although the equation is site specific, it could be applied on plantation and natural stands with similar edaphic and climatic conditions so that sustainable harvesting and scientific management of these bamboo forests can be planned accordingly. Identification of bamboo is very difficult as within species morphological variations occur. Hence, detailed study on taxonomic parameters as well as its molecular studies of all bamboo species found in the state needs to be carried out to generate database to avoid confusion in identification. Also, taxonomic study of all endemic bamboos must be undertaken in detail. As bamboo is becoming an important sustainable resource with wide potentials, the educated youths of this century can utilize and incorporate their innovative ideas into crafts and other utilization articles to uplift the livelihood of the rural people.

2.2. Objective-wise Major Achievements

<table>
<tr><th>S. No.</th><th>Cumulative Objectives</th><th>Major achievements</th></tr>
<tr><td>1</td><td>To assess the species wise growing stock of bamboo and quantify harvestable bamboo resources in the district.</td><td>

108 sampled plots were laid and detailed bamboo enumeration was done in Mangkolemba, Kubolong, Ongpangkong (N), Ongpangkokng (S), Changtongya and Longchem block.
A total of 15 bamboo species were recorded with 1841 clumps from the sampled plots.
120 culms of Bambusa tulda were harvested to find the biomass. Age wise allometric bamboo biomass equation was developed:

<table>
<tr><th>Age class</th><th>Equation</th><th>R^2</th></tr>
<tr><td>1-2 yr</td><td>Biomass (B) $=0.074547 \times D^{2.031796} H^{(6.655535 \times 0.074547)}$</td><td>0.979</td></tr>
<tr><td>2-3 yr</td><td>Biomass (B) $=0.081067 \times D^{1.862632} H^{(7.623133 \times 0.081067)}$</td><td>0.931</td></tr>
<tr><td>>3 yr</td><td>Biomass (B) $=-15.032421+ 3.325163 \times D + 0.794888 \times H$</td><td>0.855</td></tr>
<tr><td></td><td>B= Biomass ; D= Diameter (cm); H= Height (m)</td><td></td></tr>
</table>

Altogether, a total of 22 species of bamboos were recorded from Mokokchung district, among them 15 are from sample plots and 7 are from other areas including home gardens, community forests etc. (Table 15)
Sporadic bamboo flowering was encountered during the survey viz., B. Balcooa, D. sikkimensis, D. hamiltonii, and S. dullooa.
Few unidentified species were recorded, the photographs of the species were sent to experts for further identification and confirmation is awaited. However, a detailed taxonomic expedition of bamboo in the region is required.
Information on DEM, road network, drainage system was acquired/ derived from authentic sources. Many of the resources were later updated from satellite images.

</td></tr>
</table>

2	**To generate species wise distribution map of bamboo resources.**	• The following satellite images were acquired and utilised in the project: Satellite image / Spatial resolution / Date: LISS IV — 5.8 m — 16th May, 2018 Sentinel 2 — 10-20 m — 19th Nov, 2021; 19th Dec, 2021 Landsat 8 — 30 m — 10th April, 2020 • Image classification of LISS IV was done and a detailed land use/ cover map was prepared. Different classes viz. Very dense forest, Moderately dense forest, Open Forest, Open/ barren land, Settlement, Water bodies, Scrub land, Fallow land, Current shifting cultivation etc. were categorized. • A total of 526 ground truth points (GTPs) were recorded from Mangkolemba, Kubolong, Ongpangkong (S), Ongpangkong (N), Changtongya and Longchem blocks.
3	**To document various utilization pattern of bamboo resources.**	• 334 households were surveyed and their bamboo utilization had been documented. • 90 articles of bamboo products were recorded.

Satellite image	Spatial resolution	Date
LISS IV	5.8 m	16th May, 2018
Sentinel 2	10-20 m	19th Nov, 2021 19th Dec, 2021
Landsat 8	30 m	10th April, 2020

2.3. Outputs in terms of Quantifiable Deliverables*

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, and Reason thereof:
1.	Knowledge on species diversity and quantum of growing stock for harvesting can be generated.	No. of plots laid out in the field and analysis of the field data.	108 sampled plots were laid (Fig. 9) and detailed information regarding bamboo enumeration was collected from the sampled plot.	None
2.	Species wise distribution map of bamboo resources will be constructed in GIS environment.	LISS IV satellite imagery and DEM was acquired and visual classification of satellite image of	Dominant species wise bamboo resources of the district were generated. (Fig. 13)	None

		Mokokchung district was done.		
3.	Utility on various aspect of bamboo resources will be documented in the area.	No. of households interviewed for collecting the information regarding utilization and no. of articles documented.	334 households were surveyed and species-wise bamboo utilization was recorded. (Appendix-1a)	None

(*) As stated in the Sanction Letter issued by the NMHS-PMU.

2.4. Strategic Steps with respect to Outcomes (in bullets)

S. No.	Particulars	Number/ Brief Details	Remarks/ Enclosures
1.	New Methodology developed:	NA	NA
2.	New Models/ Process/ Strategy developed:	01	(Table 8)
3.	New Species identified:	NA	NA
4.	New Database established:	• Bamboo growing stock/biomass of Mokokchung district of Nagaland estimated. (Table 13) • Harvestable bamboo quantified and map generated. (Fig. 11 & Table 18) • Dominant species-wise distribution map generated. (Fig. 13) • Specie-wise utilization pattern of bamboo documented. (Appendex-1a)	NA
5.	New Patent, if any:	NA	NA
	I. Filed (Indian/ International)	NA	NA
	II. Granted (Indian/ International)	NA	NA
	III. Technology Transfer (if any)	NA	NA
6.	Others, if any:	NA	NA

3. Technological Intervention

S. No.	Type of Intervention	Brief Narration on the interventions	Unit Details (No. of villagers benefited / Area Developed)
1.	Development and deployment of indigenous technology	NA	NA
2.	Diffusion of High-end Technology in the region	NA	NA
3.	Induction of New Technology in the region	NA	NA
4.	Publication of Technological / Process Manuals	NA	NA
	Others (if any)	NA	NA

4. New Data Generated over the Baseline Data

S. No.	New Data Details	Existing Baseline	Additionality and Utilisation of New data (*attach supplementary documents*)
1.	A map showing the harvestable bamboo bearing areas will be generated.	No existing record was available.	The map generated will be helpful especially for the people into bamboo trading business as it will show the abundance of bamboo available in the accessible area for harvesting. (Fig. 11)
2.	Specie-wise distribution map of dominant bamboo will be generated.	No existing record was available.	The distribution map so generated with their corresponding growing stock would be beneficial for planners, policy makers and resource managers for accurate information of the current state and spatial distribution. (Fig. 13)
3.	Specie-wise utilization pattern of bamboo will be recorded.	Paper on utilization of bamboo in Mokokchung district was carried out by Walling and Puro (2018) but detailed study was not carried out.	Detailed list of species-wise utilization pattern of bamboo generated would be as a reference for students, researchers, and other scientific communities. (Appendix- 1a)

4.	Documentation of utilization pattern of bamboo will be done.	Likewise, similar study was done on documentation of utilization pattern by Walling and Puro (2018) but detailed study was not done.	This document will be helpful for people to learn more about various utilization aspect of bamboo in making different products. (Appendix- 1b)

5. Linkages with Regional & National Priorities (SDGs, INDC, etc.)/ Collaborations

S. No.	Linkages /collaborations	Details	No. of Publications / Events Held	Beneficiaries
1.	Sustainable Development Goals (SDGs)	This project in way will assist in achieving the following developmental goals: SDG 1, SDG 7, SDG 11, SDG 12, SGD 13, SDG 15 & SGD 17	Nil	State Forest Department and other scientific communities
2.	Climate Change/INDC targets	NA	NA	NA
3.	International Commitments	NA	NA	NA
4.	National Policies	Participated in national seminars organized by NMHS at Almora, Kosi-Katarmal, Uttarakhand	02 seminars	All institutions involved with NHMS programme.
5.	Others collaborations	NA	NA	NA

1. Financial Summary (Cumulative)*

The cumulative financial summary was being prepared as per the given Performa and was audited by competent authority which is attached in Annexure-I

*Please attach the **consolidated and audited Utilization Certificate (UC) and Consolidated and *Year-wise* Statement of Expenditure (SE)** separately, *ref*. **Annexure I.**

7. Quantification of Overall Research Progress

S. No.	Parameters	Total (Numeric)	Attachments* with remarks
1.	IHR State(s) Covered:	01	Fig. 1
2.	Fellowship Site/ LTEM Plots developed:	01	Fig. 3
3.	New Methods/ Model Developed:	01	Table 8
4.	New Database generated:	• A total of 22 bamboo species were recorded. • Documentation of 90 articles were recorded.	Table 15 Appendix- 1b
5.	Types of Database generated:	• Quantitative data on bamboo growing stock, species diversity and utilization pattern.	Table 13 Table 15 Appendix- 1a
6.	No. of Species Collected:	NA	NA
7.	New Species identified:	NA	NA
8.	Scientific Manpower Developed (PhDs awarded/ JRFs/ SRFs/ RAs):	01 JPF/SPF	Appendix- 7
9.	No. of SC Himalayan Researchers benefited:	NA	NA
10.	No. of ST Himalayan Researchers benefited:	01	NA
11.	No. of Women Himalayan Researchers empowered:	01	NA
12.	No. of Knowledge Products developed:	NA	NA
13.	No. of Workshops participated:	01	Participated as a Resource person in a workshop organised by Nagaland Forest Management Project (NFMP). (Appendix- 3)
14.	No. of Trainings participated:	01	Participated an online international training on Bamboo for Rural Livelihood conducted by NIRDPR-NERC, Guwahati, Assam. (Appendix- 3)
15.	Technical/ Training Manuals prepared:	NA	NA
	Others (if any):	NA	NA

***** Please attach the soft copies of supporting documents word files and data files in excel.

8. Knowledge Products and Publications*

S. No.	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/ Enclosures***
		National	International		
1.	Journal Research Articles/ Special Issue (Peer-reviewed/ Google Scholar)	-	-	-	-
2.	Book Chapter(s)/ Books:	-	-	-	-
3.	Technical Reports/ Popular Articles	-	-	-	-
4.	Training Manual (Skill Development/ Capacity Building)	-	-	-	-
5.	Papers presented in Conferences/ Seminars	03	-	-	Appendix- 3
6.	Policy Drafts (if any)	-	-	-	-
7.	Others (specify)	-	-	-	-

*Please append the list of KPs/ publications (with impact factor and URL link details) with due Acknowledgement to NMHS.
**Please provide supporting copies of the published documents.

9.Recommendation on Utility of Research Findings, Replicability and Exit Strategy

The research finding under the project has great utility as information on species wise bamboo growing stock is inadequate. The growing stock/ biomass information generated shall be useful in better understanding of the contribution of bamboos in overall biomass and carbon budget of the region, state, and prospect of bamboo utilisation in the region and the pertaining decision making to improve the livelihood opportunities of the indigenous people of the region.

The methodology adopted in the present project may be replicated for the entire state to have a comprehensive bamboo database. The details are given below:

9.1 Utility of the Fellowship Findings

S. No.	Research Questions Addressed	Succinct Answers
1.	**Does the growing stock vary between bamboo species? If so, to what extend?**	It was observed that growing stock per unit area vary between different bamboo species. Due to different form, size, edaphic and other ecological conditions, dimension of the clump and area occupancy overall **growing stock vary between bamboo species.** It was observed that the area occupancy by *Dendrocalamus spp* is more as compared to *Bambusa spp.*
2.	**Can species mapping**	Proper species-wise map will help in locating the species for

	be an important tool for its resource management?	precise growing stock estimation and sustainable harvesting which in turn will help in management and utilization of the resources and aid in the development of bamboo product manufacturing.
3.	**How are bamboos being utilized in the study area?**	A total of 334 household surveys were covered for socio-economic and its utility was documented. The major uses are highlighted below: 1. *Bambusa pallida*: Shoot, Wall, Mat etc. 2. *Bambusa tulda*: Shoot, Flooring, Scaffolding etc 3. *Pseudostachyum polymorphum*: Shoot, Weaving stick for mekhela making, Wall etc. 4. *Dendrocalamus hamiltonii*: Shoot, Basket, Cup, Plate, Mat etc 5. *Dendrocalamus sikkimensis*: Flooring, Container, Storage of water etc. 6. *Schizostachyum dullooa*: Shoot, Wall, Roof, Container, Mat, etc. 7. *Bambusa balcooa*: Ladder, handles for implements etc. 8. *Dendrocalamus longispathus*: This species is solely used in making mats for wrapping dead bodies: a past usage of coffin, Warrior shield, Chicken coop etc.

9.2 Recommendations on Replicability and Exit Strategy:

Particulars	Recommendations
Replicability of Fellowship, if any	• Since, there is scanty information regarding bamboo mapping and its growing stock in the state, this project is a baby step towards filling this gap. The outcome of this project will not only give us a baseline data on the quantification of resources, their extend of availability with accessibility but also will guide us in carrying out such studies. This project can be replicated in other state as well as in other parts of Indian Himalayan Regions. • The study was done in Mokokchung district dominated by Ao tribe. Hence, documentation on bamboo utilization was done for this Ao tribe only. Similar studies can be done for others tribal communities within the state to have a bigger picture of utilization prospects.

Exit Strategy:	• The outcome of this project can be used for species wise mapping and monitoring of the spatial extent of bamboos in similar climatic and physiographic zone that would be beneficial for planners and resource managers. • An up-to-date land use/cover map will be helpful for forest department and other land resource managers of the state and central government. • Pictorial documentation of bamboo articles will give us an insight of different bamboos utilised by Ao tribe and their cultural association with it.

(**NMHS FELLOWSHIP COORDINATOR**)

(Dr. Dhruba Jyoti Das, Scientist F, RFRI)

(Signed and stamped)

(**HEAD OF THE INSTITUTION**)

(Dr. Nitin Kulkarni, Director, ICFRE-RFRI)

(Signed and stamped)

Place: RFRI, Jorhat- Assam.
Date:…../……/……..

PART B: COMPREHENSIVE REPORT

EXECUTIVE SUMMARY

Bamboo a versatile plant has been known to exist since time immemorial. It has a strong link with the tribal community as it had co-existed along with their lives for ages and is an integral part of many indigenous people's livelihood. More than 1,500 species of bamboo under 90 genera are found worldwide (FAO, 2014). About 14 million hectares of the earth surface is covered by bamboos with 80 percent in Asia (Tewari, 1992). Regarding genetic resources, India is second only after China.In India there are around 148 species belonging to 29 genera (Sharma and Nirmala, 2015), of which about 66% growing stock is concentrated in North Eastern states of the country (Hore,1998; Adkoli,2002). They are naturally distributed in the forest of North-eastern region forming a rich belt of diversity and variety. Porter-field (1933) suggested that ''bamboo is one of those providential developments in nature which, like the horse, the cow, wheat, and cotton, have been indirectly responsible for man's own evolution''. Bamboo is an important forest resource as it has wide usages and because of its versatility it can be a great alternative to timber, food to tribal and rural poor community and this plant is valued equally by scientists, artisans, and craftsmen. Bamboo has manifold of application in terms of construction, scaffolding, fodder, tools, fishing gear, handicrafts etc. It is an efficient agent for preventing soil erosion and conserving soil moisture (Christanty et al. 1996, 1997; Mailly et al. 1997; Kleinhenz and Midmore 2001). The tender shoots are consumed in the form of dry, fermented, and fresh by the people of Nagaland.

The state of Nagaland is blessed with abundance of bamboo. Studies on distribution, above ground biomass, species availability and its uses are however, are inadequate till date. The indigenous people have vast knowledge on utilization and management of bamboo that needs to be documented for proper conservation and management of these resources. This present study thus aims to bring forth a comprehensive account of its diversity, distribution and uses which will be helpful for planner, bamboo growers and other related work to bamboo in the state. The study also attempts to quantify the annual requirement of bamboo based on specie-wise utilization in Mokokchung district.

The state of Nagaland is in the eastern Himalayan region. The study area Mokokchung district falls under Nagaland which has an area of 1,719 km^2. The district lies between 94.29 and 94.76 degrees East longitude and 26.20 and 26.77 degrees North latitude. The altitude zone ranging from 155 to 2000 above msl. The district is occupied by NW-SE trending hill with six distinct ranges viz., Asetkong, Changkikong, Japukong, Langpangkong, Ongpangkong and Tsurangkong and comprised of some major rivers namely: Melak, Dikhu and Tsurang. The people of the state are predominantly agrarian. Besides, home-garden, community forests and individual bamboo plantations are some of the important land uses in the region.

Field visits were done in Mokokchung district where 108 sample plots with a size of 0.1 ha (31.62m X 31.62m) were laid. Complete enumeration was done where the number of culms, clumps and the bamboo species occurring inside the plot was recorded. To find out the biomass both destructive and non-destructive method was followed. Biomass of *Bambusa tulda* was calculated following biomass equations development by destructive sampling method since it was found to be the dominant species in the district. The remaining species were calculated by existing equations generated by other researchers. Data on socio-economic state of the district was collected with help of standard questionnaire by interviewing individual households in the study area. A total of 334 households were covered in various blocks. Information was gathered on the availability of different species, source of bamboo, its durability, usage etc. All the observations and important points by the interviewees were noted. Sources of the bamboos were also identified. Records on different bamboo species used for utilization, the quantities collected annually and an inventory was made for articles used. Bamboos were identified with their taxonomical keys following standard manual and consulting domain experts/ taxonomists in and outside the institute.

During our investigation, 22 species out of the reported 46 species of bamboo in the state were found from Mokokchung district. *B. tulda* in most of the areas was found as Plantation. *Bambusa* and *Dendrocalamus* genus has the maximum number of species in the study area followed by *Melocanna*, *Giganthochloa*, *Pseudostachyum* and *Schizostachyum*.

A site specific allometric equation was developed for *Bambusa tulda*. Average culm density and above-ground biomass of all bamboo species recorded as 6193 culms/ha and 107.93 t/ha respectively in Mokokchung. As *B. tulda* had more usage in their basic lives' activities, it was observed that this bamboo found space in home garden, jhum land and as block plantation. Species like *B. pallida*, *S. dullooa* and *D. hamiltonii* were found in the wild and were sparsely distributed.

People were interviewed to know their dependency and utilization of bamboo. It was found that their dependency was more towards *B. tulda* and *D. hamiltonii* in their daily activities as compared to other bamboo species available in the region. People usually harvest *B. tulda* from plantation site and *D. hamiltonii* from the wild. Uses of bamboo varied from domestic need for households to commercial purposes, it had a broad spectrum of uses in the district. Each species had specific use based on the properties. Altogether 90 articles were documented from the surveyed area. It was observed that people mainly use *B. tulda, D. hamiltonii* and *S. dullooa* for making articles, construction purposes etc. This reveals that the people had high dependency on bamboo resources in the area. Bamboo products with higher market and demand were muluk (basket for storage), per (winnower), chikok (spadel) and chisang (flat spoon). Some articles were hardly woven or found at present as they are diminishing considerably, this may be due to people opting for synthetic or ready-made products in the market. Bamboo products were also being observed to be replaced by plastic in the study area.

From the present study it can be seen that there is a research gap pertaining to bamboo taxonomy that can be taken seeing the paramount importance of the species. Since the morphological characters differ within same species due to change in ecological zones, its identification is very tricky. Therefore, correct taxonomic identification keys and others molecular markers of these bamboo species are required. Moreover, extensive, and in-depth study on species diversity is required to know emphatically about its diversity and local distribution at the state level. The study also revealed that natural bamboos are also depleting because of unscientific harvest, over exploitation etc. Therefore, ex-situ or in-situ conservation efforts can be taken up by establishing bambusetum or by declaring some bamboo rich areas as bamboo sanctuaries posed a foremost need of an hour for this valuable green wealth. Youths in particular can take the help of elderly skilled artisans and combine their innovative ideas and knowledge to improvise and improve bamboo craftship and upgrade it into next level to find local and international markets which can be a good alternative of plastic.

Fellowship Report No.: ***n ofN*** *(n = Sequential number; N= Total no. of fellowships granted to the Institute/ University)*
(02 of 03)

Researchers Details

Type of Fellowship (HRA/HJRF/HJPF)	Name of Himalayan Researcher	Date of Joining	Date of Resignation **	Research Title	Name of the PI & Designation
HJPF	Ms. Temjensola Jamir	04/07/2018	31/03/2021 (Project ended)	Estimation of Species Wise Bamboo Resources and Assessment of their Utilization Pattern in Mokokchung District of Nagaland, India	Dr. Dhruba Jyoti Das (Scientist- F)

*If the appointed researcher resigned in the mid of the fellowship duration, then also mention the name of the Himalayan researcher who carried forward the fellowship.

1 INTRODUCTION

1.1 Background/ Summary of the Associateship / Fellowship Study undertaken:

Bamboo, is a fast growing, resilient, perennial evergreen plant that has been known to be very close to people's lives, especially in the rural communities, it is considered as the most valuable resource because of its diversified utility and has been critical for the survival of mankind for centuries. It is an ancient woody grass belonging to the sub family Bambusoideae of the family poaceae. Worldwide there are more than 1,500 species under 90 genera of bamboo, which are unevenly distributed in the various parts of the humid tropical and sub-tropical belt between 46° north and 47° south latitude, and is commonly found in Africa, Asia and Central and South America. Some species may grow successfully in the mild temperate zones in Europe and North America. Bamboo forests, cover an area of 37 million ha, equivalent to almost 4% of the world's total forest coverage (FAO, 2014). There is partial available information on the bamboo growing stock of the world as most of the countries do not provide data. However, as per one estimate about 332 million tonnes of bamboo growing stock are available in Asian countries and about 57 million tonnes of bamboo growing stock are available in African countries (FAO, 2007).

According to Widjaja (2004), the fast growth rate of bamboo makes it ideal as reforestation plant. Furthermore, bamboo produces the highest amount of oxygen among other trees. Its ability to absorb carbon is also high enough to overcome the problem of CO_2 concentration in the air. Additionally, bamboo serves as water purifier that can be used in the remediation of critical soil (Zhou et al., 2005; Mishra et al., 2014). China has the highest bamboo biodiversity in Asia, with over 500 species, followed by Japan, India, Indonesia and Myanmar each with more than hundred species (SFA, 2005).

In India, natural bamboo forests are estimated to be 10.03 million ha and about two thirds of the total bamboo area are located in northeast India (INBAR, 2015). India is the second richest country in terms of bamboo genetic diversity (Bystriakova et al., 2003) which is distributed throughout the length and breadth of the country with a total 148 species belonging to 29 genera were reported to be found in India (Sharma and Nirmala, 2015), although no list of species was provided. North Eastern Himalayan region of India has a great diversity of bamboo resources. Bamboo is one of the important minor forest produces that assist in subsistence income of tribal folk to a greater extent (Sundriyal et al., 2002). In addition, bamboo has ecological functions and the potential to be solution of environmental problems such as global warming (Thokchom and Yadava, 2015) as well as social economic values (Banik, 2010; Pande et al., 2012).

Among all the bio-resources, bamboo is one of the most important resources as it has been a part and partial of the social, economic structure and a source of livelihood for the all communities in northeast from time immemorial (Bendangtemjen, 2016). The tribal communities of the region and especially Nagas use this potential resource for food, shelter, furniture, handicraft, medicines and various ethno-religious purposes (Marden and Brandenburg, 1980; Tewari, 1992). Forty-six (46) species of bamboo are known to exist in Nagaland. So far, scientifically managed bamboo plantation covers an area of 13,982 hectares (NBDA, 2009). Many workers around the world have done bamboo mapping especially in Meghalaya by (Goswami et al., 2010), Malaysia (Jusoff, 2007), China (Meng, 2006), Mizoram (Das, 2012) etc. but species wise mapping and estimation of growing stock has not been done till date in North East India hitherto. Hence, this present study entitled **"Estimation of Species Wise Bamboo Resources and Assessment of their Utilization Pattern in Mokokchung District of Nagaland, India"** is designed as a pilot study to throw light on possibilities of species wise mapping and their quantification.

1.2 Baseline and Scope of the Associateship / Fellowship:

North-east is considered predominantly as under developed area and one of the main reasons behind this is lack of adequate livelihood options and employment opportunity in the region. Though very popular in subsistence level yet Bamboo has not been able to find its desired place in the rural economy due to lack of awareness about the economic potential and utility of bamboos. Northeast has not only over 60% of bamboo species reported to occur in India but also considered to be the potential area in the country as far as bamboo resources are concerned. Bamboo resources of Northeast are having vast opportunity of providing livelihood and employment to the local communities but a complete enumeration of species wise availability of bamboo resources is lacking; also lack of reliable data on biomass, growing stock, productivity, area, and growth is negatively impacting the resource strengthening initiatives, therefore the study to estimate species wise growing stock and distribution in Mokokchung district of Nagaland as a pilot study is taken up.

1.3 Overview of the Major Issues to be addressed:

Bamboo despite being a versatile plant species with varied utilities and socio-cultural association, its proper resource mapping is still lacking throughout the country. Attempts have been made by premier research and survey organizations to map bamboo area in many parts of the country. Countries like China, Cambodia, Australia etc. had attempted mapping of bamboo resource as well. The accuracy however is the issue that needs to be addressed properly. Further, Spatial species-wise resource mapping of bamboo would be useful in resource evaluation, conservation of biodiversity and their ecological management for the policy makers, industrialists, farm managers & local farmers. Knowledge on the extent and amount of materials available is extremely necessary for judicious utilization and management of any resources available to us. This report had tried to bring out species-wise account of bamboo for looking at the dominant species of the district. The present study has concentrated on one district with more sampling intensity to bring out an accurate estimation of bamboo resources. The rural people are dependent on bamboo for its variety of uses but proper documenting and promoting of its article has been neglected.

1.4 Brief summary of the activities under taken by the researcher:

The present investigation was carried out in Mokokchung district of Nagaland having geographical coordinates between 94.29 and 94.76 degrees East longitude and 26.20 and 26.77

degrees North latitude and covers an area of 1,719 km^2 having a population of about 194,622 with a population density of about 120 person per square km. The district is the cultural center of the Ao Naga tribe and is also considered as the intellectual and cultural capital of Nagaland. Christianity is the predominant religion and the rest belongs to an immigrant business community that practices other religions and faiths. It is located at an elevation of 1,325 meters above sea level and is bounded by Assam to its North, Wokha Districtto its West, Tuensang District and Longleng District to its East and Zunheboto District of Nagaland to its South. The town of Mokokchung is its headquarters as well as the urban hub of the district. The region has several ranges that run more or less parallel to each other. The entire district is sub-divided into 6 ranges namely: Tsurangkong, Japukong, Changkikong, Asetkong, Langpangkong and Ongpangkong ranges each having their own distinct meaning.

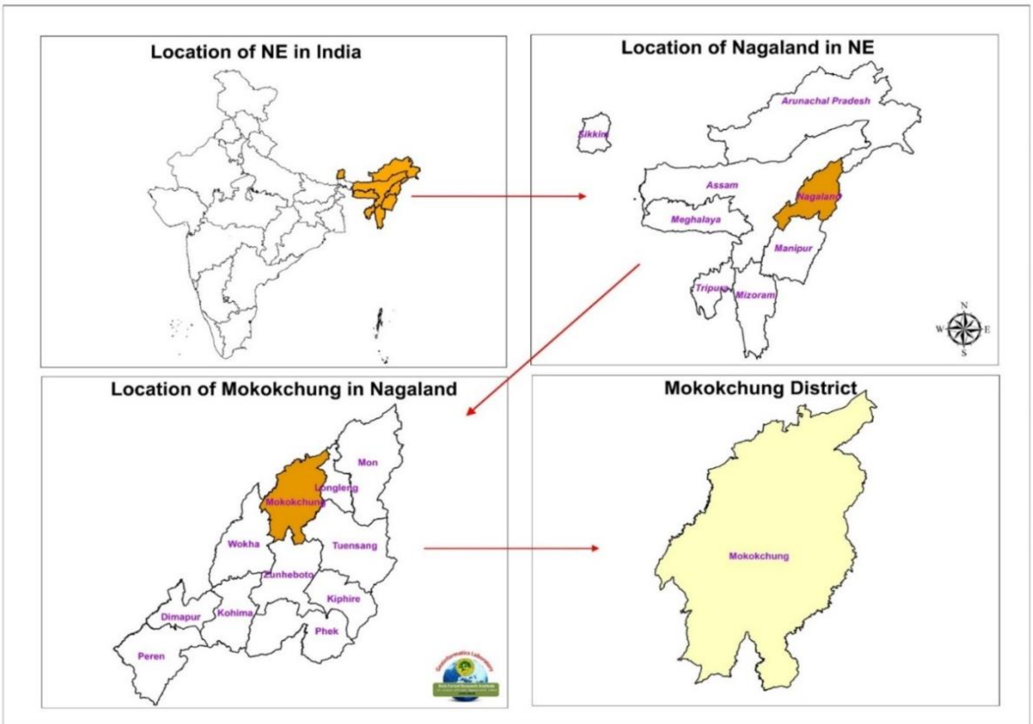


Fig 1: Map showing the district of Mokokchung

Some of the major rivers in the district are Melak, Dikhu, and Tsurang that come within the Brahmaputra basin. Types of soil present in the district are alluvial, non-laterite red soil and forest soil. Climate is mild throughout the year. The forest is a degraded secondary tropical forest. Almost all the area is under jhum, natural forests, and restored jhum lands. Important species are Bamboos, *Alnus nepalensis*, which is the basis of the Alder-based shifting cultivation practice, *Albizia spp*, *Macaranga spp*, *Ficus hispida*, *Duabanga grandiflora* and *Michelia champaca*.

The districts have nine administrative revenue circles namely Alongkima, Changtongya, Chuchuyimlang, Kubolong, Longchem, Mangkolemba, Merangmen, Ongpangkong and Tuli. Six Rural Development Blocks which is not included in the administrative circles viz: Longchem, Mangkolemba, Changtongya, Kubolong, Ongpangkong (N), Ongpangkong (S). Each of these blocks is further sub-divided into villages. In Mokokchung district according to 2011 census, the least no. of village is 9 and maximum is 33. (Table 1) However, these figures are subjected to change with successive census.

Table 1. No. of Villages in Mokokchung district

Sl. No.	Block	No. of Villages
1	Longchem	16
2	Mangkolemba	33
3	Changtongya	29
4	Kubolong	10
5	Ongpangkong (S)	9
6	Ongpangkong (N)	10

*Source (District Census Handbook Mokokchung Census, 2011)

2 METHODOLOGIES, STARTEGY AND APPROACH

2.1 Methodologies used for the study: an outline of methodology adopted is given in the following flow diagram (Fig. 2):

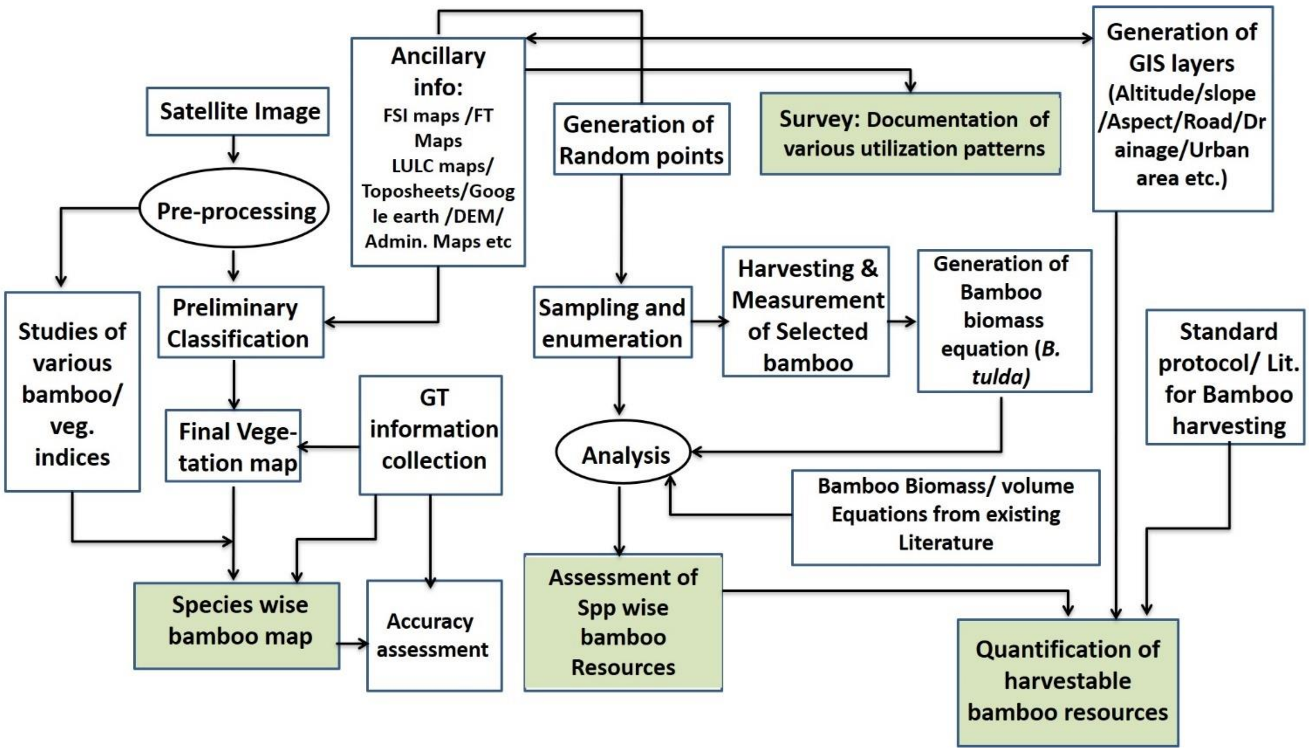


Fig 2: Paradigm of the study

Objective wise methodology is given below:

Objective 1: To assess the species-wise growing stock of bamboo and quantify the harvestable bamboo resources in the district.

2.1.1 Reconnaissance Survey:

A reconnaissance survey was done to have an overview of the study site. During the survey it was found that *Bambusa tulda* was the major species in the area followed by *Dendrocalamus* *hamiltonii*, *Schizostachyum dullooa*, *Bambusa pallida, Dendrocalamus longispathus, Dendrocalamus sikkimensis, Bambusa balcooa*, *Pseudostachyum polymorphum, Gigantochloa parvifolia* and other bamboo species.

2.1.2 Selection of biomass and volume equation:

Literatures pertaining to species-wise biomass equations of different bamboo species found during the reconnaissance survey were reviewed. Since, *Bambusa tulda* was the dominant species in the study area, a site-specific allometric equation was developed to find the biomass accurately. For the remaining species, the already existing biomass equations were used (Table 2).

Table 2: Bamboo species and their respective equations

Sl No.	Bamboo species	Equation used	References
1	*Bambusa balcooa*	log(Y)=2.149+2.284(log((DBH)))	Nath et al. 2009
2	*Bambusa tulda*	Present study	
3	*Bambusa pallida*	Y=-0.32+1/1.85DBH+1/6.46H	Rawat et al. 2018
4	*Pseudostachyum polymorphum*	log(Y)=log(a)+b(logDBH)	Singnar, P. et al. 2017
5	*Gigantochloaparvifolia*	$Y=0.1794DBH^{2.2214}$	Xayalath et al. 2019
6	*Dendrocalamus hamiltonii*	Y=2.43+1.17DBH-0.07H	Rawat et al. 2018
7	*Dendrocalamus longispathus*	$y=0.279DBH^{1.824}$	Puangchit et al. 2019
8	*Dendrocalamus sikkimensis*	$Y=0.1794DBH^{2.2214}$	Xayalath et al. 2019
9	*Schizostachyum dullooa*	log(Y)=log(a)+b(logDBH)	Singnar, P. et al. 2017
10	Other bamboo species	$Y=0.1794DBH^{2.2214}$	Xayalath et al. 2019

2.1.3 Generation of biomass equation for *Bambusa tulda:*

Bamboo culms were selected randomly from the study area. Destructive sampling was followed to generate the biomass equation. Culms of *Bambusa tulda* occurring within the clump were divided into three age classes i.e., 1-2 years, 2-3 years, and >3 years. Under each age class, three girth classes were made (15-21 cm, 21-27 cm, 27-33 cm). Representative culms (120 Nos.) of different ages falling in definite girth classes were harvested at ground level. The harvested bamboos were segregated into culms, leaves & branches and their fresh weights were measured in the field. The culm length was also noted. To determine the ratio of dry weight to fresh weight, representative samples of each component of culm, branch, and leaf were brought to the laboratory and kept in the oven at 80℃ until a constant weight was obtained. The total dry weight or biomass for each component of the sampled bamboos were calculated following.

$$TDW = TFW \times SDW / SFW$$

Where, TDW = total dry weight or biomass; TFW = total fresh weight; SDW = sub-sample dry weight; SFW = sub-sample fresh weight.

We use Diameter at Breast Height (D) and Height (H) as independent variables to predict the biomass. The allometric equation for different age classes was developed based on the best fit model to predict the AGB by calculating the coefficient of determination (R^2), root mean square error (RMSE), and Akaike information criterion (AIC).

$$\text{RMSE} = \sqrt{\sum_n \left(w_{predicted} - w_{measured}\right)^2 / n}$$

AIC= n x ln (MSE) + 2P

Where, $w_{predicted}$ and $w_{measured}$ biomass respectively, n is the number of culm samples, MSE= mean, square error, P= number of parameters used in the model.

2.1.4 Sampling design:

A plot size of 0.1 ha (31.62 m X 31.62 m) was laid randomly in bamboo forest. Thus, a total of 108 plots were laid randomly. Sampling and data collection were done from the sample plots.

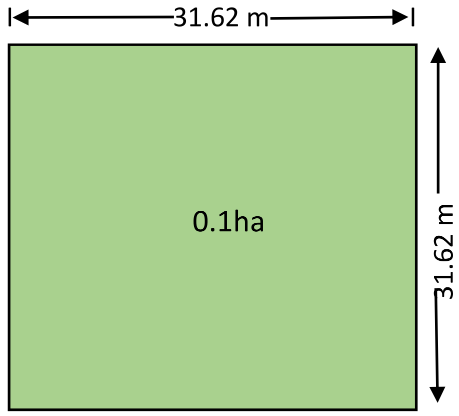


Fig 3: Sample plot layout

2.1.5 Field data collection:

Culms in each sampled plot were classified according to their ages and number of culms in each clump were counted. The determination of the culm age was based on the features of culm sheath, the development of branches and leaves, and the external colour of the culm (Singnar et al., 2017). By studying the features three ages classes were made: 1-2 years, 2-3 years, and >3 years old. Complete enumeration was done and all the details of bamboo were recorded in the clump enumeration form (Appendix- 8). Some unidentified bamboo species which were not very common were also encountered during the survey. Photographs were taken and the culm sheaths of bamboo were brought to the institute for further identification.

2.1.6 Data analysis for growing stock estimation:

The details so collected in the clump enumeration form were analyzed using MS- Excel 2019. To estimate the growing stock of *B. tulda,* the equation so developed in the present study was used while for other bamboo species existing equations were used to calculate the growing stock of the whole district.

2.1.7 Quantification of harvestable bamboo:

For quantification of harvestable bamboo, the data recorded in the clump enumeration form were used where the culms were quantified under different ages and diameter classes. Ecologically fragile areas like high slope (slope>60°) were also considered during quantification of harvestable bamboo.

Objective 2: To generate species wise distribution map of bamboo resources

2.1.8 Generation of Land use/cover map

Multi spectral satellite images LISS 4 with a spatial resolution of 5.8 m (dated 16/05/2018) were primarily used along with Landsat 8 with a spatial resolution of 30m (dated 10/04/2020) and sentinel 2 with a spatial resolution of 10-20 m (dated 18/11/2021 & 19/12/2021). Ancillary data/information including Survey of India topographic sheets and high resolution true colour images from Google Earth were also used during classification and accuracy assessment. Other maps including Administrative Maps collected from state forest department, Forest cover and type map, prepared by Forest Survey of India (FSI) were used wherever felt necessary. ARC-GIS package and ERDAS Imagine was used for GIS database creation, analysis, and Digital image processing, respectively.

2.1.9 Image Classification

The images procured were geometrically rectified and registered using SOI toposheets and GPS points collected from field. Contrast enhancement of the images was performed for better visual interpretability. This was followed by re-projection of the images in Universal Transverse Mercator projection (datum- WGS 84; Zone-46). Reconnaissance Survey of the study site was undertaken for broad understanding of the study area and to get acquainted with the general patterns of vegetation, forest types and topography of the area. The major vegetation types, their floristic composition, physiognomy, physiographic distribution in the field and variation, tonal patterns and texture were observed on the satellite image which would be helpful during image classification.

Nine land use/vegetation classes were identified in the study area. Forests are categorized based on their type (as per Champion and Seth's revised classification, 1968) and crown density (Very Dense forests with crown density >70%, Moderately Dense forests with 40-70%, open forests with 10-40% and non-forests with <10% crown density). Hybrid approach combining the advantages of both automated and visual methods was followed for classification of digital remote sensing image which was further fine-tuned based on ancillary data sources viz. forest cover, forest type maps and ground truth information collected from every nook and corner of the study sites.

2.1.10 Mapping of bamboo area

The LISS IV multi spectral satellite data (Fig. 4) was first visually interpreted based on the image characteristics viz. tone, texture, association etc. The ground truth information collected during the survey was incorporated during visual interpretation. The auxiliary information from other sources viz., Survey of India Toposheets, forest cover and type map generated by Forest survey of India, other available thematic maps generated by state forest departments etc. were analysed and incorporated during the classification. Information collected from socio-economic survey and other pertaining literature was also associated during the classification. Different band combinations including the standard false colour composite (FCC) with green, red and NIR band combination coupled with image enhancement techniques have been tried for better visualization.

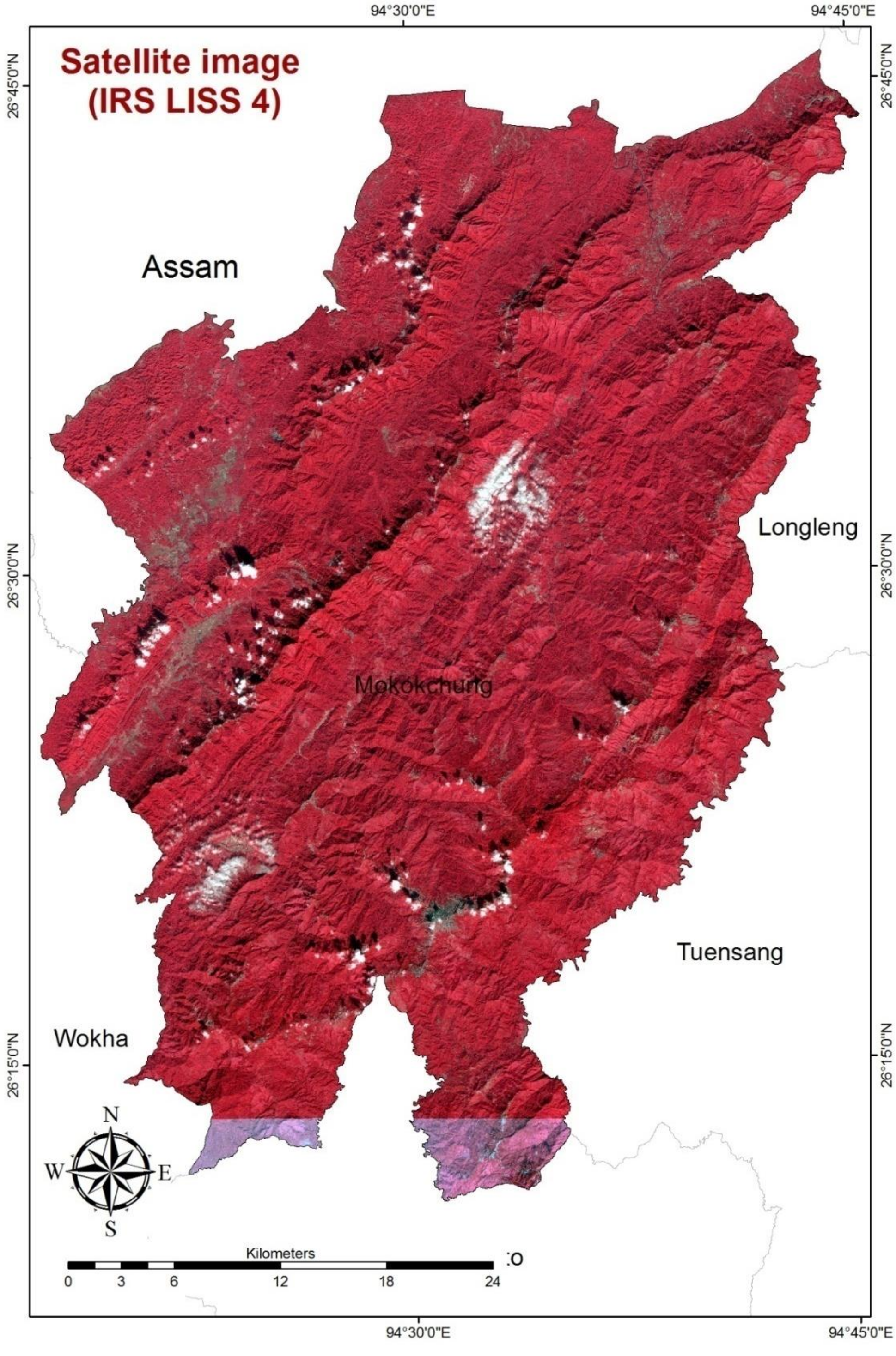


Fig. 4: LISS IV satellite image of study area

2.1.11 Generation of species-wise bamboo map

For species wise bamboo demarcation, digital index-based classification was done. Visual classification was not found suitable in segregating the various bamboo species. About 526 GPS point information (Fig. 5) were noted from various parts of the study area. All the associated attribute information like Latitude, Longitude, Altitude, land use and vegetation type information, type of bamboo, associated tree species etc. were noted.

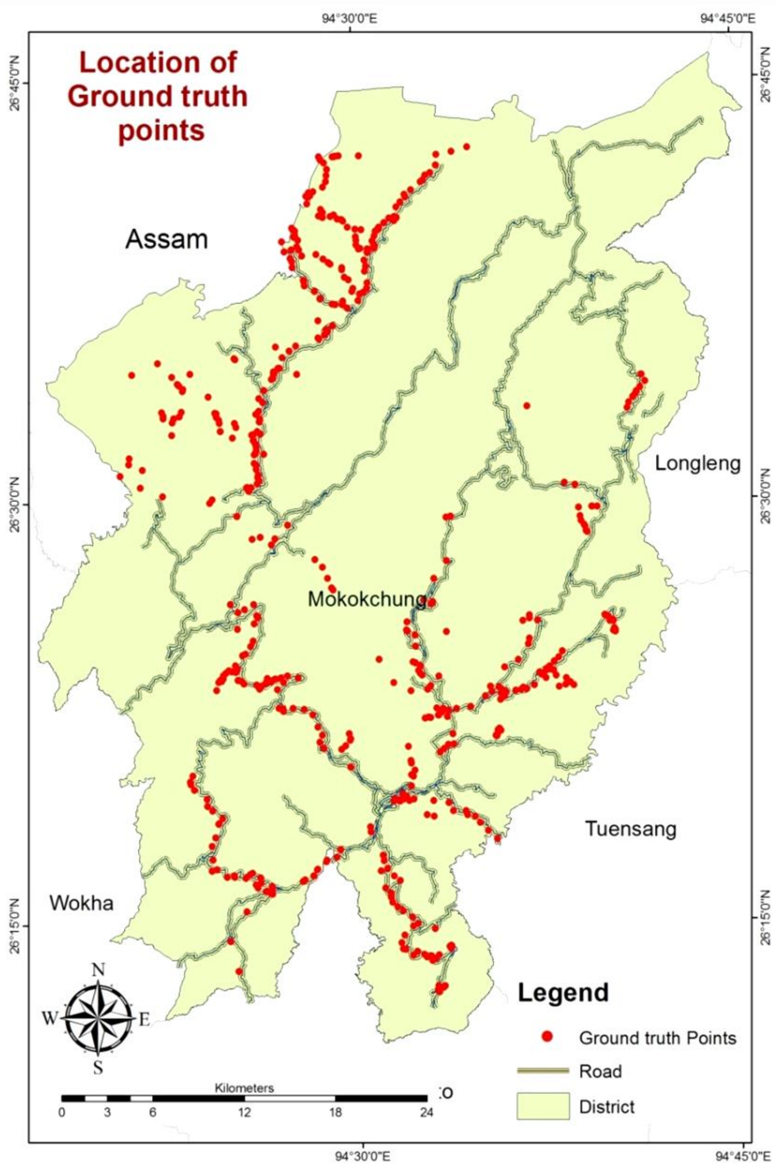


Fig 5: Ground truth points of Mokokchung district

Several vegetation indices were tested to demarcate out bamboo bearing area. Finally, the following indices were found the most pertinent. The details of the indices are given below:

Ratio Vegetation Index (RVI): RVI, the simple and most widely calculated vegetation index, was first described by Jordan in 1969. RVI range from 0 to infinity.

$$\mathrm{RVI} = \frac{\mathrm{NIR}}{\mathrm{RED}}$$

Where, NIR stands for near infra-red and RED stand for red band of the image.

Normalized Difference Vegetation Index (NDVI): The formation of NDVI is credited to Rouse et al. (1973). NDVI ranges between -1 and +1 and has proved effective in reducing terrain effect and sensitive to green vegetation.

$$\text{NDVI} = \frac{\text{NIR}-\text{RED}}{\text{NIR}+\text{RED}}$$

Transformed Normalized Difference Vegetation Index (tNDVI): tNDVI (Robert and Dunno, 2001) was formed to counter the negative values found in NDVI calculation. This is an improvement over the NDVI mathematical equation and generally a value of 0.5 is added to eliminate negative numbers. The values of TNDVI range between 0.0 and 1.0.

$$\text{tNDVI} = \sqrt{(\frac{\text{NIR}-\text{RED}}{\text{NIR}+\text{RED}})+0.5}$$

Soil Adjusted Vegetation Index (SAVI): SAVI is a hybrid between the ratio-based and perpendicular indices and was introduced by Huete (1988) that ranges between -1 to +1.

$$\text{SAVI} = \frac{\text{NIR}-\text{RED}}{\text{NIR}+\text{RED}+\text{L}}(1+\text{L})$$

A soil adjustment/correction factor 'L' is added. L is found to vary between 0 (very high vegetation cover) to 1 (very low vegetation cover). A value of 0.5 is used in most of the cases for intermediate vegetation densities.

Bamboo index (BI-1): Bamboo index was developed by Goswami et al. (2010) and expressed as:

$$\text{Bamboo Index (BI)} = \frac{\text{NDVI}-\text{SI}}{\text{NDVI}+\text{SI}}$$

SI stands for stress index (a measure of leaf water content) and may be expressed as

$$\text{Stress Index (SI)} = \frac{\text{NIR}-\text{SWIR}}{\text{NIR}+\text{SWIR}}$$

Bamboo index (BI-2): It was found that lot of negative values is coming in Bamboo index calculated for the present study area. Therefore, a slight modification of BI-1 was done by replacing NDVI value with tNDVI value.

Principal Component based Bamboo index (PC-BI): Ashutosh et al. (2002) developed a Principal Component transformation based bamboo index which is as follows:

$$\text{PC-BI} = \left\{\frac{\text{NIR}}{\text{R}} + \frac{\text{PC1}}{\text{PC2}}\right\} \text{X } 100$$

Where NIR and R stands for Near Infrared and Red band, PC1 and PC2 stand for Principal Component transformation 1 and 2 respectively.

All the indices mentioned above were calculated separately. Threshold value for bamboo for each index was collected from actual ground condition using GPS. The GPS point layer (ground truth information) thus generated was overlaid on various index image and pixel values were compared. Different season wise multispectral satellite images (LISS IV, LISS III, LANDSAT, Sentinal) were also analyzed to understand the pixel characteristics of certain bamboo plots. Possible bamboo pixels for each index were worked out. Finally, it was observed that tNDVI values are mostly correlating with the presence of *Bambusa tulda* in the study area. *B. tulda* is the widely used bamboos and mostly found as plantations in the study area. The classification accuracy of *B. tulda* was found quite good (83.3%) and within the acceptable limit. However, classification accuracy of other bamboos found in the study area is quite low and below the admissible limit. Therefore, only two categories of bamboos were classified during the present study viz. *Bambusa tulda* and other bamboos. The classification accuracy of bamboos is shown in the following Table 3.

Table 3:Error matrix of bamboo area classification

			Reference (ground truth) data								
				Other bamboos							
			B. tulda	*B. pallida*	*D. hamiltonii*	*S. dullooa*	*D. sikkimensis*	*P. polymorphum*	Minor Bamboos	Total	%
Classified data	*B. tulda*		10	1	1					12	83.3
	Other bamboos	*B. pallida*	2	5	1					8	62.5
		D. hamiltonii	1		5				2	8	62.5
		S. dullooa			1	4	2			7	57.1
		D. sikkimensis	1			1	4		2	8	50.0
		P. polymorphum						3	1	4	75.0
		Minor Bamboos						2	2	4	50.0
	Total		14	6	8	5	6	5	7	51	100.0
		%	71.4	83.3	62.5	80.0	66.7	60.0	28.6	100.0	

It was found that, the overall classification accuracy when all the bamboo classes are taken into consideration is quite low (64.71%). However, the accuracy increases substantially (88.24%) once only two bamboo classes viz. *B. tulda* and other bamboos are taken into consideration. The classification accuracy of *B. tulda* alone stands at 83.33% and that of other bamboo is 89.74%.

Objective 3: To document various utilization patterns of bamboo resources.

2.1.12 Collection of socio-economic data

The socio-economic data were collected in the field with the help of structured questionnaires (Annexure- 9) by randomly selecting the households. A total of 334 households were surveyed.

2.1.13 Collection of Bamboo related data

Bamboo has a variety of uses in the region therefore, a different section was made in the questionnaire in order to collect more information related to its usage.

2.1.14 Data analysis

Data so collected was analysed using MS-Excel 2019 and SPSS software.

2.2 Details of Scientific data collected and Equipment Used:

Sl No.	Scientific data	Equipment(s) used
1.	**Aboveground bamboo biomass data**	Geographical co-ordinates and elevation of each of the sample plots was recorded with the help of Global Positioning System (GPS). Enumeration sample plot of size 0.1 ha was laid out using measuring tape, compass installed in GPS and rope to demarcate the surveyed area. Culm diameter at breast height and clump diameter of the bamboo was measured using measuring tape. Required culm after measuring with a tape was harvested with one man saw. The Length of the harvested culm was then measured with a tape. Height of the culm was measured by ocular method. De-limbing of branches was done with the help of machete. Small segment of the harvested culm each from bottom, middle and above was sawn and their green weight was measured in the field with the help of electronic weighing machine précised up to milligram level. 50g of sub-sample component of both branch and leave were measured in weighing machine. Each component of culm, branch and leave was oven dried in the laboratory to calculate the dry biomass.
2.	**Data on species wise distribution map**	Geographical co-ordinates and elevation were recorded from in and around Mokokchung district with the help of Global Positioning System (GPS) for incorporating in the map. Q-GIS, ARC-GIS and ERDAS Imagine software packages were used for GIS database creation, analysis, Digital image processing, and mapping.
3.	**Data on bamboo utilization**	Geographical co-ordinates and elevation of interviewed households (HH) was recorded with the help of Global Positioning System (GPS). Camera was used to capture the photographs of the articles used by the local people.

2.3 Primary Data Collected:

Reconnaissance survey was conducted in the study area and preliminary information pertaining to bamboo were collected from field. Later, ground truth information, bamboo biomass information for *B. tulda* and sampling of bamboo plots for plot wise biomass data were collected from entire study area.

Secondary information related to bamboo biomass, growing stock, area, utilisation pattern etc. were collected form Nagaland Bamboo Development Agency, State Forest department and other line departments. The satellite digital image (LISS-IV) of the district was procured from RFRI GIS data library. GIS software like Q-GIS (Open-source), ArcGIS and ERDAS Imagine 2020 packages were used for GIS and image interpretation. Nagaland state census and other related data were collected from various online portals/websites.

2.4 Details of Field Survey arranged:

Primary information was collected during reconnaissance survey. Randoms points were generated using GIS software and sample plots demarcated on maps. Later the same was located on ground using a hand-held GPS. Sampled plots of 0.1 ha (31.62 m x 31.62 m) was laid in all the designated random points and detailed enumeration was done. Every clump was assessed within the plot, the girth of all the green sound, damaged and dry sound culm within the clump were measured and was divided according to girth classes and age. For the destructive sampling that was required for generation of bamboo biomass equation of *B. tulda*, bamboos were selected according to the required girth and each bamboo was sawn at 2 cm of the base with the help of one man saw. Further to get more information on bamboo resources and to help in stock mapping several GTPs were collected from the entire Mokokchung district.

Since the people's dependencies were more towards bamboo, a socio-economic survey was conducted with a proper structured questionnaire. The questionnaires were first tested in the field and rectified accordingly. A total of 334 households were surveyed to collect information related to its usage and recorded information of each articles used along with other socio-economic information.

2.5 Strategic Planning for each Activities:

Every village has its own rules and regulation likewise in the district of Mokokchung, village council plays an important role as all the rule are made by them therefore, an approach was first made to village council for seeking permission to work in their respective areas/villages then the work was carried out.

A reconnaissance survey was carried out to have an overview of the study area. Random plots (0.1 ha) were generated using GIS software and the same were approached and located on ground using handheld GPS receiver machine. The located plots were enumerated and all information pertaining to bamboo resources were noted down. Complete enumeration of each plot was done. Ground truth information of different land use/cover type was collected and used in generation of Land use/cover map of the study area. To develop the allometry equation, *Bambusa tulda* was harvested in winter season as the growth is dormant during that time.

Socio-economic survey was done randomly by visiting at least ten village per block and from each village at least ten households to collect information on utilization pattern of bamboo. The articles were also documented and photographs were taken.

2.6 Activity-wise Timeframe followed using Gantt/ PERT Chart:

Activity-wise Timeframe followed are showed as below:

Sl. No.	List of the project activities	Year-1				Year-2				Year-3			
		Q_1	Q_2	Q_3	Q_4	Q_1	Q_2	Q_3	Q_4	Q_1	Q_2	Q_3	Q_4
1	Collection of literature	■	■	■	■	■	■	■	■				
2	Satellite image classification	■	■	■	■	■	■	■	■	■	■		
3	Ground truthing and data collection			■	■	■	■	■	■	■	■		
4	Laying of sampling plot			■	■	■	■	■	■	■	■		
5	Data entry and updating				■	■	■	■	■	■	■		
6	Documentation and quantification of utilization patterns			■	■	■	■	■	■	■	■		
7	Field data analysis and interpretation				■	■	■	■	■	■	■	■	■
8	Final analysis and project completion											■	■
9	Report writing											■	■

3 KEY FINDINGS AND RESULTS

3.1 Major Research Findings

Objective wise results are given below:

Objective 1: To assess the species-wise growing stock of bamboo and quantify the harvestable bamboo resources in the district.

Bamboo plants have a high potential to store considerable amounts of biomass carbon. Looking at the landscape of the district, it was found that various species of bamboos grows in the region. In the study area, the area is covered mostly by *D. hamiltonii* starting from the lower elevation to *D. sikkimensis* in the higher elevation. The other species found in the area are *B. balcooa, B. pallida, P. polymorphum, G. parvifolia, D. longispathus, S. dullooa, B. tulda* etc. *B. tulda* however, is mostly being carried out extensively for plantation in community forests and also the homestead garden because of its vast usage. Nonetheless, studies on biomass accumulation of these bamboos in the region have been neglected.

As stated above *B. tulda* is being widely cultivated in the study area. Despite its economic importance, the biomass and allometric equations are lacking therefore development of allometry equation will not only enable to evaluate the site productivity but also to establish sustainable management. Therefore, a site-specific allometric equation for the accurate estimation of biomass of *B. tulda* was developed.

3.1.1 Bamboo biomass equation of *Bambusa tulda*:

Destructive sampling was followed for biomass estimation of *Bambusa tulda*. The clum was divided into three age classes i.e., 1-2 years, 2-3 years, and >3 years. Girth (cm) was recorded. During the study, it was found that the lowest girth of *B. tulda* was 15 cm and it does not exceed more than 36 cm in the study area. *B. tulda* were categorized in three girth classes (15-21 cm, 21-27 cm, 27-33 cm) under each age class. The culm length and fresh weights of the culm, branches, and leaves were taken in the field, and a sub-sample of each component was brought to laboratory and oven dried to calculate the dry biomass. The length (m) was measured and was found to fall within the range of 8.41-23.80 m in the study area. Altogether, a total of 120 culms of *B. tulda* of various sizes were harvested.

In the present investigation, equation was developed for *B. tulda* for three age classes. Different volume equations which were previously done by other workers (Rawat, 2018; Yen, 2010 etc.) (Table 4) were used and comparison was done using Linear mixed models (LMM). Two independent variables (D and H) were used for making the biomass equation. Based on the best fitted the overall biomass model for *B. tulda* was generated age-wise.

Table 4: Models selected for comparison

Model no.	Function form
1	Y= -a+b x D+c x H
2	$Y = aD^b \times H^{ca}$
3	$Y = aD^2 \times H \times b$
4	$Y = aD^b x H^c$
5	$Y = a+b (D^2 \times H)$
6	$Y = a+b (D+cDH^2)$
7	Y = aD+b+cD x H
8	$logY= alog \times D^2 \times H+b$
9	logY= a+blog x D+clog x H

The models were verified for the best fit by calculating the coefficient of determination (R^2), root mean square error (RMSE), and Akaike information criterion (AIC). The lesser the value of RMSE and AIC with R^2closer to 1 (Brahma et al. 2017), better the equation and reliability of the predicted model. Below are the equations used for the above test models:

$$\text{RMSE} = \sqrt{\sum_n \left(w_{predicted} - w_{measured}\right)^2 / n}$$

AIC= n x ln (MSE) + 2P

Where, $w_{predicted}$ and $w_{measured}$ biomass respectively, *n* is the number of culm samples, MSE= mean, square error, P= number of parameters used in the model.

For age class 1–2-year-old *B. tulda*, the resultant best fit model was model 2 which exhibited the greatest predictive power and had the smallest value of RMSE and AIC and R^2 near to 1, (Fig. 6 & Table 5). D and H were the main predictors used for estimation of biomass.

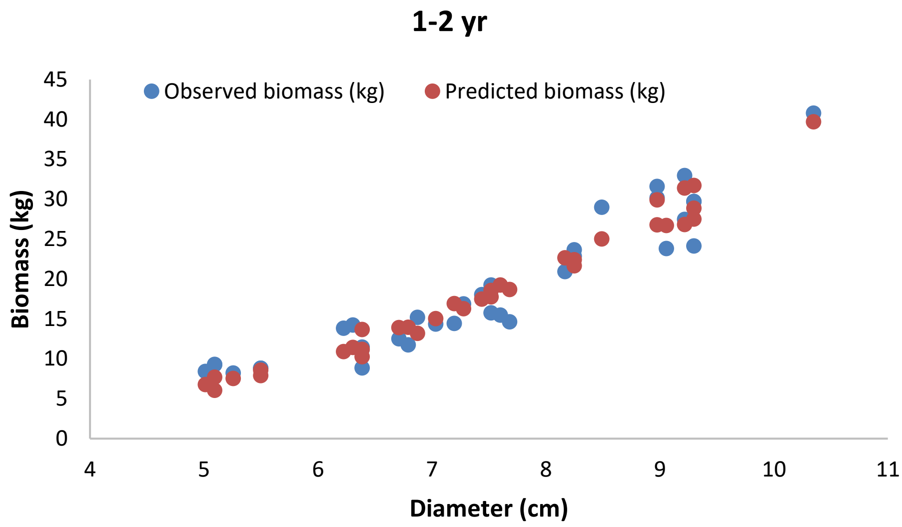


Fig. 6: The scattered plot of observed biomass and predicted biomass against D based on D and H for 1-2 yr*B. tulda*.

Table 5: Below are the candidate models, their coefficients and performance criteria used to develop the best fitted equation to estimate the biomass of *B. tulda* for the age class 1-2 year.

Model	Equations	Coefficients			Performance criteria		
		a	b	c	R^2	RMSE	AIC
1	V= -a+bD+cH	-23.758408	4.761869	0.435664	0.890	2.822	78.621
2	**$V=aD^bH^{ca}$**	**0.074547**	**2.031796**	**6.655535**	**0.979**	**2.157**	**59.798**
3	$V=a(D^2H)$ b	0.020030	0.920008		0.933	2.639	71.919
4	$V=aD^bH^c$	0.074584	2.031733	0.496024	0.936	2.157	59.798
5	$V=a+b(D^2H)$	3.112732	0.015923		0.933	2.196	59.055
6	$LogV=alogD^2H+b$	0.086974	1.767763		0.887	2.857	77.496
7	logV=a+blogD+clogH	-64.597259	78.349702	13.060031	0.839	3.412	91.907

V= AGB (kg); D= diameter at breast height (cm); H= height (m); a, b and c are the parameters.

In age class 2–3-year, our result clearly shows that model 2 (Fig. 7& Table 6) represents the best fit to predict the biomass with high R^2 (0.9317) value.

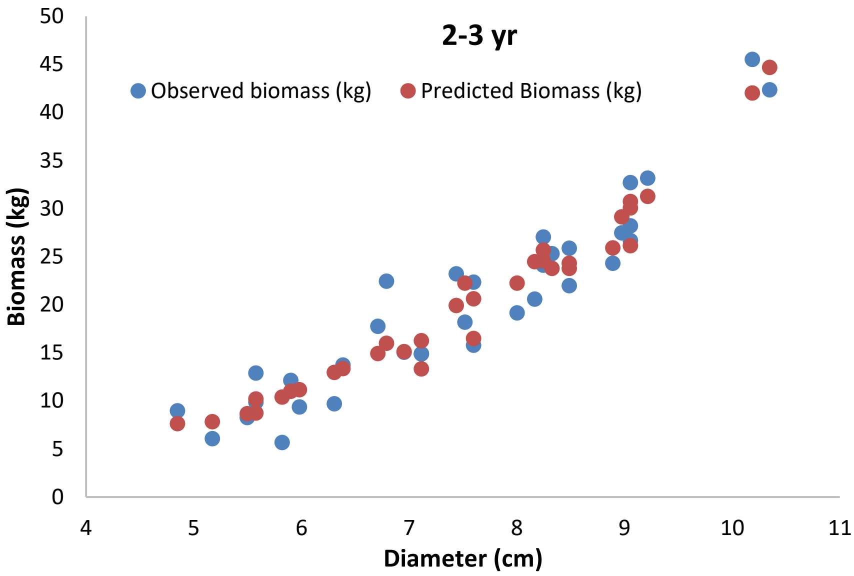


Fig. 7: The scattered plot of observed biomass and predicted biomass against D based on D and H for 2-3 yr*B. tulda*.

Table 6: Below are the candidate models, their coefficients and performance criteria used to develop the best fitted equation to estimate the biomass of *B. tulda* for the age class 2-3 year.

Model	Equations	Coefficients			Performance criteria		
		a	b	c	R^2	RMSE	AIC
1	V= -a+bD+cH	-28.533715	4.361538	1.012557	0.911	2.8177	76.4434
2	**$V=aD^bH^{ca}$**	**0.081067**	**1.862632**	**7.623133**	**0.931**	**2.4796**	**67.7505**
3	$V=a(D^2H)$ b	0.021486	0.920179		0.924	3.1456	81.9290
4	$V=aD^bH^c$	0.081075	1.862502	0.618058	0.931	2.4796	67.7505
5	$V=a+b(D^2H)$	3.638612	0.016916		0.924	2.6077	69.1768
6	$LogV=alogD^2H+b$	0.078597	1.970033		0.866	3.4940	89.0704
7	logV=a+blogD+clogH	-2.512470	4.288700	1.423101	0.931	2.4796	67.7505

V= AGB (kg); D= diameter at breast height (cm); H= height (m); a, b and c are the parameters.

Likewise for the age class more than 3-year-old, model 1 (Fig. 8& Table 7) was found to be best fit to predict the biomass having high R^2 (0.855) value as compared to the other models.

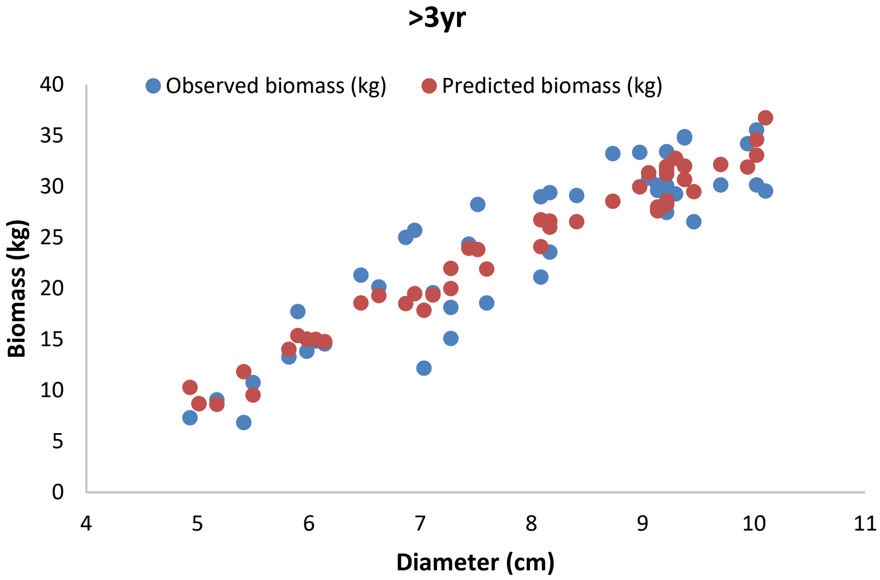


Fig. 8: The scattered plot of observed biomass and predicted biomass against D based on D and H for >3 yr *B. tulda*.

Table 7: Below are the candidate models, their coefficients and performance criteria used to develop the best fitted equation to estimate the biomass of *B. tulda* for the age class >3 year.

Model	Equations	Coefficients			Performance criteria		
		a	b	c	R^2	RMSE	AIC
1	**V= -a+bD+cH**	**-15.032421**	**3.325163**	**0.794888**	**0.855**	**3.192**	**110.449**
2	$V=aD^bH^{ca}$	0.552884	1.115691	0.944127	0.840	3.358	115.020
3	$V=a(D^2H)$ b	0.021629	0.920205		0.789	5.790	162.053
4	$V=aD^bH^c$	0.553031	1.115614	0.521961	0.840	3.358	115.020
5	$V=a+b(D^2H)$	9.397581	0.013126		0.789	3.851	125.347
6	$V=a+bD+cDH^2$	-10.435115	3.978336	0.001311	0.834	3.417	116.586
7	V=aD+b+cDH	4.801437	-12.574083	4.441470	0.828	3.472	118.021
8	$LogV=alogD^2H+b$	11.988300	-58.009734		0.840	3.359	115.035
9	logV=a+blogD+clogH	-57.316518	25.835301	10.351335	0.840	3.358	115.020

V= AGB (kg); D= diameter at breast height (cm); H= height (m); a, b and c are the parameters.

In this study, we used Linear mixed model as many workers have found it to be more superior in giving stable models (Silesh 2015; Nath et al. 2009). All different models were used and tried to compare their goodness of fit to develop allometric equations for *B. tulda* of different age classes. After evaluating the goodness of fit of model using RMSE and AIC to determine the allometric equation and based on the coefficient of determination (R^2 value), it indicates that the diameter is a good predictor of above-ground biomass of *B. tulda* for all the age classes. The best equations developed for different age classes are given below in Table 8:

Table8: Year wise B. tulda equation developed for this present study

Age	Equations developed	R^2
1-2 yr	$V=0.074547 \times D^{2.031796} H^{(6.655535x0.074547)}$	0.979
2-3 yr	$V=0.081067 \times D^{1.862632} H^{(7.623133x0.081067)}$	0.931
>3 yr	V=-15.032421+ 3.325163 x D + 0.794888 x H	0.855

Table 9: Summary statistics of different age group for *B. tulda*

Statistics	1-2 years			2-3 years			> 3 years		
	Dia (cm)	Height (m)	Biomass (kg)	Dia (cm)	Height (m)	Biomass (kg)	Dia (cm)	Height (m)	Biomass (kg)
Mean	7.41	15.99	18.525	7.49	15.83	20.161	7.86	15.93	23.747
Standard Error	0.25	0.55	1.457	0.25	0.56	1.652	0.23	0.53	1.262
Standard Deviation	1.46	3.26	8.622	1.46	3.25	9.634	1.57	3.59	8.469
Minimum	5.03	9.05	8.228	4.85	10.39	5.652	4.93	7.93	6.858
Maximum	10.35	22.16	40.792	10.35	23.81	45.508	10.11	22.86	35.543
Count	35	35	35	34	34	34	45	45	45

In this study, the biomass for age 1–2-year ranges from 8.22 to 40.79 kg, 5.65 to 45.51 kg (2-3 year) and 6.85 to 35.54 kg in age class more than 3-year-old respectively. It was also found that the diameter of culm does not exceed more than 36 cm in the surveyed area.

As site-specific allometric equation is not possible for all the bamboo species available in the region, existing equations already done by other researchers having similar ecological regions were used to find the biomass (Table 10).

Table 10: The table below shows the bamboo species along with their equations used

Bamboo species	Equations available	References
Bambusa balcooa	log Y=2.149+2.284 (log((D)))	Nath et al. 2009
Bambusa tulda	Present study	
Bambusa pallida	Y=-0.32+1/1.85D+1/6.46H	Rawat et al. 2018
Pseudostachyum polymorphum	log(Y)=log (1329.4) +2.79(logD)	Singnar, P. et al. 2017
Gigantochloa parvifolia	$Y=0.1794(D^{2.2214})$	Xayalath et al. 2019
Dendrocalamus hamiltonii	Y=2.43+1.17D-0.07H	Rawat et al. 2018
Dendrocalamus longispathus	Y=0.279D1.824	Puangchit et al. 2019
Dendrocalamus sikkimensis	$Y=0.1794(D^{2.2214})$	Xayalath et al. 2019
Schizostachyum dullooa	log(Y)=log (1571.3) +1.37(logD)	Singnar, P. et al. 2017
Other bamboo species	$Y=0.1794(D^{2.2214})$	Xayalath et al. 2019

3.1.2 Growing stock of all species:

3.1.2.1 Growing stock per unit area

Growing stock of bamboo per hectare was estimated for Mokokchung district. It was found that *Bambusa tulda* was the preferred species in the study area. The average number of *B. tulda* found in the age class 'current year' was estimated 448.61 number per hectare followed by '1-2 yr' (1722. 08No.s/ha), 2-3 yr (1711. 81No.s/ha) and > 3yr (2310. 83No.s/ha). The biomass of *B. tulda* was found to be highest in '>3 yr' (44581.49 kg/ha) > '2-3 yr' (29337.95 kg/ha) > '1-2 yr' (25633.71 kg/ha) > 'current yr' (8372.40 kg/ha). The details of the growing stock per unit area of all the bamboo species found in Mokokchung district are given in the table below:

Table 11: The average number of culms and biomass per hectare for major bamboo species (Green sound bamboos).

Bamboo species	Current yr		1-2yr		2-3yr		>3 yrs		Total	
	Culm (No.s/ ha)	Biomass (kg/ ha)	Culm (No.s/ ha)	Biomass (kg/ ha)	Culm (No.s/ ha)	Biomass (kg/ ha)	Culm (No.s/ ha)	Biomass (kg/ ha)	Culm (No.s/ ha)	Biomass (kg/ ha)
(1) *B. tulda*	448.61	8372.4	1722.08	25633.71	1711.81	29337.95	2310.83	44581.49	6193.33	107925.55
(2) Other Bamboos:	537.12	3583.52	2472.73	13402.09	3867.05	18836.42	6224.24	33724.45	13101.14	69546.48
2.1 *Bambusa balcooa*	53.33	220.8	270	1128.33	156.67	633.5	363.33	1525.2	843.33	3507.83
2.2 *Bambusa pallida*	270.63	1315.24	660	3180.53	699.38	3513.75	197.5	941.96	1827.51	8951.48
2.3 *Dendrocalamus hamiltonii*	139.5	1443.83	804.5	7622.7	674	6298.19	1324.5	12613.18	2942.5	27977.9
2.4 *Dendrocalamus longispathus*	120	1408.8	360	3635.4	383.33	3622.17	670	7324.47	1533.33	15990.84
2.5 *Dendrocalamus sikkimensis*	170	2284.36	170	4445.68	146	3908.44	538	14290.46	1024	24928.94
2.6*Gigantochloa parvifolia*	350	6072.5	1165	11806.3	750	7938.1	4990	48035.7	7255	73852.6
2.7 *Schizostachyum dullooa*	158.95	696.56	818.95	3503.34	1445.79	6195.58	2151.58	9241.31	4575.27	19636.79
(3) *Unidentified Bamboos*	173.53	2687.96	792.35	8834.36	657.06	7061.25	830.59	9479.7	2453.53	28063.27

Growing stock of bamboo per hectare was also estimated for green damaged, dry sound and dry damaged bamboos. *B. tulda* was found to be dominant with an average of 778.9 number per hectare for the 'green damaged' bamboos followed by *D. hamiltonii* (176.1 No.s/ha) and *S. dullooa* (137.3 No.s/ha). *B. tulda* was also found to be dominant in respect to biomass for 'green damaged 'with an average of 5845.9 kg/ha >*D. hamiltonii* (712.7 kg/ha) >*S. dullooa* (302.1 kg/ha). Like in other categories *B. tulda* was found dominant in both 'dry sound' and 'dry damaged.' Though the number of culms was found to be less for unidentified bamboos, the biomass was more as compared to *S. dullooa*. This may be due to the culm structure which has thicker wall than *S. dullooa*. Details are given below:

Table 12: The average number of culms and biomass per hectare for major bamboo species (Green damaged, dry sound and dry damaged bamboos)

Bamboo species	Green damaged		Dry sound		Dry damaged	
	Culm (No.s/ ha)	Biomass (kg/ ha)	Culm (No.s/ ha)	Biomass (kg/ ha)	Culm (No.s/ ha)	Biomass (kg/ ha)
(1) Bambusa tulda	778.9	5845.9	252.7	2874.9	390.6	2202.2

(2) Other Bamboos:	506.4	2121.6	296.1	2165.3	434.0	1680.4
2.1 *Bambusa balcooa*	5.6	8.6	0.0	0.0	4.1	4.2
2.2 *Bambusa pallida*	29.2	87.1	26.6	150.2	36.1	174.3
2.5 *Dendrocalamus hamiltonii*	176.1	712.7	64.4	540.7	138.1	589.4
2.6 *Dendrocalamus longispathus*	12.2	78.0	4.3	50.1	5.5	20.9
2.7 *Dendrocalamus sikkimensis*	8.8	133.0	6.9	54.8	4.5	41.3
2.3*Gigantochloa parvifolia*	3.5	64.7	6.5	38.4	6.4	19.6
2.8 *Schizostachyum dullooa*	137.3	302.1	133.4	962.7	145.6	508.2
(3) Unidentified Bamboos	132.2	730.4	53.5	365.7	91.8	319.2

The sample plot distribution in Mokokchung is shown in the following figure (Fig. 9).

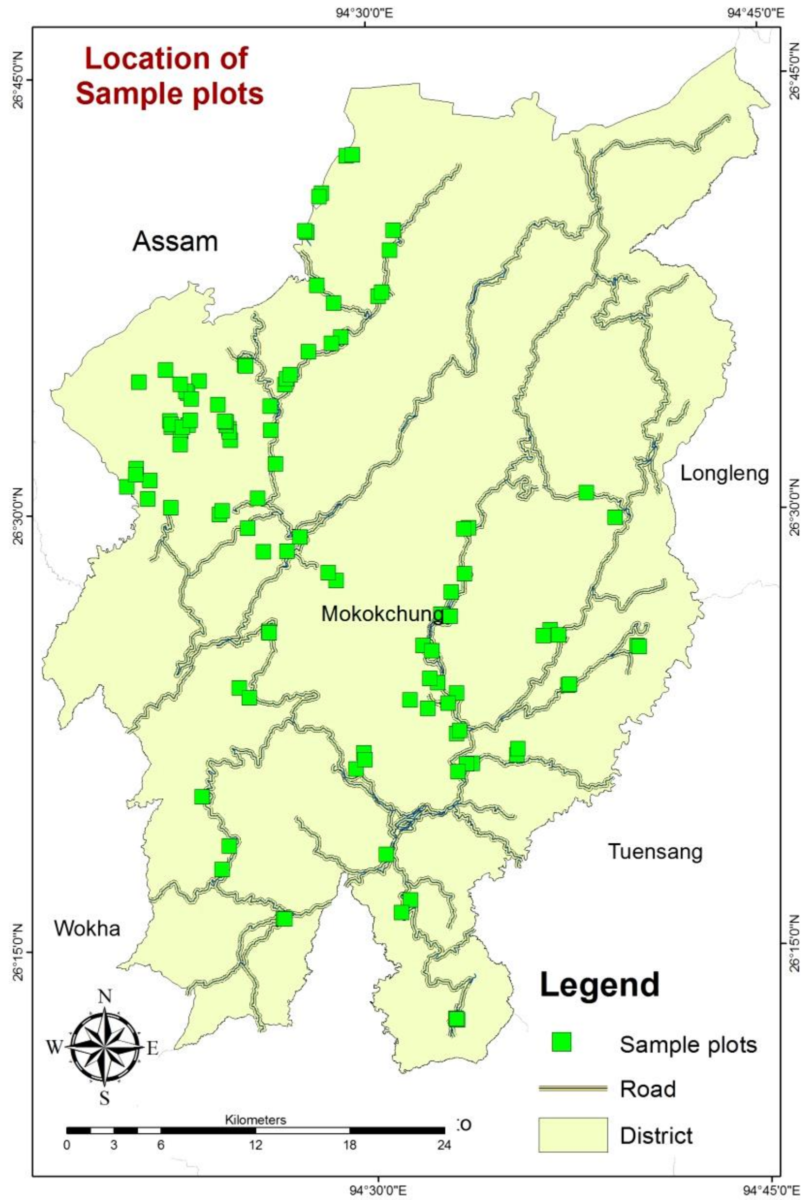


Fig 9: Point layer map of the sample plots

3.1.2.2 Total Green sound of Bamboo Biomass

The total ‘green sound’ of bamboo was estimated for the district of Mokokchung. The total number of culms and biomass ascends in all the age classes. The total estimated culm of ‘green sound' was 218.08 million of which '>3 yr' contributed the maximum likewise in biomass the total was 2.28 Tg of which '>3 yr' contributed the highest (Table 13). Similarly, total green damaged, dry sound and dry damaged bamboo biomass was estimated. Total 'green damaged' culm in the district was found to be 13.09 million having 95.19 Gg biomass. The total 'dry damaged' was found to be more (6.7 million culms with biomass of about 38.01 Gg) than the total 'dry sound' with about 4.3 million culms and biomass of 48.57 Gg where the major contribution was of *B. tulda* amongst all other bamboo species (Table 14).

Table 13: Total number of culms and biomass for major bamboo species (Green sound)

Bamboo number and biomass	Current yr		1-2yr		2-3yr		>3 yrs		Total	
	Culm (1000 Nos)	Biomass (Gg)	Culm (1000 Nos)	Biomass (Gg)	Culm (1000 Nos)	Biomass (Gg)	Culm (1000 Nos)	Biomass (Gg)	Culm (1000 Nos)	Biomass (Gg)
Bambusa tulda in pure patches	6497	121.3	24941	371.3	24792	424.9	33468	645.7	89698	1563
Bambusa tulda in mixed bamboo patches	690	14.9	2542	40.3	2472	48.7	3406	76.0	9110	180
TOTAL	**7187**	**136.1**	**27483**	**411.6**	**27264**	**473.6**	**36874**	**721.7**	**98808**	**1743**
Other bamboos in pure patches	2605	17.4	11994	65.0	18757	91.4	30191	163.6	63547	337
Other bamboos in mixed bamboo patches	1836	8.1	8666	34.7	16769	55.2	28456	101.2	55726	199
TOTAL	**4442**	**25.5**	**20660**	**99.7**	**35526**	**146.5**	**58647**	**264.8**	**119273**	**536**
Grand Total	**11629**	**161.6**	**48142**	**511.3**	**62790**	**620.1**	**95521**	**986.4**	**218082**	**2279**

Table 14: Total number of culms and biomass for major bamboo species (Green damaged, dry sound and dry damaged)

Bamboo species	Green Damaged		Dry Sound		Dry damaged	
	Culm (1000 Nos)	Biomass (Gg)	Culm (1000 Nos)	Biomass (Gg)	Culm (1000 Nos)	Biomass (Gg)
1.Bambusa tulda	12792.37	93.34	4034.41	46.46	6237.15	35.59
2.Other Bamboos:	299.73	1.85	324.73	2.11	475.44	2.42
2.1 Bambusa pallida	105.19	0.34	103.75	0.58	140.99	0.63
2.2 Dendrocalamus hamiltonii	143.11	0.80	72.18	0.64	154.95	0.59
2.3 Schizostachyum dullooa	46.09	0.26	116.44	0.68	127.10	0.39
2.4 Dendrocalamus sikkimensis	1.07	0.04	2.05	0.02	1.34	0.04
2.5 Pseudostachyum polymorphum	0.00	0.02	1.26	0.01	1.57	0.17
2.6 Unidentified bamboos	4.26	0.39	29.05	0.18	49.49	0.59
Total	**13092.10**	**95.19**	**4359.14**	**48.57**	**6712.59**	**38.01**

A total of 22 species were recorded from the study area (Table 15). Few unidentified species which were not so common in the surveyed area were also recorded, the scientific name is yet to be ascertained. Sporadic bamboo flowering was also encountered during the survey viz, *B. balcooa, D. sikkimensis, D. hamiltonii*, and *S. dullooa*. The species diversity was found to be high as compared to the state bamboo diversity where a total of 46 species were recorded by Nathani, 2011.Block wise bamboo distribution in Mokokchung district is also given in Table 16 and Fig.10.

Table 15: List of the major bamboos recorded in the study area

S.N.	*Name*	S.N.	*Name*
1.	*Bambusa alemtemshii*	9.	*D. hookeri*
2.	*B. balcooa*	10.	*D. longispathus*
3.	*B. nagalandeana*	11.	*D. sikkimensis*
4.	*B. pallida*	12.	*Melocanna baccifera*
5.	*B. mokokchungeana*	13.	*Gigantochloa parvifolia*
6.	*B. rangaensis*	14.	*Pseudostachyum polymorphum*
7.	*B. tulda*	15.	*Schizostachyum dullooa*
8.	*Dendrocalamus hamiltonii*		

*Some of the bamboos, sparsely distributed and found in lesser number within the study area include Aning, Aonak, Alulem-small, Alulem-medium, Aou (white), Talon, Aliba village (all local names) are yet to be identified.

Table 16: Block-wise bamboo distribution of Mokokchung district

Bamboo species	**(1) Mangkolemba**	**(2)Longchem**	**(3)Kubolong**	**(4)Ongpangkong – N (5) Ongpangkong – S (6) and Changtongya**
Bambusa alemtemshii	-	-	-	+
B. balcooa	+	-	+	+
B. nagalandeana	-	-	-	+
B. pallida	+	+	+	+
B. mokokchungeana	-	-	-	+
B. rangaensis	-	-	+	+
B. tulda	+	+	+	+
Dendrocalamus hamiltonii	+	+	+	+
D. hookeri	-	-	-	+
D. longispathus	+	-	+	+
D. sikkimensis	+	+	-	+
Melocanna baccifera		+	+	+
Gigantochloa parvifolia	+	+	+	-
Pseudostachyum polymorphum	+	+	+	+
Schizostachyum dullooa	+	-	+	-
*Legend: "+" Present, "-" Absent				

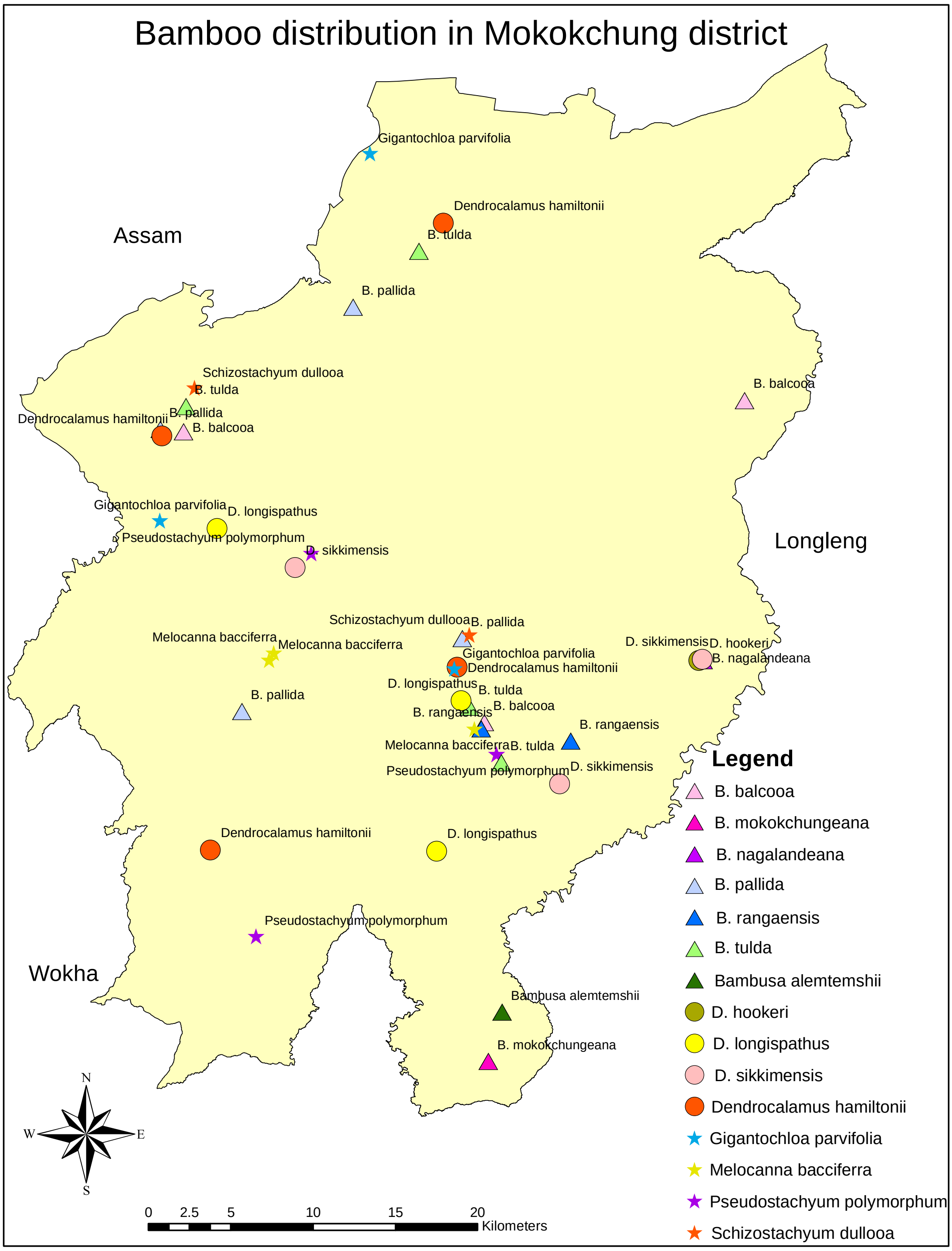


Fig. 10: Species wise distribution map of bamboo

3.1.3 Quantification of harvestable bamboo species:

As observed in the study area bamboos are mostly harvested erratically without following any harvesting techniques which hinders the clump thus results in poor production of culms. To have a sustainable bamboo forest quantification of harvestable bamboo is an important factor to know the existing number of culms and green biomass. Certain criteria were followed to quantify the harvestable bamboos. Age class '>3 years' were considered harvestable since it is considered mature once it acquires the age of 3 or >3 years. Further it was found that the demand of >3 years bamboo was more as compared to other age classes. Slope was also considered as scientifically slopes >60 degree is avoided for harvesting any woody plants which may trigger land slips and soil erosion. Accordingly, Mokokchung district was classified based on slope (Table 17 and Fig. 11). It was found that the district has negligible area of slopes >60 degree.

Table 17: Slope classification of Mokokchung district

Slope in degree	Area in km^2	Normalised Area (km^2)
Flat	22.1	21.3
1-10	434.57	418.6
10-20	629.51	606.4
20-30	477.02	459.5
30-40	186.84	180.0
40-50	30.94	29.8
50-60	2.86	2.8
60-70	0.39	0.4
70-80	0.15	0.1
80-90	0	0.0
Total	1784.38	1719.0

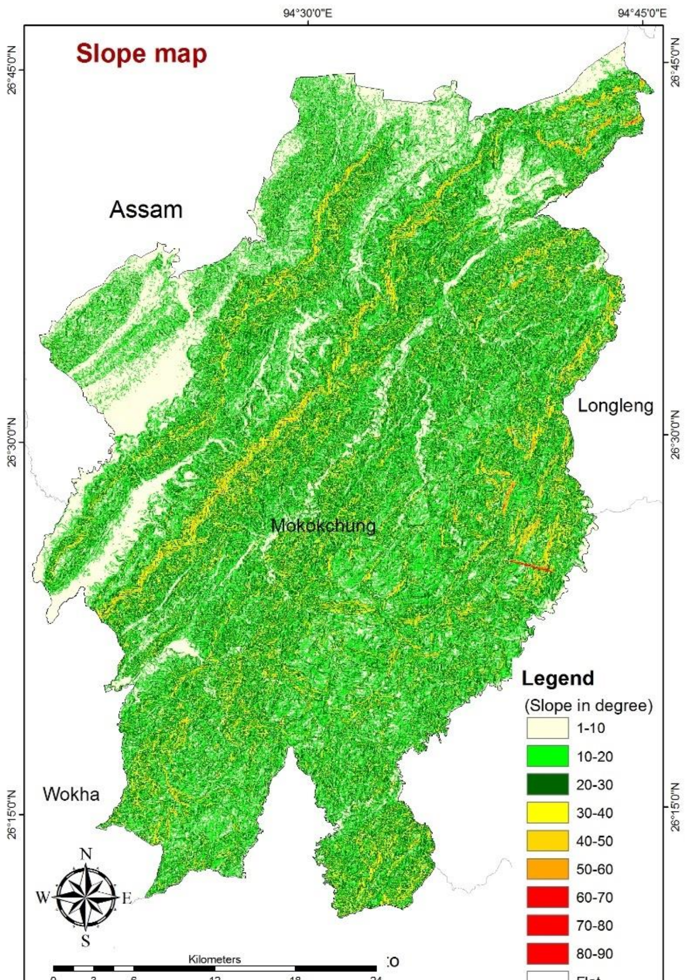


Fig 11: Slope classification map of study area

Since most of the areas in Mokokchung district falls under slopes <60 degree, the entire population of culms '>3years' age class may be considered as 'harvestable'. The number of harvestable bamboos in the study area is estimated 61.31 million. Species wise, the number of *B. tulda* culms was found to be more in the study area (36.87 million) followed by *S. dullooa* (20.89 million), *D. hamiltonii* (1.54 million), *B. pallida* (0.72 million) and others. As well as the biomass of harvestable bamboo in the study area is estimated 857.10 Gg. Species wise, the biomass of *B. tulda* found to be more with 721.66 Gg followed by *D. hamiltonii* (15.39 Gg), *S. dullooa* (7.19 Gg), *D. sikkimensis* (5.78 Gg), *B. pallida* (3.42 Gg) and others. The number of culms was higher for *S. dullooa*, but the biomass was lower compared to *D. hamiltonii* due to the thicker culm thickness in *D. hamiltonii*.

Details of the harvestable culms of bamboo along with their biomass of Mokokchung district are given below (Table 18):

Table 18: Bamboo specie wise harvestable bamboo along with number of culms and corresponding biomass

Harvestable bamboos	>3 yrs		Total	
	Number (1000)	Biomass (Gg)	Number (%)	Biomass (%)
Bambusa tulda	36874	721.66	60.1	77.34
Other Bamboos:	24444	211	39.9	22.66
Dendrocalamus sikkimensis	179	5.78	0.3	0.619
Schizostachyum dullooa	2089	7.19	3.4	0.77
Bambusa pallida	724	3.42	1.2	0.367
Dendrocalamus hamiltonii	1543	15.39	2.5	1.649
Other minor species	19909	179.65	32.5	19.25
Total	**61318**	**933.09**	**100**	**100**

The information collected from Mokokchung forest division reveals that there is no up to date data available on harvested bamboo culms in the district. However, an old estimate of harvested bamboos during the year 2014-15 was collected. It was found that a total of 30,66,074 culms of bamboo were harvested during the year. In absence of recent data, the 2014-15 data can be used as an indicator which worked out to be about 5.0% approximately of the harvestable bamboo available in the district. This signifies a minimum resource utilization in Mokokchung which can be boost up using scientific means and method, value addition and establishment of market linkage for the farmers and bamboo cultivators. The assessment of net bamboo resources concerning harvesting practices and the current rate of bamboo plantation is pivotal for a complete understanding of sustainable development in Nagaland and its potential impact on future bamboo coverage. The available data/information indicates that the quantity of harvested culms does not surpass the existing bamboo stock, signifying a commendable commitment to sustainable harvesting practices within the community. Sustainable harvesting, as implied by this balance, is important for maintaining the ecological integrity of bamboo resources over time.

The information on plantation area in Mokokchung district has been collected from NBDA and it was found that a total of 10862 ha of land were brought under bamboo plantation within a span of 16 years or so. It was also found that *B. tulda* is the most preferred species for plantation in the district.

Objective 2: To generate species wise distribution map of bamboo resources.

LULC map was created with the help of LISS IV satellite image. Land cover maps representing spatial information on different classes of physical coverage of study area, e.g. forests, bamboo, agriculture, built-up, waterbody etc are showin in Fig. 12.

Bamboo distribution map was generated (Fig. 13) based on various satellite images. Three classes were made as far as bamboo was concerned namely: *B. tulda*, other bamboos and mixed bamboos. Here 'other bamboos' includes *B. pallida*, *D. hamiltonii*, *D. sikkimensis*, *S. dullooa* and other minor species which covers very less area. In the 'mixed bamboo' the area mostly consist of three to four bamboo species associated with one major species. In the study area, *B. tulda* was found to be dominant with an area coverage of about 8.4 % of total geographical area of the district. The species was mostly cultivated as compared to other bamboo species which were found in the wild and were sparsely distributed. The details of area distribution and percentage are given in the Table 19:

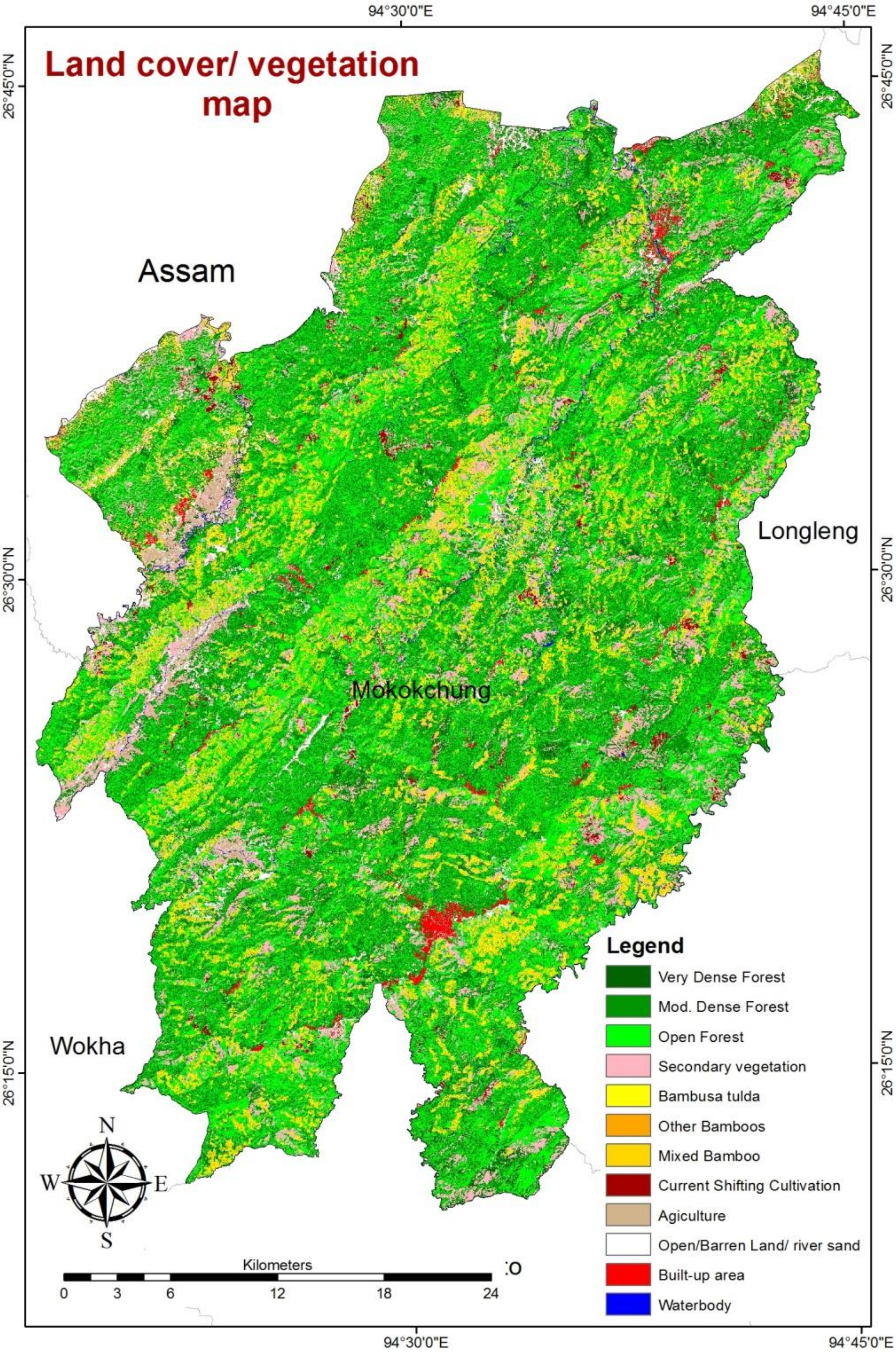


Fig. 12: Land Use Land Cover map of Mokokchung district

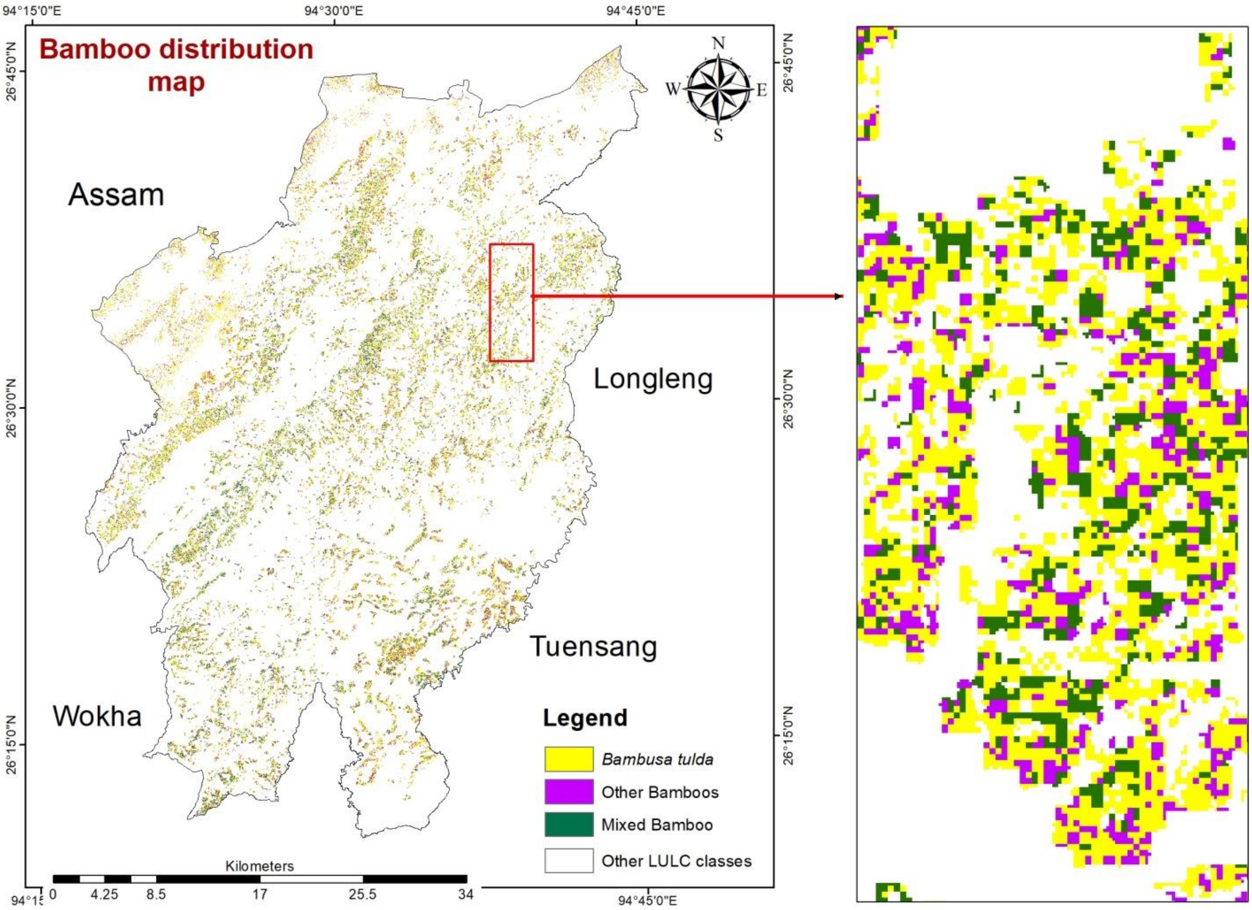


Fig. 13: Bamboo distribution map of Mokokchung district

Table 19: Area distribution and its corresponding percentage of Mokokchung district

Class	Sub-class	Area (km²)	% of the geographical area
1.Forest	1.1 Very Dense Forest	136.45	7.9
	1.2 Mod. Dense Forest	502.71	29.2
	1.3 Open Forest	553.47	32.2
	1.4 Secondary vegetation	219.06	12.7
2.Bamboos	*2.1 Bambusa tulda*	144.83	8.4
	2.2 Other Bamboos:	48.50	2.8
	2.2.1 Bambusa pallida	36.05	2.1
	2.2.2 Dendrocalamus hamiltonii	8.02	0.5
	2.2.3 Schizostachyum dullooa	3.22	0.2
	2.2.4 Dendrocalamus sikkimensis	1.21	0.1
	2.2.5 Other minor unidentified bamboos	0.007	0.0
	2.3 Mixed Bamboo	36.40	2.1
	Total Bamboo (2.1+2.2+2.3)	229.74	13.4
3. Non-forests	3.1 Current Shifting Cultivation	14.21	0.8
	3.2 Agriculture	11.01	0.6
	3.3 Open and Barren Land/ river sand	30.57	1.8
	3.4 Built-up area	14.80	0.9
	3.5 Water body	6.97	0.4
	Grand Total (1+2+3)	**1719.00**	**100.0**

Objective 3: To document various utilization patterns of bamboo resources.

Bamboo supports the local livelihood in many ways but the utilization has been customary and mostly traditional applications. To know the utilization pattern of bamboo in the study area socio-economic survey was conducted through formal and informal interviews and observations. For the socio-economic survey, a structured questionnaire was prepared where a total of 334 respondents were surveyed covering the whole district. Engagement sessions were conducted with local entities, such as Village Councils, Gaon Buras, and other community bodies. During these meetings, knowledge on scientific harvesting methods and sustainable bamboo utilization was shared (Appendix-1f).

3.1.4 Description of the surveyed areas:

A total of 32 villages namely: Longsa, Mangmetong, Yaongyimri New, Phangsang, Khensa, Longkhum, Yaongyimsen, Kubolong, Alongchen, Chami, Imchalu, Kanimu, Longjang, Longpa, Mupongchuket, Sungratsu, Longchem, Nokpu, Aonokpu, Alongtaki, Changdang, Lakhuni, Saring, Japu, Khar, Longjemdang, Longtho, Mangkolemba, Medemyim, Merangmen, Moayimti and Watiyim were visted and surveyed to collect the soio-economic data Fig. 14.

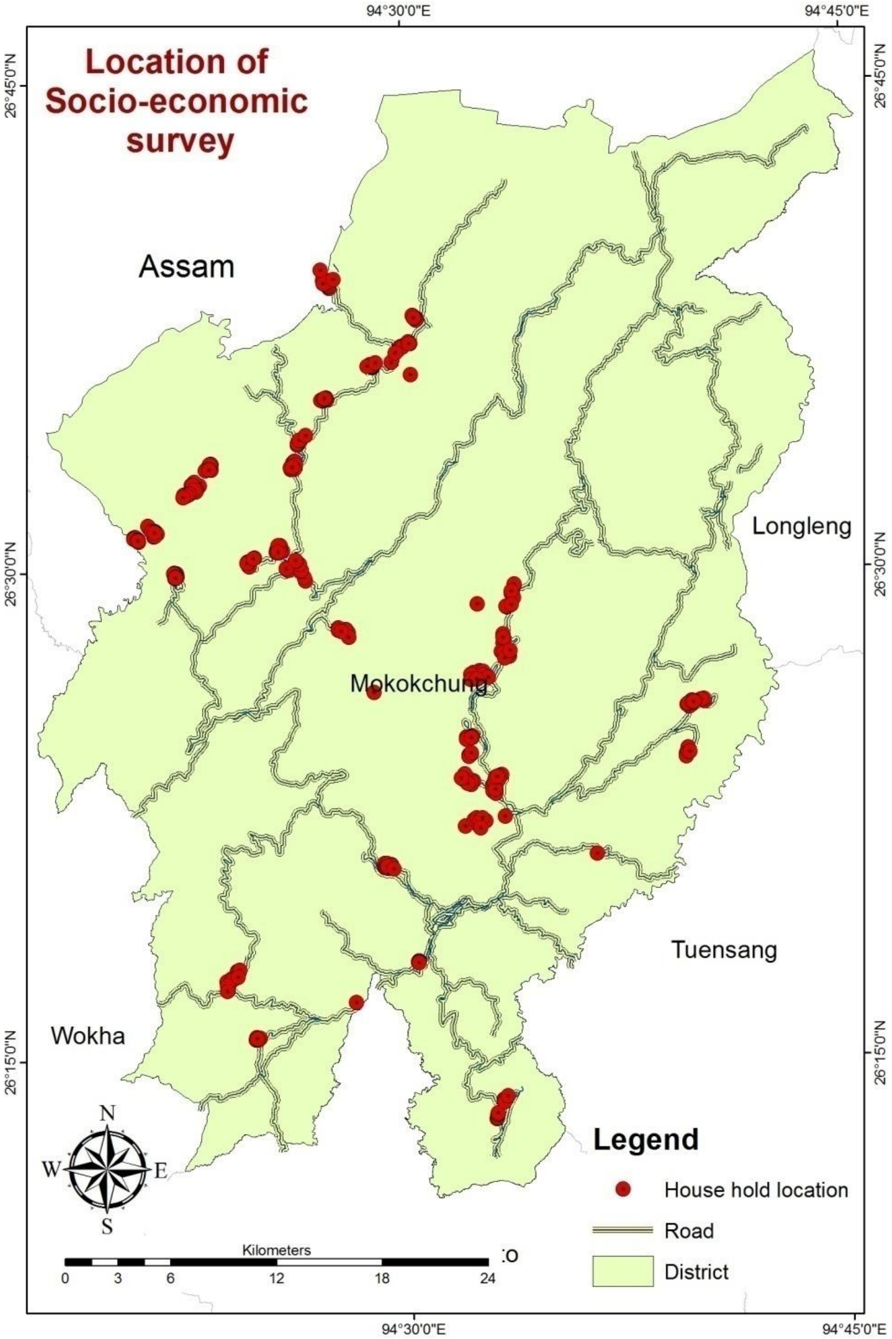


Fig 14: Point layer map showing the HH surveyed villages.

3.1.5 Demographic characteristics of respondents:

Mokokchung district is dominated by the 'Ao' community so the percentage of Ao was highest (93.11%) and the rest consist of a handful of other communities (Fig. 15). Being a Christain-dominated district, 99.40% was Christain and 0.60% followed Hindusim. Analysis of demographic characteristics was done for the respondents of the region (Fig. 16). The result shows that majority of the respondents were male (94.01%) while 5.99% were females (Fig. 17). The results also shows that the highest number of respondents (44.61%) in their age group fell under 60-80 years (Fig. 18). Most of the respondents were farmers and very few respondents were found to be craftsmen. The major income source in the study area was agriculture (crops, vegetables etc.) (Fig. 19). This also indicates that with time the craftsmanship is also fading away.

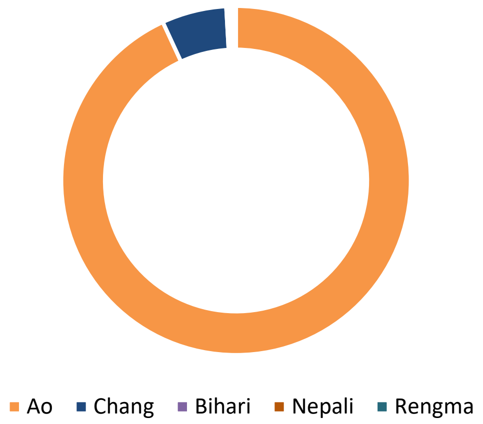


Fig. 15: Tribes in Mokokchung district (%)

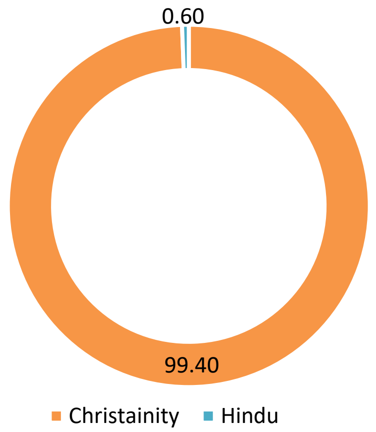


Fig. 16: Religions followed in Mokokchung district (%)

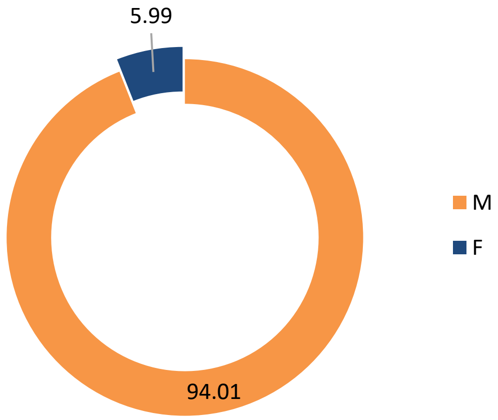


Fig. 17: Gender ratio of the district (%)

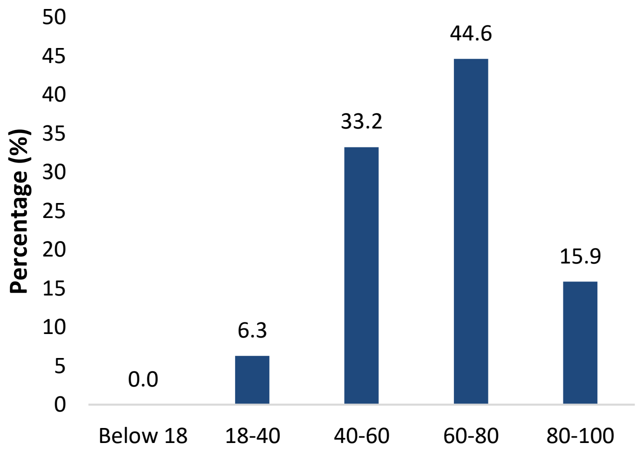


Fig. 18: Age of the respondents

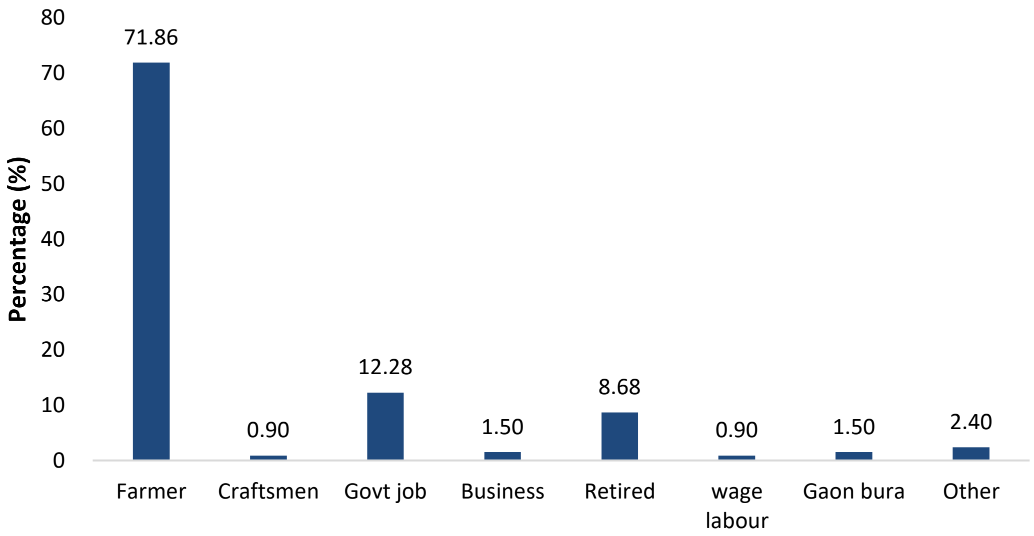
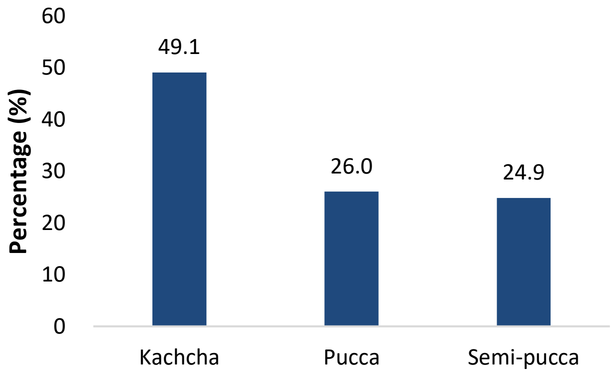


Fig. 19: Occupation of the respondents in the surveyed area

The majority of the study area was under the village, and the type of house was 49.10% kachcha, 26.05% pucca, and 24.85% semi-pucca (Fig.20). People in this region mostly belong to nuclear family system (97.60%) and only 2.40% were found to belong to joint family (Fig. 21). In the gender ratio, the male members were found to be more as compared to females with the number of the adult male being 49.91%, number of male children 10.93%, adult females 37.22%, and female children 9.94% in the surveyed areas (Fig 22). Being an agarian society their dependency was primarily on agriculture for their livelihood. Around 19.46% of the respondent's monthly income falls within the range from 2500/- to 5000/- (Fig. 23). Looking at the livestock profile (Fig. 24), chicken was found to be reared more in almost all the surveyed area.



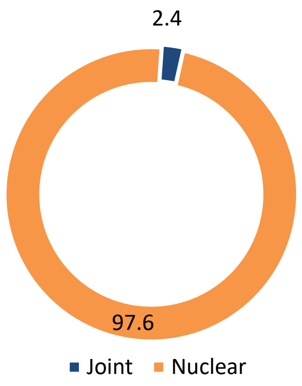


Fig. 20: Type of house in the study area (%)

Fig. 21: Type of family (%)

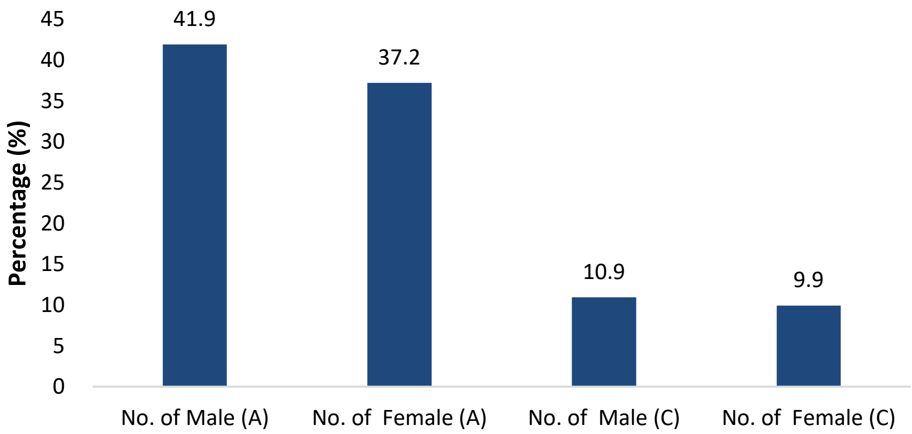


Fig. 22: Gender ratio (%) (A=Adult, C=Children)

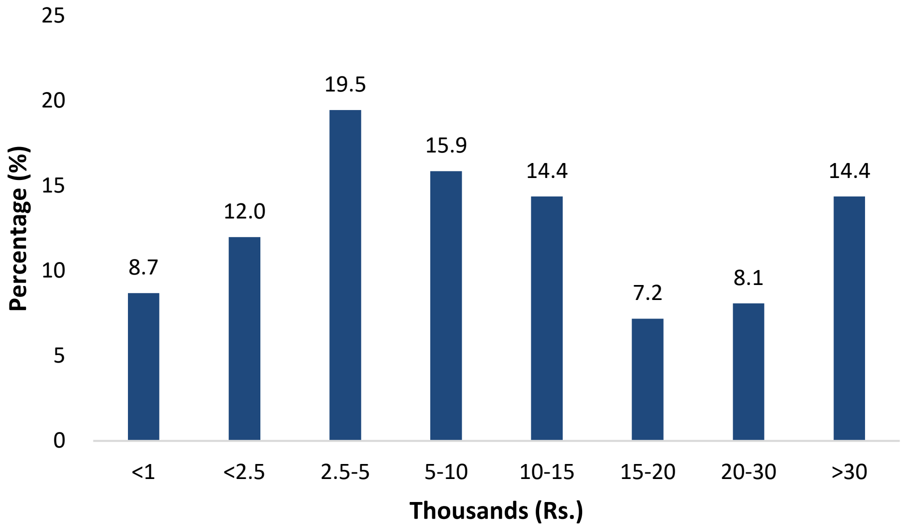


Fig. 23: Average monthly income of the respondents in the study area

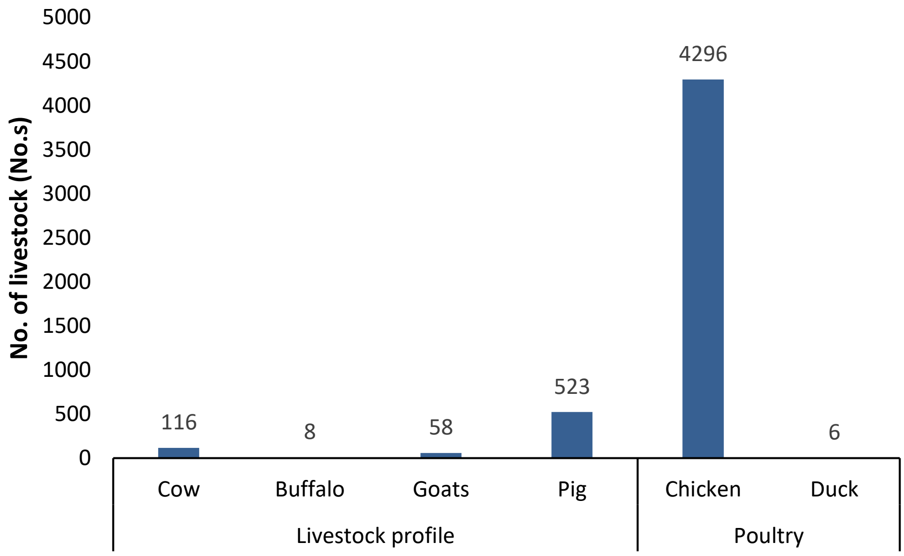


Fig. 24: Livestock profile in the study area

3.1.6 Bamboo utilized in the study area:

In the study area, the presence of *B. tulda* was conspicuous as the people in the area had at least a clump of *B. tulda* cultivated in their vicinity as many were dependent on it in their day-to-day activities (Fig. 25). It was also observed that the respondents were mostly dependent on two species viz., *B. tulda* and *D. hamiltonii* in particular (Fig. 26) as they had multiple usages both indoor as well as outdoor in the surveyed area. Collection of bamboo was mostly done from the wild, *D. hamiltonii* and *B. tulda* were collected from the plantation site as well (Fig. 27). The purpose of the collection was for their own use as there was no proper market for selling bamboo culms or articles (Fig. 28). Regarding the collection of bamboo by the respondents, an average of about 80 culms were collected during the season between September to February and fewer culms were collected during the off-season as it becomes prone to insect attack (Fig. 29). The harvesting method was selective in the study area i.e., the respondents showed that culms of the right size were selected depending on the intended utilization and on their maturity. The distance usually travelled for the collection of bamboo was on an average of 1.3km.

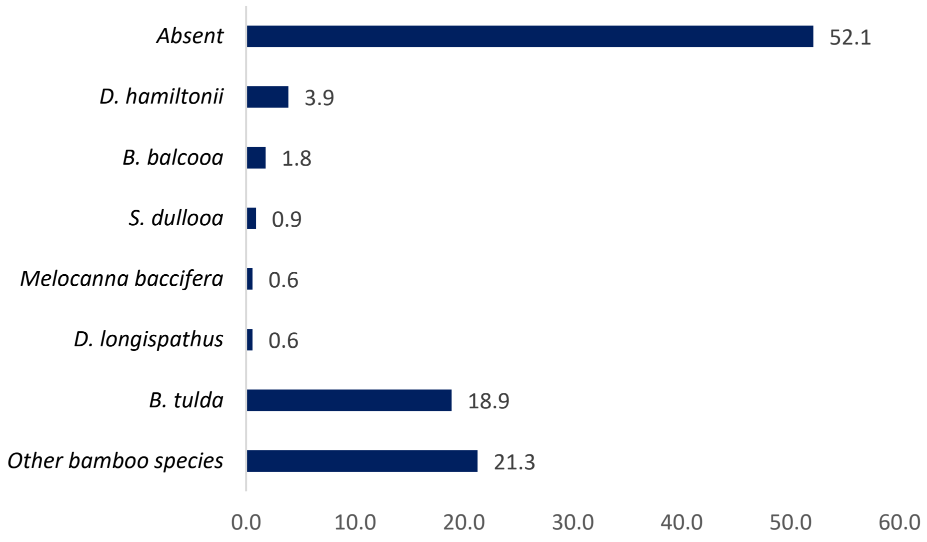


Fig. 25: Bamboo species available in and around the house in the study area (%)

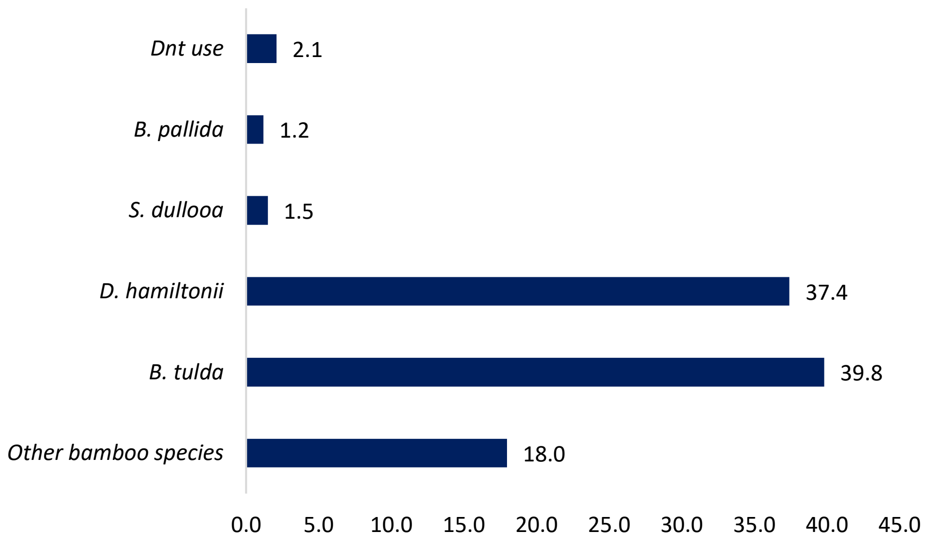


Fig. 26: Mostly used bamboo by the respondents (%)

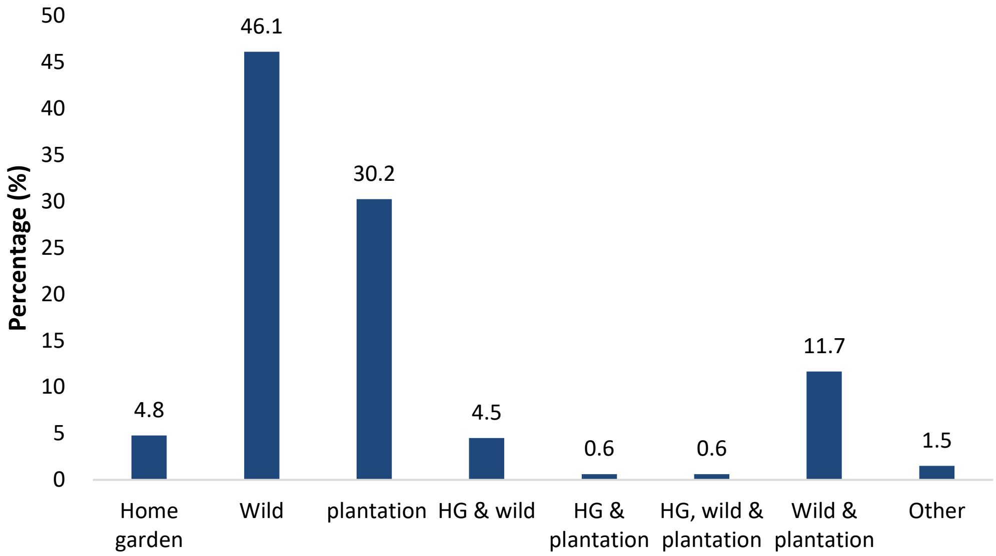


Fig. 27: Source of bamboo of the respondents in the study area

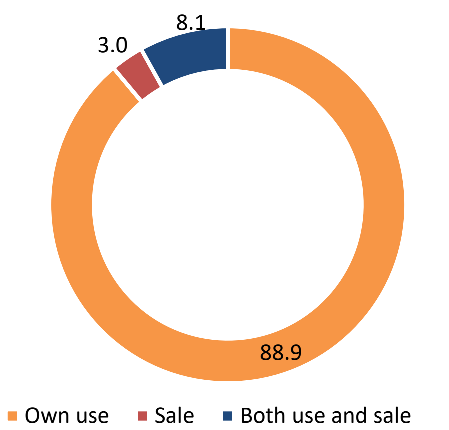


Fig. 28: Purpose of collection (%)

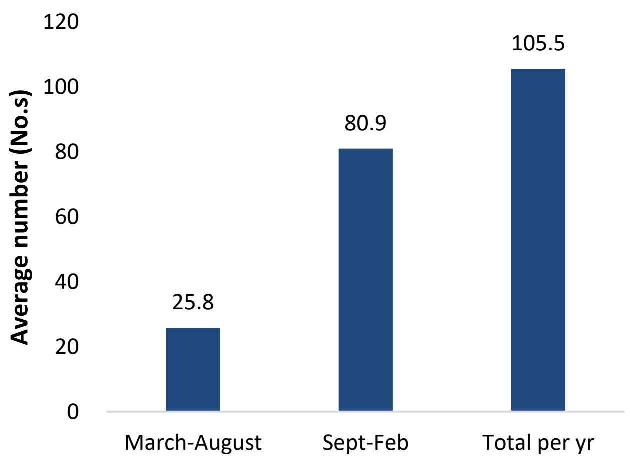


Fig. 29: Average culms collected by HH members annually

In Mokokchung, in most of the villages, people do not have a proper platform for selling the bamboo products. People mostly weave it for their own use (Fig. 30). Orders were placed directly to the village craftsmen and limited products were made accordingly as per the order in terms of number (Fig. 31) when an order was placed. The craftsmen would not make an extra and keep it for sale as there was no demand. A handful depended on it for livelihood. Looking at the market channel in regard to bamboo articles, the district does not have a platform to promote the products which results in a direct impact on the people for their interest in weaving.

If we look at the earnings of craftsmen per year was very discouraging as one cannot depend on it for livelihood. They would earn roughly between 1000-5000/- per year which was scanty and not possible to run a family (Fig. 32). Therefore, many would opt for other means of livelihood in the study area.

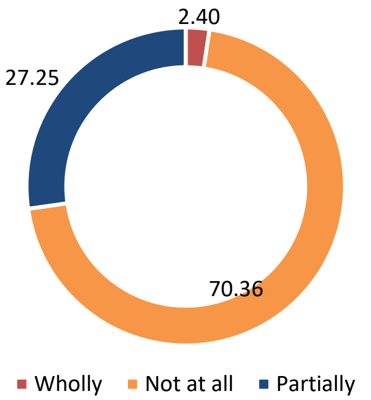
Interviewees were asked on the products that were mostly utilized in the study area. It was found that 'muluk' and 'per' (Fig. 33) were found to be present in almost all the surveyed households. The two products were mostly used in their day-to-day activities. Muluk was used for storing vegetables and other items, mainly used as a storage box. *Dendrocalamus hamiltonii* was used for making muluk. Per (winnower) was used in every household either for winnowing the grains or for keeping edible items for drying under the sun. *Schizostachyum dullooa* was preferred for making per as it has longer internodes as compared to *Dendrocalamus hamiltonii*.

The durability of bamboo in different uses was also asked to respondents looking at the major usages (Fig. 34). Construction of a house, made from bamboo would last between 20 to 25 years. The longevity would last more so if the walls of the house were exposed to smoke which would dry out the bamboo completely and give a smoking effect that acts as a coat and a resistance to insect attack. Handicrafts depend on the person's usage, usually, they last for about 5-7 years. For furniture, many of the household owns a stool which is made of bamboo and plastic. The average longevity of the furniture was about 15 years. Big furniture's were not made in the villages as the bamboo needed treatment for preservation and they do not have the money to purchase the machines.

Every household in the study area owns a garden that was demarcated by boundaries made of bamboo. The fences were changed biannually as the bamboo gets exposed to the soil directly which results in deterioration of the bamboo. Mats were also one of the major uses as grains and other food items were used for drying. The average longevity of the mats is about 12-15 years.

Based on their utilization of bamboo, the respondents were asked to rank the bamboo species (Fig. 35). *Bambusa tulda* was preferred more in the study area and it was found that the species was being cultivated both in their homestead as well as plantations were practiced as it had high demand, especially for scaffolding, household uses and other constructions activities. It was observed that in the study area the plantation of bamboo was being dominated by *Bambusa tulda* which could result in monoculture and thread to other bamboo species.

The second preference was given to *Dendrocalamus hamiltonii*, this species was vastly preferred for its shoots which was consumed in dry, fermented, pickled and fresh form and was used as a split or, many keep it at home which would be used as a quick tie-up rope. Thirdly, *Schizostachyum dullooa* was preferred which was used in construction to make the walls and floors. Because of its thin wall, the species was not much used for heavy activities.



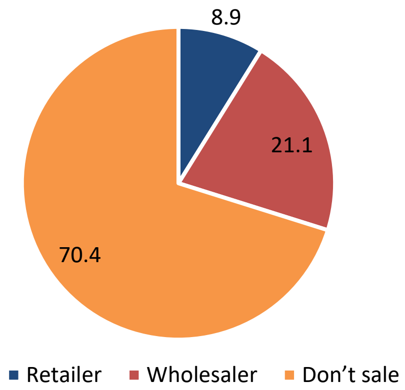


Fig. 30: Bamboo products produced by HH for sale (%)

Fig. 31: Bamboo products mainly sold (%)

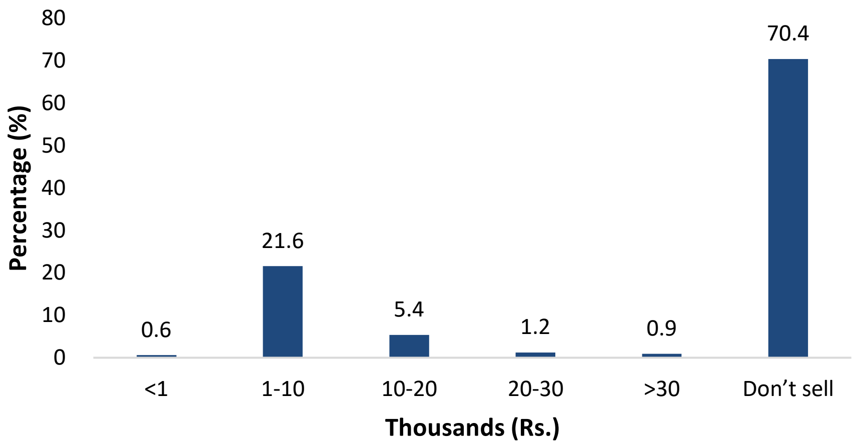


Fig. 32: Earning of community from bamboo product yearly

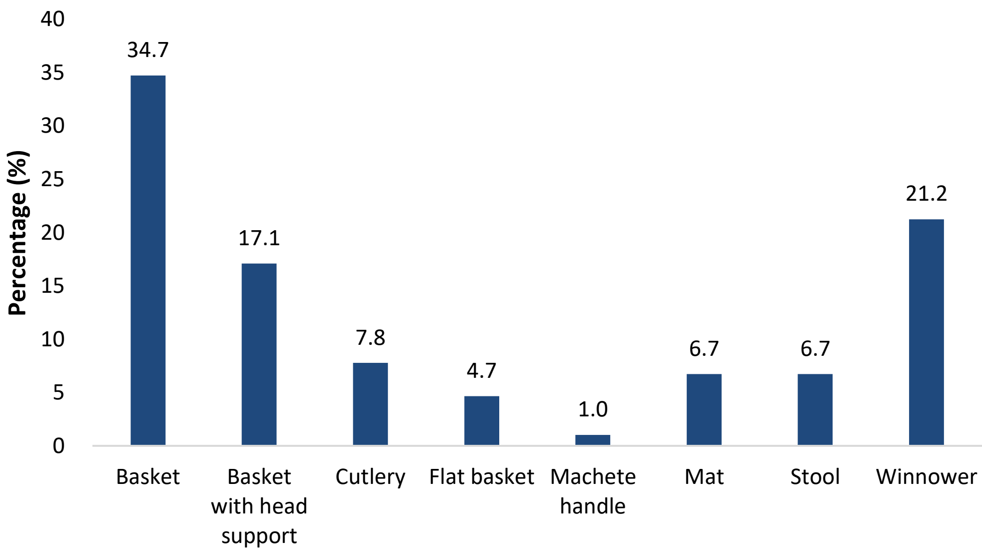


Fig. 33: Bamboo products mostly bought by HH for utilization (%)

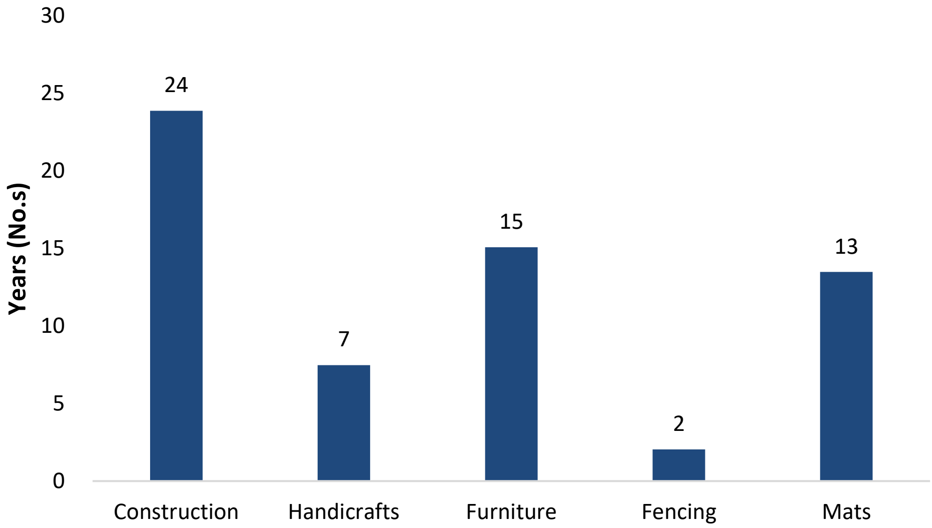


Fig. 34: Assumptions made by the respondents for durability of bamboo in different uses

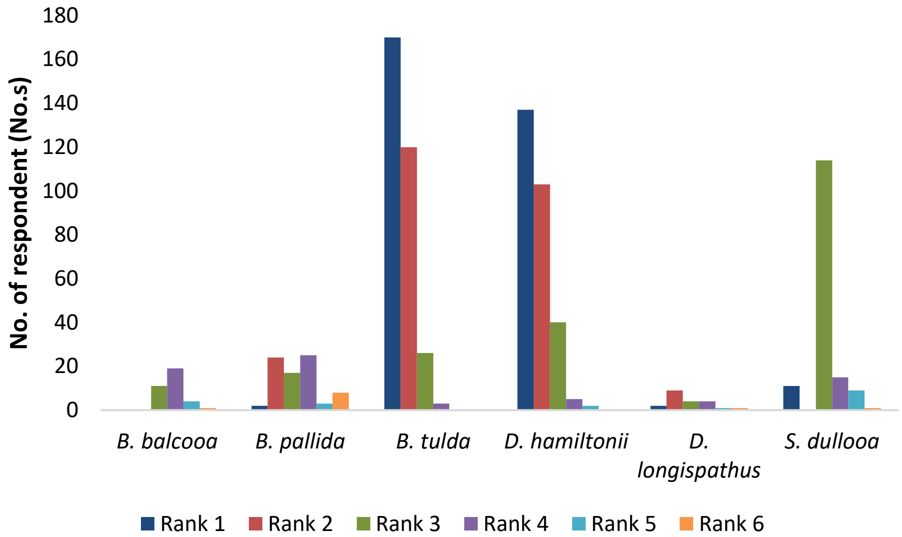


Fig. 35: Ranking of bamboo according to respondents' preference

Questions were also asked to know the respondent's view/perspective on whether the bamboo had increased or decreased over the years in the study area. The results showed that about 42.81% respondents were of the view that bamboo resources have been decreasing over time and 30.24% had responded it was increasing (Fig. 36). Comparing the bamboo products to similar products made from other materials, the respondents were asked about their preferences. The respondents were of the view that products made of bamboo were superior in terms of look and attractiveness. The durability of the product was found to be more and sustainable as well. It was found that the price of bamboo products was less in comparison with other similar products made up from other materials. However, many of the people were of the opinion that they would opt for products made from other materials than bamboo due to their variety of options in terms of design and overall look.

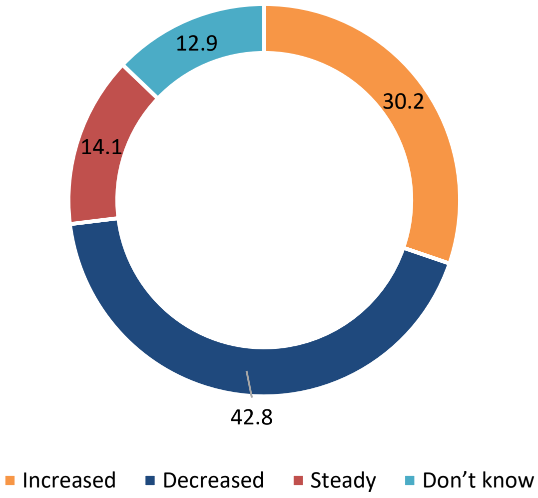


Fig. 36: Perception of the respondents on bamboo resources in the district (%)

3.1.7 Species-wise quantification of bamboo based on utilization pattern:

Based on the utilization pattern, it has been broadly classified into 9 categories to know the uses and rate of extraction per year of different bamboo species.

3.1.7.1 Bamboo as handicraft:

People of Mokokchung district are fond of various bamboo based handicrafts and they have been weaving for several decades. The indigenous techniques of weaving had been passed on from generation to generation. With the influence of modernization, many of the children were sent away from villages to the town for better studies which had shown significant shift in their interest from weaving to other activities. It was observed that many of the weavers at present fall above 70 years of age which shows that the youth of today were least interested in weaving and the practice of weaving was slowly diminishing from the study area. Quantification was done based on the utilization, and it was found that *Dendrocalamus hamiltonii* was preferred more for weaving. A total of 2547 (Fig. 37) culms of *Dendrocalamus hamiltonii* were extracted for weaving annually which estimates approximately 26.37 t/yr (Fig. 38) of biomass.

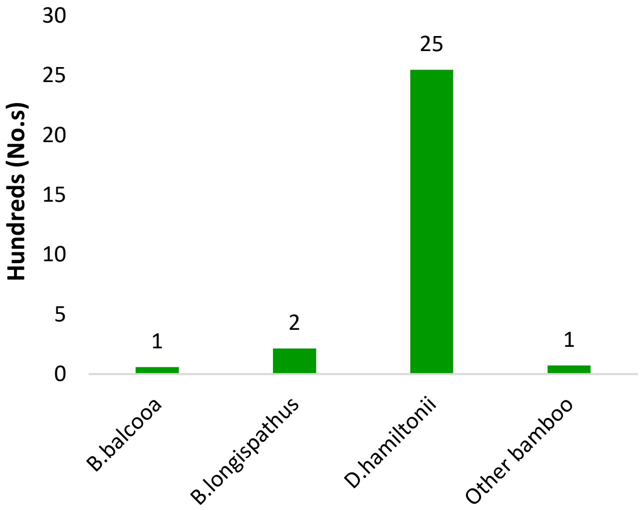


Fig. 37

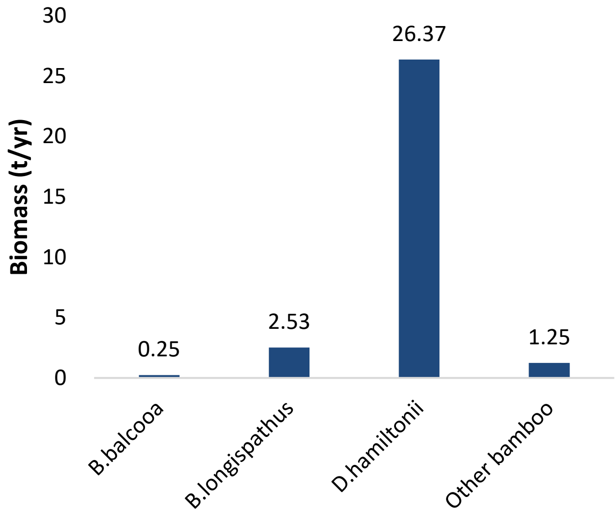


Fig. 38

Fig. 37 & 38: Handicraft: Quantity of culms used by household per year along with their corresponding biomass

3.1.7.2 Bamboo as a housing material:

Due to its versatility such as favorable mechanical properties, high flexibility, the fast-growing rate, low weight, and low purchasing costs, bamboo is a major construction material in many countries, particularly in rural areas. The bamboo provides major framework material for any traditional houses in rural Nagaland. Even today in almost all the villages in Nagaland people live in houses made of bamboo, it is being used as a key element for housing as it is cheap and easily available raw material. The elastic and strong tensile nature of bamboo gives a good and fine finishing to traditional houses (Tangjang et al., 2014). Some of the important species used by the community for housing purposes in the study site were *B. tulda*, *D. hamiltonii* and *S. dullooa*. The whole skeleton framework of the traditional house was made mostly by *B. tulda* which was cultivated. The different component of bamboo species was used for the construction of almost all parts of the rural house including posts, foundation, frames, walls, ceiling, floors, and beams. These traditional houses were considered resistant to earthquakes. Nonetheless, traditional construction techniques of bamboo in flooring, roofing, post and beam, and also in the false ceiling and fencing remain undocumented (Sundriyal et al., 2002). Each bamboo species has a specific use based on its properties.

The culms of *S. dullooa* are used for walls where the culms are split into half and beautifully plaited, also *B. pallida* was used as an alternative to *S. dullooa*. *S. dullooa* and *B. pallida* were preferred more for making walls as the walls were thin as compared to other species found in the study area. 8-9 months old D*. hamiltonii* are harvested, splits are made from the culm and are used as a tying material which holds the bamboo during construction. Annually, 232 thousand culms (Fig. 39) of *S. dullooa* were used by the district for making walls which accounts to 1.02 thousand tonnes of biomass per year (Fig. 40). Likewise, 30 thousand culms (Fig. 39) of *B. tulda* were found to be used for framing the house i.e., 0.67 thousand tonnes of biomass per year (Fig. 40). Major portion of the culm (80-90%) was used during the construction where the longevity of the house lasts for about 20-25 years which could go up to 50 years and more specifically because of the smoke emanating from the ever-present fire which act as a preservative from insect attack. Therefore, we can say that a house made of bamboo acts best as a storage for carbon especially when the longevity of the house is substantially high.

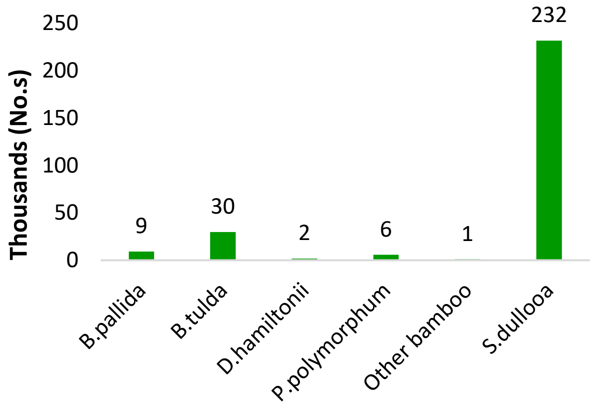


Fig. 39

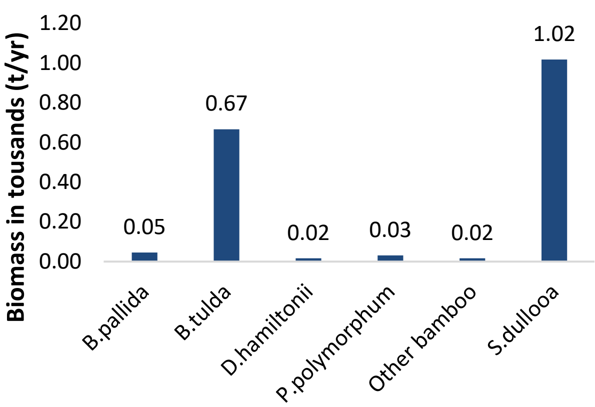


Fig. 40

Fig. 39 & 40: Construction: Quantity of culms used by household per year along with their corresponding biomass

3.1.7.3 Bamboo as fencing:

Most of the houses have their own homestead garden in the study area and they would set up their own boundaries with the help of bamboo. *Bambusa tulda* was extensively used for fencing and was replaced biannually. The fences were constructed in different appearances that result from different orientations. The common procedure in fencing was the erection of short-cut bamboo culms on the ground followed by a closely interlocking bamboo split against the bamboo beam. Around 357 thousand culms (Fig. 41) were used with storage of about 8.04 thousand tonnes of biomass per year (Fig. 42).

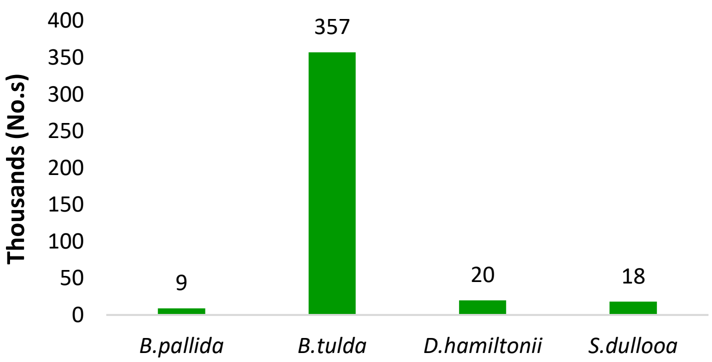


Fig. 41

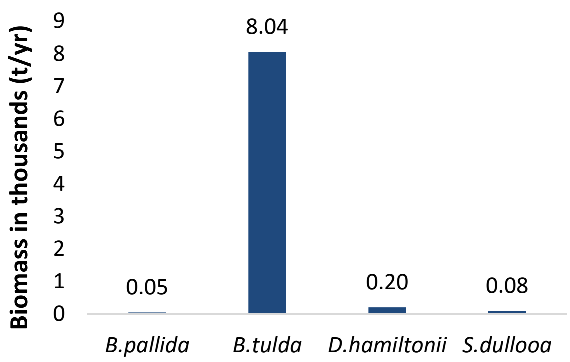


Fig. 42

Fig. 41 & 42: Fencing: Number of culms used by the respondents annually along with their biomass

3.1.7.4 Bamboo as mats:

Current year bamboo was also weaved into mats which were mainly used for drying the grains and other vegetable items. About 8 thousand culms (Fig. 43) of *D. hamiltonii* were used for weaving mats where approximately 0.085 thousand t/yr biomass (Fig. 44) was stored for about 12-15 years.

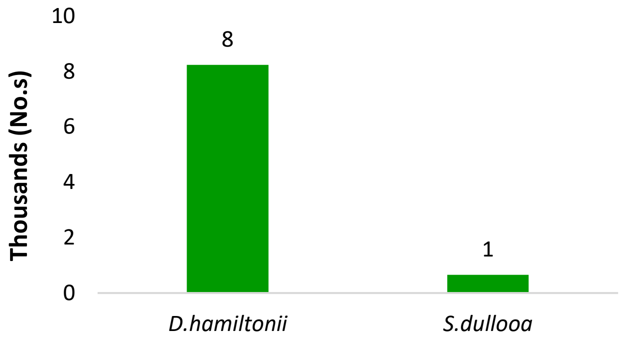


Fig. 43

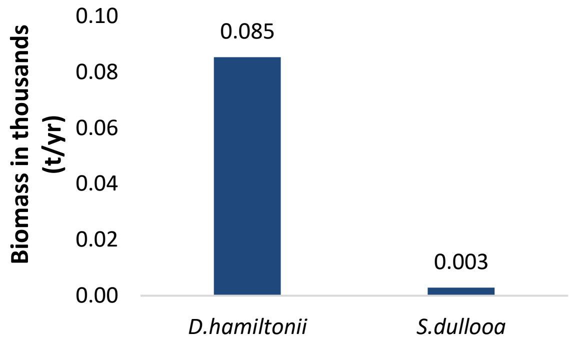


Fig. 44

Fig. 43 & 44: Mats: Quantity of culms used by HH for weaving mat along with their biomass

3.1.7.5 Bamboo as edible shoots, fishing, fuelwood, furniture, and cutlery:

Bamboo shoots are one of the delicacies of the Naga people. It is being prepared in different form by different tribes and each has its own dishes. It can be consumed in fresh, dry, and fermented forms. Fermented water is also being used for making different cuisines. In the study area it was found that *D. hamiltonii* shoots were preferred more as it had a slightly sweeter taste as compared to other bamboo species. The shoots are generally stored for a longer period of time after fermentation. During the shoot formation, the shoots stay under the ground i.e., between the month of June to September. Once the shoots emerge out it grows rapidly, the shoots are harvested between 2-4 weeks after it emerges above the ground. It was estimated that, 520 thousand culms (Fig. 45) of *D. hamiltonii* were harvested yearly for consumption with a biomass of about 5.38 thousand t/yr (Fig. 46).

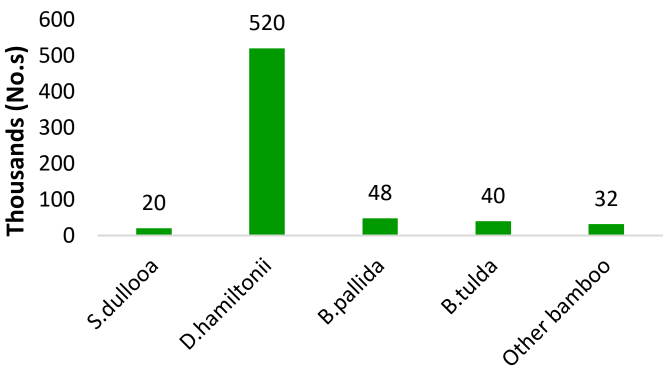


Fig. 45

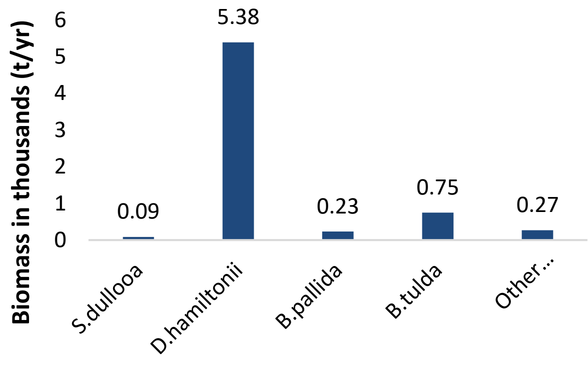


Fig. 46

Fig. 45 & 46: Edible shoots: Quantity of bamboo shoots consumed by HH annually (No.s) along with their corresponding biomass

People of the hills also practice fishing, here young culms of *Dendrocalamus hamiltonii* are harvested and weaved into fishing gears. Yearly about 85 hundred culms (Fig. 47) are harvested with biomass of 0.88 hundred t/yr (Fig. 48). The abundance of *B. tulda* are more in the study area; the consumption for the use of fuelwood was also found to be more for *B. tulda* as compared to other species. Many of the bamboo species are grown in the wild which becomes difficult to. *B. tulda* was cultivated in the homestead and in the plantation site which becomes easy in terms of accessibility and harvesting. Approximately 196 thousand culms of *B. tulda* (Fig. 49) with biomass of 4.40 thousand t/yr are harvested annually for the use of fuelwood (Fig. 50).

In the study area, the practice of making high-end furniture is not very common. The only dominant piece of furniture that was found in the area was a stool which was locally called 'mura'. *B. tulda* was used for making this stool and it would last for at least 15 years. The longevity of the stool depends upon the user and some last for nearly about 40 years. Because of its longevity, the culms are harvested less. It was found that about 226 culms per year (Fig. 51) and 38.63 biomass t/yr are being used for this purpose (Fig. 52). Two types of cutleries are used in the study site: a flat spoon (chisang-local name) to serve rice and a round shape which was used both for serving the curry and as a pestle (chikok-local name). *B. tulda* was found to be used for making the cutlery. It would last for about 8 years and it was estimated that about 1716 culms are harvested annually for making the cutlery (Fig. 51).

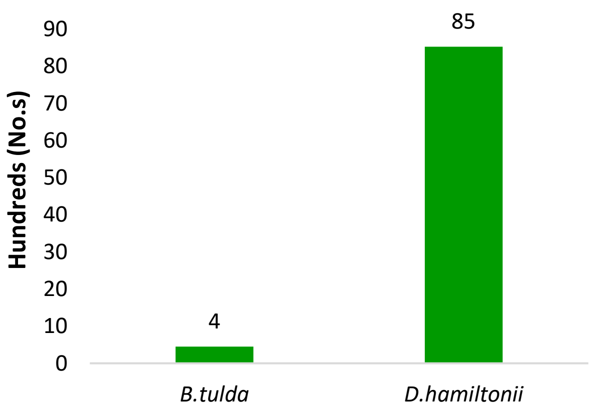


Fig. 47

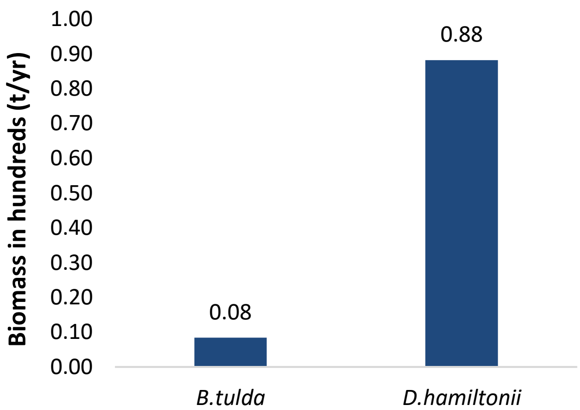


Fig. 48

Fig. 47 & 48: Fishing: Quantity of culms used by HH along with their corresponding biomass

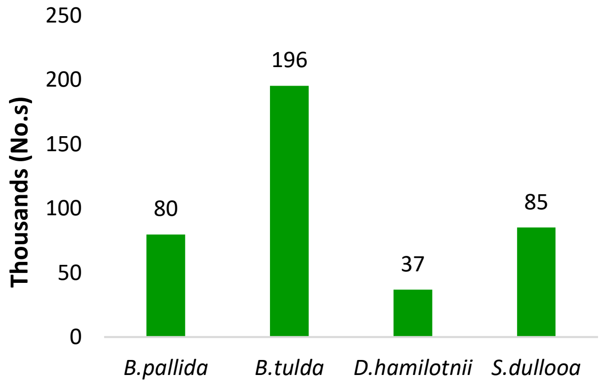


Fig. 49

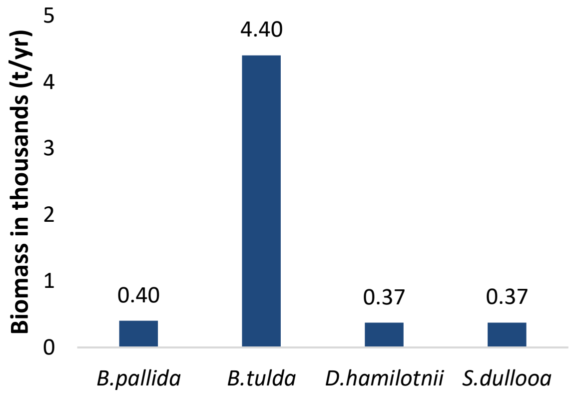


Fig. 50

Fig. 49 & 50: Fuelwood: Quantity of culms used by the respondents along with their biomass

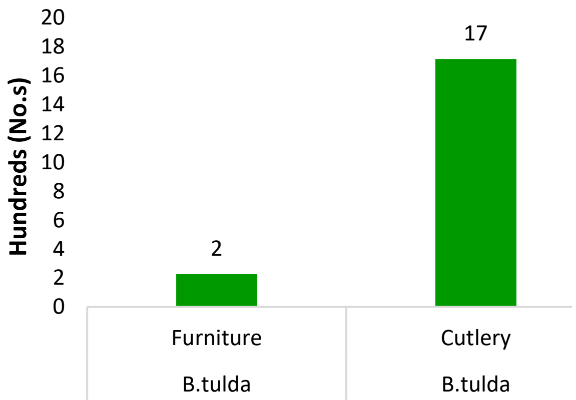


Fig. 51

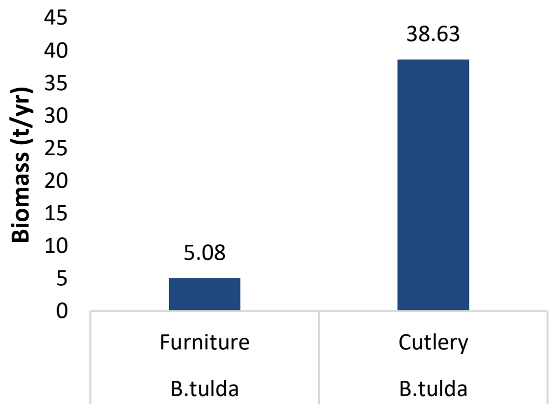


Fig. 52

Fig. 51 & 52: Furniture and Cutlery: Quantity of culms used by the community along with their biomass

Table 20: Based on the utilization of bamboo by households in the study area, below are the break-up of species-wise quantity used and its biomass

Bamboo species	Quantity of culm used by total HH (No./yr)	Biomass (t/yr)
B. balcooa	60	0.25
B. tulda	624564	13912.61
B. pallida	145521	725.85
B. longispathus	215	2.53
D. hamiltonii	597711	6173.88
P. polymorphum	5630	31.30
S. dullooa	355942	1562.58
Other Bamboos	32854	285.63

In the present study, although the culm density seems to be more for *S. dullooa*, the biomass is relatively low which may be the result of a thin-walled culm structure compared to a thick wall culm.

Table 21: Showing the species-wise utilization pattern of bamboo for Mokokchung district:

Bamboo species	Handicrafts	Construction	Edible shoots	Fencing	Furniture	Cutlery	Mats	Fishing	Fuel wood
Bambusa balcooa	✓								
Bambusa pallida			✓	✓					✓
Bambusa tulda		✓	✓	✓	✓	✓		✓	✓
Dendrocalamus sikkimensis	✓	✓							
Dendrocalamus hamiltonii	✓	✓	✓	✓			✓	✓	✓
Dendrocalamus longispathus	✓								
Pseudostachyum polymorphum		✓							
Gigantochloa parvifolia		✓							
Schizostachyum dullooa		✓	✓	✓			✓		✓
Other Bamboos			✓						

3.2 Key Results:

- **Development of Biomass equations of *Bambusa tulda*:** To find the biomass of bamboo species destructive and non-destructive method was followed. Destructive method was done for *Bambusa tulda* to get a site specific allometry equation and the remaining species were calculated by existing equations. Three age class-based equations were developed for *B. tulda* based on two independent variables (Diameter and Height).

Age	Equations developed	R^2
1-2 yr	$V=0.074547 \times D^{2.031796} \times H^{(6.655535 \times 0.074547)}$	0.979
2-3 yr	$V=0.081067 \times D^{1.862632} \times H^{(7.623133 \times 0.081067)}$	0.931
>3 yr	$V=-15.032421+ 3.325163 \times D + 0.794888 \times H$	0.855

- **Estimation of total above-ground bamboo biomass:** The total 'green sound' of bamboo was estimated for the district of Mokokchung. The total number of culms and biomass ascends in all the age classes. The total estimated culm of 'green sound' was 218.08 million of which '>3 yr' contributed the maximum likewise in biomass the total was 2.28 Tg of which '>3 yr' contributed the highest.

- **Bamboo diversity in Mokokchung:** A total of 22 bamboo species were recorded from the study site. A detailed taxonomical exploration may be done in this regard.

- **Quantification of harvestable bamboo:** Quantification of harvestable bamboo was done and the result shows that number of harvestable bamboos in the study area is estimated 98.93 million. Species wise, the number of *B. tulda* culms was found to be more in the study area

(36.87 million) followed by *S. dullooa* (20.89 million), *D. hamiltonii* (1.54 million), *B. pallida* (0.72 million) and others. As well as the biomass of harvestable bamboo in the study area is estimated 857.10 Gg. Species wise, the biomass of *B. tulda* found to be more with 721.66 Gg followed by *D. hamiltonii* (15.39 Gg), *S. dullooa* (7.19 Gg), *D. sikkimensis* (5.78 Gg), *B. pallida* (3.42 Gg) and others.

- The study area was dominated by 'Ao community' and majority of the respondents were male (94.01%) while 5.99% were females. The number of craftsmanship in the area seemed to be decreasing as the major income sources in the study area were agriculture as most of them were inclined towards farming.
- The people were found to be dependent more on *B. tulda* and *D. hamiltonii*. *B. tulda* was mostly cultivated in almost all of the region and *D. hamiltonii* was found in the wild.
- The region had no proper market for selling the handicrafts therefore the articles were weaved only when an order was placed as there was no demand. Only a handful depended on handicrafts for livelihood. Hence, many would seek other means for living.
- Muluk (basket) and per (winnower) were found in almost all the household. The former was made of *B. tulda* which was used as storage and the later was made of *D. hamiltonii* or *S. dullooa* which was used as winnower and to dry vegetables.
- Based on utilization the highest ranking was given to *B. tulda* followed by *D. hamiltonii* and *S. dullooa*. As *B. tulda* was most preferred in the area the forest was being cleared for plantation which may trigger an imbalance to the ecosystem.
- Based on species-wise quantification on utilization, it was broadly classified into 9 categories to know the uses and rate of extraction. Annually a total of 2547 culms were harvested for making different types of handicrafts which was estimated to be around 26.37 t/yr of biomass.
- Bamboo provides a major framework material for housing in the study region. Species such as *B. tulda, D. hamiltonii* and *S. dullooa* were used. *B. tulda* gives the structure of the house, *S. dullooa* was used for flooring and walls and *D. hamiltonii* the culms were split and used for typing or holding the bamboos together. On an average, about 231945 culms (1018.24 t/yr) of *S. dullooa* were used for making walls and 29612 culms of *B. tulda* for framing the house i.e., 666.87 t/yr.
- Bamboo used for fencing was common in the study area. Around 357thousand culms were used with storage of about 8.04 t/yr. *B. tulda* was preferred more as the culms were sturdy and straight. *D. hamiltonii* was harvested for making mats with an annual harvest of about 8246 culms having 0.085 thousand t/yr biomass.
- Bamboo shoots are being used as one of the vegetables which was added in several dishes as it was one of the delicacies of the people. Shoots of *D. hamiltonii* was preferred over other species because of its mild sweet taste. Every year about 520 thousand culms were harvested

with a biomass of 5.38 thousand t/y which were prepared in dry, fermented, pickled and fresh form. Fishing was also a common practiced where *D. hamiltonii* was harvested for making fishing gears. Annually 8522 culms were harvested with biomass of 0.88 hundred t/yr.

- Many were dependent on bamboo for fuelwood as well. Around 195547 culms of *B. tulda* was harvested with biomass of 4.40 thousand t/yr. *B. tulda* was also used for making stool which was the only piece of furniture made of bamboo recorded from the study site. About 226 culms per year was harvested with 5.08 biomass t/yr, less number of culms were recorded as the longevity of stool lasts for years. Two types of cutleries were common which was found in almost all household. The cutleries were made of *B. tulda* with an annual harvest of about 1716 culm having 38.63 t/yr of biomass.

3.3 Conclusion of the study undertaken:

- The present study provides a holistic picture of the bamboo resources present in the study area. The species wise quantum (stock) of bamboo resources along with their spatial distribution and utilization pattern amongst the rural people is also better understood during the present study. This data and knowledgebase would further facilitate the decision makers in judicial management of the resources and also help in development of appropriate strategy for its utilization and conservation.
- Bamboo Biomass estimation will be of immense help as bamboo is an integral part in the day-to-day activities of the Nagas. Biomass is an important element for assessment as it determines the environmental condition and health of an ecosystem. Further, the equation developed for *Bambusa tulda* biomass estimation can be used in other districts and the outcome is expected to be accurate as it all falls under the similar geographical region.
- The map showing the distribution of major bamboo species in the present study is very important as it will be easy to calculate the quantity and coverage of bamboo. Dominant specie wise mapping in this study can be replicated in other parts of the region. Though only the dominant species was mapped in this study, further research can be done focussing on the lesser-known species or more specifically the endemic species of bamboo. The endemic species may be mapped and conservation initiative can be encouraged so as to preserve it. Remote sensing has been found to play a vital role in bamboo resource estimation in the present study.
- It was found that of all the species found in the region, people's dependency was more towards *B. tulda*, *D. hamiltonii* and *S. dullooa*.
- Socio economic survey was also done in the study area to know the dependency of the tribes on bamboo as a whole. People in the region have traditional knowledge of the usage of the plant species but it was observed that older men had more knowledge and valued more than women and younger people. Bamboo crafts can be modernized to increase market and artistic value and at the same time promote and enhance in ways to efficiently use the plant.

Bamboos are mostly found in the wild and are more susceptible to harvesting. Therefore, awareness program may be initiated to sensitize the people about ecological and socio-economic importance of bamboos.

4 OVERALL ACHIEVEMENTS

4.1 Achievements on Objectives:

22 species of bamboo were recorded from the study area. The dominant species was found to be of *Bambusa tulda, Dendrocalamus hamiltonii* and *Schizostachyum dullooa*. The foremost genus found in the district was *Bambusa* and *Dendrocalamus*. *B. tulda* was mostly found in the plantation site, *Dendrocalamus hamiltonii* was mostly found in moist valleys along the stream and *S. dullooa* was found in abundance in bamboo forests. All the culms were recorded according to their girth and ages classes and Specie-wise growing stock was also calculated.

Specie-wise bamboo map was generated for the dominant species available in the district to know the growing stock. The map generated will help planners for proper scientific management of the bamboo forest. In the study area, some pockets of bamboo area are harvested extensively which affects the growth of new culms.

Specie-wise utilization pattern of bamboo was documented along with their products. A total of 90 articles were documented from the study area. It was found that People's dependency in the studied region was more towards *B. tulda* and *D. hamiltonii*. The two bamboos were mostly used for their basic activities.

4.2 Establishing New Database/Appending new data over the Baseline:

- Bamboos are significant plants species of the north eastern region and the region being a part under IHR known to have many such species. The state was reported to have 46 bamboo species yet district-wise bamboo diversity and other aspects like biomass and growing stock was still lacking.
- Bamboo resources in Mokokchung district of Nagaland had not been studiedin detailed except few studies pertaining to utilization and diversity that too in a limited area around the district headquarter covering few villages: Longkhum, Khensa, Mekuli and Chungtia (Walling, & Puro,2018). The very report makes an effort to bring out holistic data from all blocks of the district in such a way that all the villages lying within each block were sampled for information on utilization pattern and diversity.
- The present investigation documented that the district alone is known to have 22 species which is high compared to others studies done in different IHRs (Tamang, 2013, Nongkynrih, 2019, Sharma, 2016 and Konyak and Swüro, 2021).
- The average culm density of the stand was found to be more for *Gigantochloaparvifolia* (7255 No.s/ha), *Bambusa tulda* (6193.33 No.s/ha), *Schizostachyum dullooa* (4575.26 No.s/ha),

Dendrocalamus hamiltonii (2942.5 No.s/ha), *B. pallida* (1827.51 No.s/ha), *D. longispathus* (1533.3 No.s/ha), *D. sikkimensis* (1024 No.s/ha), *B. balcooa* (843.33 No.s/ha) and others.

- Biomass estimation of bamboo was done which will serve as a baseline for other researchers. Result suggested that the average biomass of *B. tulda* was found to be 107925 kg/ha followed by *G. parvifolia* (73852.6 kg/ha), *D. hamiltonii* (27977.9 kg/ha), *D. sikkimensis* (24928.9 kg/ha), *S. dullooa* (19636.79 kg/ha), *D. longispathus* (15990.8 kg/ha), *B. pallida* (8951.4 kg/ha), *B. balcooa* (3507.8 Kg/ha) and others respectively.
- In addition, a map showing the bamboo distribution and growing stock was generated which will help in sustainable management of the forest in the study area.
- Since time immemorial the lives of the people were inter-webbed with bamboo in Nagaland. Documentation of specie wise utilization of bamboo articles of the district is also done. The documentation on articles shall also function as baseline information in terms of culture and tradition of the community associated with bamboo.

4.3 Generating Model Predictions for different variables:

- *Bambusa tulda* is the dominant species found in the study area and hence a site-specific biomass equation of *Bambusa tulda* was developed during the study.
- A site-specific allometric equation of *Bambusa tulda* for estimating aboveground biomass using two independent variables such as diameter at breast height (D) and culm length (H) based on age classes were developed. The best fitted equations developed for different age classes are:

Age	**Equations developed**	**R^2**
1-2 yr	$V=0.074547 \times D^{2.031796} H^{(6.655535 x 0.074547)}$	0.979
2-3 yr	$V=0.081067 \times D^{1.862632} H^{(7.623133 x 0.081067)}$	0.931
>3 yr	$V=-15.032421+ 3.325163 \times D + 0.794888 \times H$	0.855

- The equation so developed was used to find the biomass of this species for the entire study area.

4.4 Technological Intervention: NA

4.5 On-field Demonstration and Value-addition of Products: NA

4.6 Developing Green Skills in IHR: NA

4.7 Addressing Cross-cutting Issues: NA

5 IMPACTS OF FELLOWSHIP IN IHR

5.1 Socio-Economic Development:

- Many people in the district are losing in touch with bamboo weaving. Hardly a handful of artisans does exist whoknows how to weave professionally. The youth of this generation have least interest in weaving as it does not generate good income. This is perhaps due to lack of proper market channel as a result farmers could not sell their products. To uplift the livelihood of the people, market linkages need to be established and proper training on how to transform bamboo into several other products may be relevant. This way the people will also get encouraged and preserve the tradition of weaving and making bamboo artifacts.
- Bamboos are also planted, harvested and traded to other parts of the states which create an opportunity for income generation. Just a handful of farmers are into this business in the study area. Rural people lack knowledge on sustainable management of bamboo forest therefore, proper hands-on training in plantation techniques, harvesting and processing should be given so that they can have adequate amount of return from their proceeds.
- As bamboo needs only basic tools for propagation and harvesting, the bamboo grooves can be managed by individual farmer as it requires less intensive management and expertise. With little access to investment capital bamboo offers significant advantages to low-income rural communities as it does not require highly skilled labor. Bamboo can grow and regenerate easily on wasteland which is not suitable for farming. As it does not require any specialized equipment it can be harvested without much difficulty.
- From socio-economic point of view, thick-walled bamboo is mostly preferred as it satisfies their everyday basic needs. *Bambusa tulda* plantation was observed in plenty in the study area. Therefore, the plantation of the preferred species should be encouraged along with intercropping to maximize the land utilization which will increase the productivity and economic returns from the land and increase their income.

5.2 Scientific Management of Natural Resources In IHR:

- Scientific management of bamboo resources is important to have sustainable flow of bamboo materials for various needs in the hilly region of the country. There are international funding that focuses only on “20 priority species” (Rao et al., 1998) thereby neglecting research on the remaining lesser known forest bamboo species to some extent.

- Resource mapping has been done in this present study to get the total growing stock of bamboo in the region and the areas covered by it. The maps created will not only show the availability but also the distribution of various bamboo species across the entire district which will be helpful in the overall management of bamboo resources in the region.
- In the wake of climate change and global warming, proper scientific management of all natural forest resources including bamboosis the need of the hour as bamboo acts as an extremely potential carbon sink thus assist in mitigating climate change.
- Extensive fibrous root system of bamboo forest helps in soil retention and water conservation. Therefore, areas susceptible to landslips, plantation of bamboo species can be recommended for protecting land resources against landslide.
- People of the study area indiscriminately harvest bamboo shoots during season for vegetables, pickle making and fermentation. Proper resource management of bamboos thus would help in opening new avenues in understanding the carrying capacity of the bamboo forest in the study area.

5.3 Conservation of Biodiversity in IHR:

- The state of Nagaland falls under the Himalayan belt under which the district of Mokokchung has been chosen for the present study. The district is blessed with abundance of natural resources and the forest here belongs mostly to the community.
- Bamboo forests are conspicuous features of the study area and these forests run right from the foot hills to the top intermixed with few tree species. In the present study, 22 species of bamboo were recorded. Among them *B. alemtemshii*, *B. mokokchungeana* and *B. nagalandeana* are reported to be endemic to the area and hence their conservation is important in order to save these species against exploitation and from being endangered or extinct in the future.
- Farmers now a days are more focussed on monoculture of bamboo, cutting down the natural forests thereby disturbing the natural ecosystem. Most of the plantations are found in and around the arable lands and being largely cultivated for local utilization or for export. Monoculture will not only threaten other bamboo species and diversity but also are host and likely vulnerable to pest and diseases. Hence, mixed plantation should be encouraged to enhance biodiversity.
- Despite the growing importance of bamboo very few studies have been undertaken for conservation in the region. Public awareness should be spread especially in the village level to better understand the importance of biodiversity conservation and how to use the resources in a sustainable manner by not disturbing the ecosystem.

- Proper training and knowledge should be imparted to help them farm better. The local people need training in many of the cultivation practices including need for introduction, regeneration, utility items, harvesting technology, preservation etc.

5.4 Protection of Environment:

- **Bamboo as a substitute:** Bamboo can be used as an alternative for several other products. As the natural forest are depleting at a rate that is well past sustainable. Bamboo can play a vital role in maintaining the environment. Hardwoods are been harvested for making furniture which take about 30 to 40 years to attain maturity. The world is losing acres of forest land to deforestation. These hardwoods can be substituted by bamboo thereby protecting the forest that is left. Bamboo in the study area is locally accessible, cheap which can be substituted for flooring, reinforcement and roofing which is environmentally friendly. Bamboo products can also be substitutes for plastics materials.
- **Bamboo as greenhouse absorber:** Apart from timber substitution, bamboo is a powerful tool for capturing carbon dioxide. Some studies had shown that bamboo is capable of sequestering between 5 to 12 t Co_2/ha/year (Yuen *et al* 2017; Yiping *et al.* 2010). Thus, it plays a major part in climate change mitigation. Fast growing nature of bamboo which generally takes only about 3-4 years to attain its maturity are capable of effectively storing biomass carbon in their vegetative parts thereby tapping CO_2 until it is burned and decayed. The longevity of bamboo can be increased using proper preserving techniques. If proper management and studies are taken up it can enter the market for carbon trading which will also directly benefit the livelihood of the people.
- **Versatility:** As a versatile substitute for hardwood, it can replace wood in almost any application thereby protecting and saving the environment from being over exploited and decreasing the rate of timber consumption. A versatile plant just as the name suggest it is used as briquettes for fuel, in pulp and paper industry, chipboard, ply bamboo, flooring, roofing etc.
- **Bamboo as a tool for the soil and water conservation:** The roots of the bamboo are densely clumped which hold the upper layer of soil that prevents the top soil from water erosion and soil nutrient depletion. If planted in any slope area it holds the soil intact with its profuse root system thereby preventing landslides and also conserves water through deep percolation.
- **Bamboo and its little waste:** Once the bamboo is harvested, every part of the bamboo comes into use from roots, leaves, culm sheaths and stems. The leaves enrich the soil, it can be used as mulch and also helps retain moisture around the roots. Other parts of the plant are used for making several other products and it only limit to one's imagination.

5.5 Developing Mountain Infrastructures: NA

5.6 Strengthening Networking in IHR: NA

6 EXIT STRATEGY AND SUSTAINABILITY

6.1 How effectively the fellowship findings could be utilized for the sustainable development of IHR:

- The bamboo resource map so created along with its stock information in this present study will provide basic information of where about of the bamboos in a detailed manner. This will assist decision makers and the local authority to make sustainable use of these resources. However, since majority of the forest belongs to communities, strict rules may be placed by the Village Council members to have a sustainable harvest.
- Utilization pattern of the bamboo products has been documented in the present study. The documentation of the bamboo utilisation patterns would help in understanding the present usage and future scope and possibility of the bamboos in the region. Communities can be encouraged by introducing more value-added articles which will sustain them for their basic necessities. With the increase in demand the weaving community will also get their hands back to weaving that will help the rural people to uplift their livelihood.
- As already mentioned, this study also brings out the information regarding total growing stock of bamboo with different age classes. This way only the mature clums which is required maybe harvested while ensuring that sufficient numbers of culms are retained to nourish and support the young culms. This way their viable population will persist in nature and would supply continuous raw material for various socio-economic uses.
- In the study area, it was observed that during the emergence of bamboo shoots in the monsoon, young shoots are harvested extensively due to their high demand in the market. With well managed scientific method, harvesting of bamboo culms/shoots can be done in a sustained manner without harming the bamboo forest which otherwise adversely impacts the regeneration of bamboo forest. Harvesting practices will not only help in restocking but also improve the health of bamboo forest.

6.2 Efficient ways to replicate the outcomes of the fellowship in other parts of IHR:

The eastern IHR lies in the subtropical to temperate belt where we can find rich bamboo biodiversity in terms of its species and their abundance. In present scenario, bamboo is becoming an important component for plantation works to enhance forest carbon stock and local biodiversity. With the rise in global warming and climate change, people have become more aware of the importance of bamboo resources in carbon sequestration. Present investigation covered only a single district of the state for knowing the bamboo growing stock, diversity and its utilization pattern.

If the similar studies are replicated with more detailed studies in other part of the districts or states, chances are high to discover more new species as the NE is gifted with abundance of flora and fauna which is yet to be discovered. The specie-wise map generated in the present study will be very much helpful in the other part of the states to know the quantity of bamboo which can be a game changer for the bamboo community as we can see the demand is emerging and bamboo can be a supplement to meet the demands in a sustainable way.

At present, most of the information on bamboo is non-spatial therefore spatial bamboo information is very important in monitoring and management of bamboo resources. The spatial map created will help the planners in judicious utilization of bamboo resources and livelihood development for local inhabitants. Results from this present study can be replicated in other states of IHR as a reference for bamboo forest management.

Looking at utilization aspects, there are multiple uses of bamboo especially for IHR communities as our basic necessities are fulfilled by it. The IHR has diverse culture and every culture has its own unique uses. Documentation of utilization pattern is important as many of the traditional uses are diminishing. Thus, it is important to preserve traditional process and methods involving weaving by documenting it.

6.3 Identify other important areas not covered under this study, but needs further attention:

It is very difficult to detect bamboo when mixed with other species especially through remote sensing imaginary. Even more difficult is the shrubby bamboo that grows under the tree canopy. Study using higher resolution satellite images will provide detailed and accurate mapping of bamboo resources. It is very difficult and challenging to map bamboo because bamboos are often dispersed and mixed with other land-use and land-cover.

Site specific allometric equation for biomass estimation of the remaining bamboo species can be developed for accurate estimation of their total growing stock and carbon stock in the district.

Regeneration studies of different important tree species growing along with bamboo can be studied upon to prioritize species for conservation, propagation and their reintroduction to the wild.

Studies on diseases and pest of all the recorded bamboo species can be done for protection and maintenance of their natural population.

Hilly area often faces problem of land slip due to heavy rainfall during monsoon season. Experimental trials can be undertaken to select best bamboo species so as to assess their suitability in soil and water conservation in susceptible areas.

Standardization of propagating techniques for the endemic species can also be carried on for increasing their natural population.

Since morphological identification of bamboo species is tricky, database and identification DNA coding can be developed especially for all the recorded species.

6.4 Major recommendations for sustaining the outcomes of the fellowship in future:

- As it is evident that lives of the rural mass revolve around bamboo starting from their basic necessities from firewood to house construction. Thus, if any species become threatened then it will greatly affect them. Therefore, education should be imparted on sustainable use of bamboo stand. An inventory of natural bamboo stand resources which has been made in the present study can be used for management on a sustainable basis.
- Sustainable harvesting based on carrying capacity of the area should be followed. The only paper mill located in Tuli, Mokokchung district was shut down and one of the many reason is because of the extensive harvesting with no proper scientific cultivation and management which resulted in shortage of raw materials. Therefore, training on scientific cultivation and management should be given to the rural people of the region and awareness should be given for sustainable livelihood and rural development.
- A platform such as trade fair, exhibition etc. should be organized by the civil societies and government for promoting traditional bamboo crafts to showcase their eccentric crafts. This will not only create a market channel to give exposure to the young craftsmen to take up bamboo industry as livelihood option in the long run thereby reducing pressure on forests for timber.
- The villages are not well developed and unemployment is a major concern in the region. If proper skill development activities are introduced then people especially the youth can get involved. With the help of the government small units can be opened for bamboo-based industries for production and manufacturing of products which will give job opportunities and eradicate the desperate need for social and economic stability.
- As the region is hilly and many of the area are prone to landslides, cultivation of bamboo can be a good option. People should be encouraged to use the already available resources to mitigate the negative impacts of soil erosion. The roots of bamboo make the soil more stable because of its extensive root system thereby increasing the green cover. Plantation of bamboo species recorded in this study should also be encouraged in the degraded areas to bring in micro-environmental changes facilitating natural regeneration.
- Outcomes of this very research can only be sustained unless it is disseminated to the state forest department, local people, village headmen and other scientific communities. Villagers generally have the notion that bamboos are a material of construction only. Hence, awareness on bamboo used as potential plant for soil and water conservation, climate change mitigation, soil erosion prevention and for enhancing local biodiversity should be imparted amongst them.

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APPENDIX- 1a

BAMBOO SPECIES-WISE UTILIZATION SPECTRUM

Sl No.	UTILIZATION ASPECTS	BAMBOO SPECIES						
		Dendrocalamus hamiltonii	*Bambusa tulda*	*Bambusa balcooa*	*Schizostachyum dullooa*	*Dendrocalamus sikkimensis*	*Pseudostachyum polymorphum*	*Dendrocalamus longispathus*
1	Changpong (Storage for rice grains carried by bride to her husbands place, the basket has double-weaved design)	✓						
2	Chi-khumung (lidded tiffin basket used to carry cooked rice for midday meal in the field)	✓						
3	Makang (Used for keeping dry commodities)	✓						
4	Muluk with cover (to keep grains/vegetables)	✓						
5	Muluk (Jangko small)	✓						
6	Muluk (Jangko medium)	✓						
7	Muluk (Jangko big)	✓						
8	Muluk (to keep vegetable)	✓						
9	Tsu-shi (water is stored for emergency)				✓			
10	Poku (flat basket like wiith big holes)	✓	✓					
11	Angu-khu (fishing traps)	✓	✓					
12	Mertsung-small (used in garden)	✓						
13	Mertsung-big (used in fields)		✓					
14	Chisang (flat spoon for serving rice)		✓					

Sl No.	UTILIZATION ASPECTS	*Dendrocalamus hamiltonii*	*Bambusa tulda*	*Bambusa balcooa*	*Schizostachyum dullooa*	*Dendrocalamus sikkimensis*	*Pseudostachyum polymorphum*	*Dendrocalamus longispathus*
15	Chikok (spadle like used as curry spoon as well as for pestle)		✓					
16	Aousu (plate)	✓						
17	Mechipro (tongs)		✓					
18	Meprew (to blow air for fire)		✓					
19	Per (triangle shape winnower)	✓			✓			
20	Per (round shape winnower)	✓			✓			
21	Mosum (to store grain)						✓	
22	Chicken coop	✓	✓					
23	Nok pong (Machete holder)		✓					
24	Dust pan	✓						
25	Fence		✓		✓			
26	Taksep (for carrying fuelwood and vegetables)	✓						
27	Tsushikhu (shorter than taksep for carrying water)	✓						
28	Khu (Used in coalmine)	✓						
29	Mortar					✓		
30	Maruk (cup)	✓						
31	Liku (flat basket like without hole)	✓						
32	Menja (used for drying meat and other vegetables over fire)		✓					
33	Mura (stool)		✓					
34	Nokpang (Machate handle)		✓					
35	Chara (wall)				✓			
36	Atem (floor)				✓	✓		
37	Foot bridge		✓	✓				
38	Chong (warrior shield)							✓

Sl No.	UTILIZATION ASPECTS	*Dendrocalamus hamiltonii*	*Bambusa tulda*	*Bambusa balcooa*	*Schizostachyum dullooa*	*Dendrocalamus sikkimensis*	*Pseudostachyum polymorphum*	*Dendrocalamus longispathus*
39	Aket/Kettsu (cloth trunk)	✓	✓					
40	Penshi chi-small (common chi much lighter, both M & F carries it)	✓	✓					
41	Sentong/Oben chi-medium (used for carrying grain from the field, usually males carry it)	✓	✓					
42	Mozu chi-big (used during harvest, full paddy stem is harvested n kept)	✓	✓					
43	Shiba (Sieve to drain bamboo shoot water)	✓						
44	Yonglang (splints)	✓	✓				✓	✓
45	Balance	✓						
46	Soil erosion		✓		✓			
47	Dustbin	✓						
48	Pakti (mat)	✓			✓			
49	Kept in middle of grain for air to flow	✓						
50	Mat to cut meat	✓						
51	Mat used as fan	✓						
52	Spear		✓					
53	Machang	✓	✓	✓	✓			
54	Atsu (garden)	✓						
55	Ytsu (Chang-i-tsu) (Seive like for grains)	✓						
56	Pongsen-dry fish (tampong) (used to stored fermented fish)				✓			
57	Umbrella used in field	✓						
58	Water carrier bar		✓					

Sl No.	UTILIZATION ASPECTS	*Dendrocalamus hamiltonii*	*Bambusa tulda*	*Bambusa balcooa*	*Schizostachyum dullooa*	*Dendrocalamus sikkimensis*	*Pseudostachyum polymorphum*	*Dendrocalamus longispathus*
59	Pongdangsen (used for Cooking meat, rice etc. in bamboo)	✓	✓					
60	Apu (ladder)		✓	✓				
61	Mercisempong (mortar &pestel)		✓					
62	Shijok (Skewer like used for smoking meat)	✓	✓					
63	Sadem (to hold veg plants)		✓	✓	✓			
64	Cup holder		✓	✓				
65	Tsukten (place where the bamboo products are smoked)	✓	✓					
66	Bamboo vase	✓						
67	Fruits or chicken carrier (oval shap/pineapple shape)	✓	✓					
68	Taki (cup made of freshly cut bamboo)	✓						
69	Tzutapongsong (cup to fetch water)	✓						
70	Sarangkang (smaller than poku)	✓						
71	Tsukyatsu (used for shoving the grains while drying)	✓	✓					
72	Lakok (container to keep local brew)	✓						
73	Medem pong (smoke pipe)	✓						
74	Aju pong (smoke pipe)	✓						
75	Odi pong (smoke pipe)	✓						
76	Sungosenzukba (seive draining tea)	✓						
77	Bamboo flask (used in the field)	✓	✓					

Sl No.	UTILIZATION ASPECTS	*Dendrocalamus hamiltonii*	*Bambusa tulda*	*Bambusa balcooa*	*Schizostachyum dullooa*	*Dendrocalamus sikkimensis*	*Pseudostachyum polymorphum*	*Dendrocalamus longispathus*
78	Putsulen (Ao-chungli)/Fumuru (Ao-mongsen) (Stand to keep hot pot)	✓						
79	Casket- small basket to keep arrow during war (spikes)	✓						
80	Showpiece from the roots of bamboo	✓	✓	✓				
81	Pig sty	✓	✓		✓			
82	Esu (dry bamboo shoot)	✓	✓	✓	✓			✓
83	Etsuktsu (bamboo shoot water)	✓						
84	Etsuk (Fermented bamboo shoot)	✓						
85	Zukulak (fresh bamboo shoot)	✓	✓	✓	✓			✓
86	Zuku (only the tip portion is fermented)	✓						
87	Bamboo mat for sleeping	✓			✓			
88	Fuel wood	✓	✓	✓	✓	✓	✓	✓
89	bamboo used a split pipe in jungle (running water)	✓	✓		✓			
90	sipping straw						✓	
	Total	**63**	**39**	**9**	**17**	**3**	**4**	**5**

DOCUMENTATION OF UTILIZATION PATTERN OF BAMBOO IN THE STUDY AREA

Fig. A: Mertsung-small (Used in kitchen garden)

Fig. B: Mertsung-big (Used in fields)

Fig. C: Taksep (Used for carrying fuelwood and vegetables)

Fig. D: Different types of Angu-khu (Fishing traps)

Fig. E: Chikok (Spadle used as curry spoon/ as pestle)

Fig. F: Chisang (Flat spoon mostly used for serving rice)

Fig. G: Mechipro (Tongs)

Fig. H: Mercisempong (Mortar & pestle)

Fig. I: Maruk (Cups)

Fig. J: Salt container

Fig. K: Poku (Flat open basket like used in the fields)

Fig. L: Ytsü (Holes in the middle, used for sieving)

Fig. M: Liku (Flat open basket like, used for drying vegetables)

Fig. N: Ytsü (Small holes all around, used in the field for sieving)

Fig. O: Per (Triangle shape-Winnower)

Fig. P: Per (Round shape-Winnower)

Fig. Q: Mat used for cutting meat

Fig. R: Apu (Ladder)

Fig. S: Tsü-shi (Water stored for emergency use eg. When a house catches fire)

Fig. T: Boundary wall

Fig. U: Machang (An open space made by bamboo)

Fig. V: Atsü (Kitchen Garden)

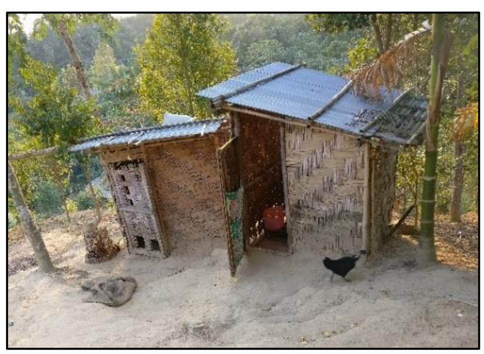


Fig. W: Bathroom made of bamboo

Fig. X: House made of bamboo

Fig. Y: Foot bridge

Fig. Z: Use of bamboo culm sheath for small plant sapling

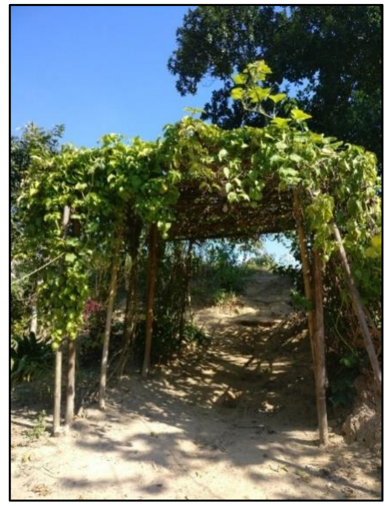


Fig. Aa: Sadem (Used for giving support to vegetable plant)

Fig. Ab: Dustbin

Fig. Ac: Atsütakdang (To hold the soil from erosion)

Fig. Ad: Menja (Three to four layers used for drying meat, vegetables and fuelwood)

Fig. Ae: Tsükden (Place where the bamboo products are placed for drying by smoking)

Fig. Af: Mozü chi-big (Used during harvest, the whole paddy stem is harvested and kept)

Fig. Ag: Sentong/Oben chi-medium (Used for carrying grain, usually males carry it from the field)

Fig. Ah: Penshi chi-small (Used for carrying grain both male and female carry it)

Fig. Ai: Nok (Machete)

Fig. Aj: Nokpang (Machete handle)

Fig. Ak: Nok pong (Machete stand)

Fig. Al: Balance

Fig. Am: Casket (Small conical shape basket to carry arrows during war)

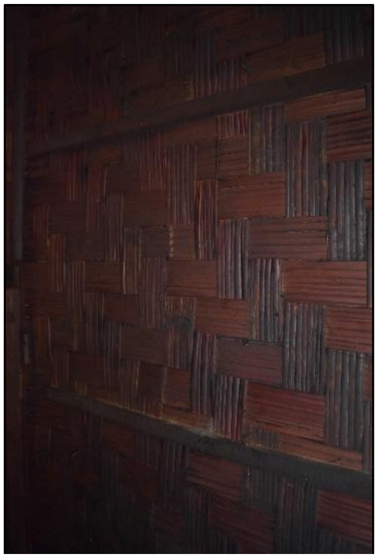


Fig. An: Ceiling

Fig. Ao: Floor

Fig. Ap: Kept in middle of grain for air flow

Fig. Aq: Mosum (Huge basket used for storing grains)

Fig. Ar: Ladok (Container to keep local brew)

Fig. As: Shiba

Fig. As(a) **Fig. As(b)**

(Two types of sieves: As(a) used while brewing alcohol & As(b) used to drain bamboo shoot water)

Fig: At: Chi-khumung (Lidded tiffin basket used to carry cooked rice for midday meal in the field)

Fig. Au: Umbrella used in the field

Fig. Av: Bamboo flask (Used for carrying tea to the fields)

Fig. Aw: Tsüshikhu (Used for carrying water)

Fig. Ax: Pakti (Mat)

Fig. Ay: Tsükyatsü (Used for shoving the grains while drying)

Fig. Az: Muluk (To keep grains/ vegetables)

Fig. Ba: Mat used as fan

Fig. Bb: Aousu (Plate)

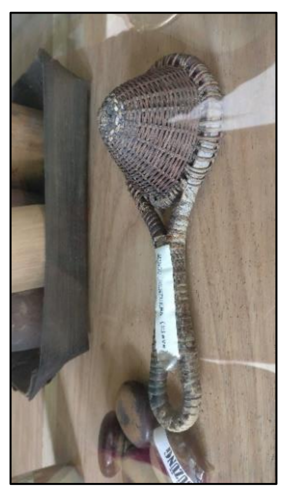


Fig. Bc: Sungosenzükba (Sieve for draining tea)

Fig. Bd: Shijok (Skewer like used for smoking meat)

Fig. Be: Tampong (Used for storing fermented fish)

Fig. Bf: Putsulen (Used for keeping hot pot)

Fig. Bg: Makang (Used for keeping dry commodities)

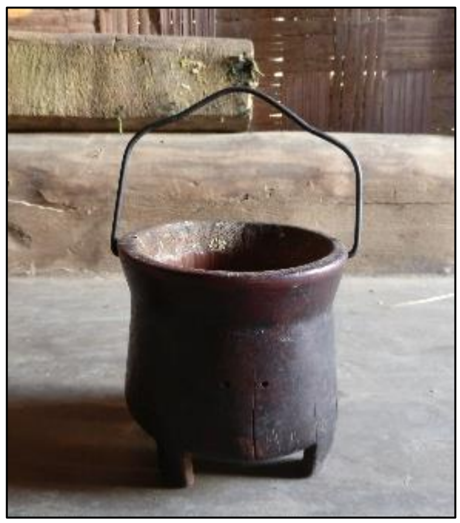


Fig. Bh: Mortar

Fig. Bi: Yonglang (Splints)

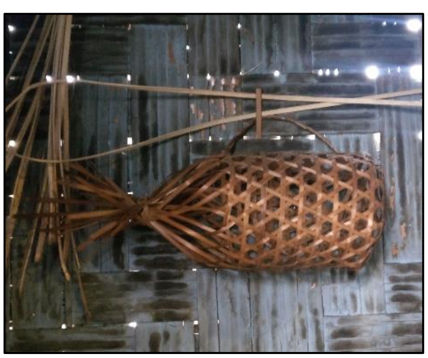


Fig. Bj: Used for carrying fruits/chicken during journeys

Fig. Bk: Chicken coop

Fig. Bl: Basket to keep vegetables

Fig. Bm: Dust pan

Fig. Bn: Water carrier bar

Fig. Bo: Smoking pipes

Fig. Bp: Mura (Stool)

Fig. Bq: Pongdangsen (Used for cooking meat,rice etc.)

Fig. Br: Cup and holder

Fig. Bs: Decorative basket

Fig. Bt: Khu (Used in coalmine)

Fig. Bu: Showpiece made from roots

Fig. Bv: Vase

Fig. Bw: Replica of head hunting, displayed outside Morung

Fig. Bx: Aket/ketsü (Cloth trunk)

Fig. By: Changpong (Storage for rice grains carried by bride to her husbands place, the basket has double-weaved design)

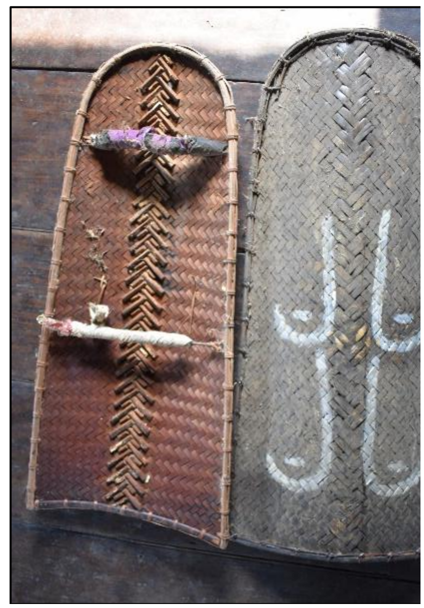


Fig. Bz: Chong (Warrior shield)

Fig. Ca

Fig. Ca

Fig. Ca

Fig. Ca

Fig.Ca: Züku (Fermented tip portion of bamboo), **Cb:** Etsük tsü (Bamboo shoot water), **Cc:** Etsük (Fermented bamboo shoot), **Cd:** Esü (Dried bamboo shoot)

PHOTOGRAPHS FROM FIELD WORK

Fig. A

Fig. B

Fig. C

Fig. A, B & C : Laying of sample plots

Fig. D

Fig. E

Fig. D & E: Measuring the girth of bamboo clumps

Fig. F: Measuring the girth of bamboo clumps

Fig. G: Harvesting of culms

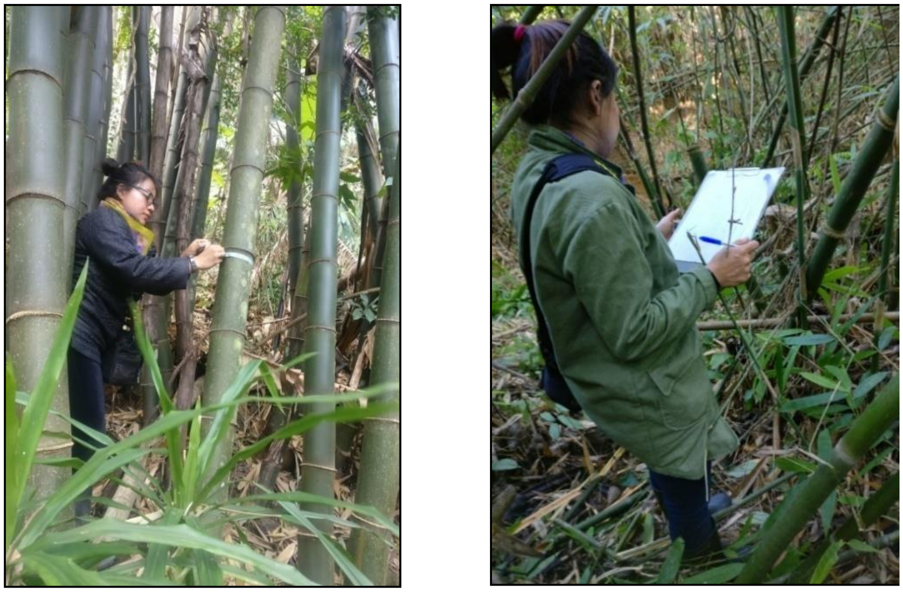


Fig. H: Measuring girth of culms and noting their measurments

Fig. I: Harvesting of culms

Fig. J: Cross cutting of green culms in every internode for fresh weight

Fig. K: Separating of branches and leaves for weighting fresh weight in the field

Fig. L: Weighting fresh weight of leaves

Fig. M: Weighting fresh weight of culms

Fig. N: Weighting sub-sample of leaf

Fig. O: Weighting sub-sample of culm

Fig. P: Weighting sub-sample of branch

Fig. Q: Noting down the fresh weight of samples

Fig. R: Sub-sample of culm from three section lower, middle and upper brought to laboratory for dry weight

Fig. S: Three components brought to laboratory for dry weight

Fig. T: Packing the sub-samples fro oven dry

Fig. U: Weighting of sub-samples until constant weight was obtained

PHOTOGRAPHS FROM SOCIO-ECONOMIC SURVEY












BAMBOO SPECIES RECORDED


Bambusa alemtemshii


Bambusa nagalandeana


Bambusa pallida


Bambusa tulda


Bambusa balcooa

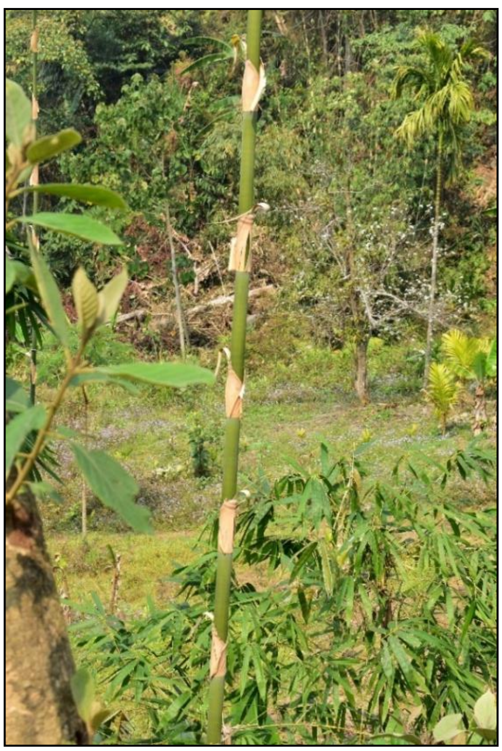
Dendrocalamus hamiltonii

Dendrocalamus hookeri

Dendrocalamus longispathus

Dendrocalamus sikkimensis


Oxythenanthera parvifolia




Melocanna baccifera

Schizostachyum dullooa

Pseudostachyum polymorphum

Appendix 2– Copies of Publications duly Acknowledging the Grant/ Fund Support of NMHS- **NA**

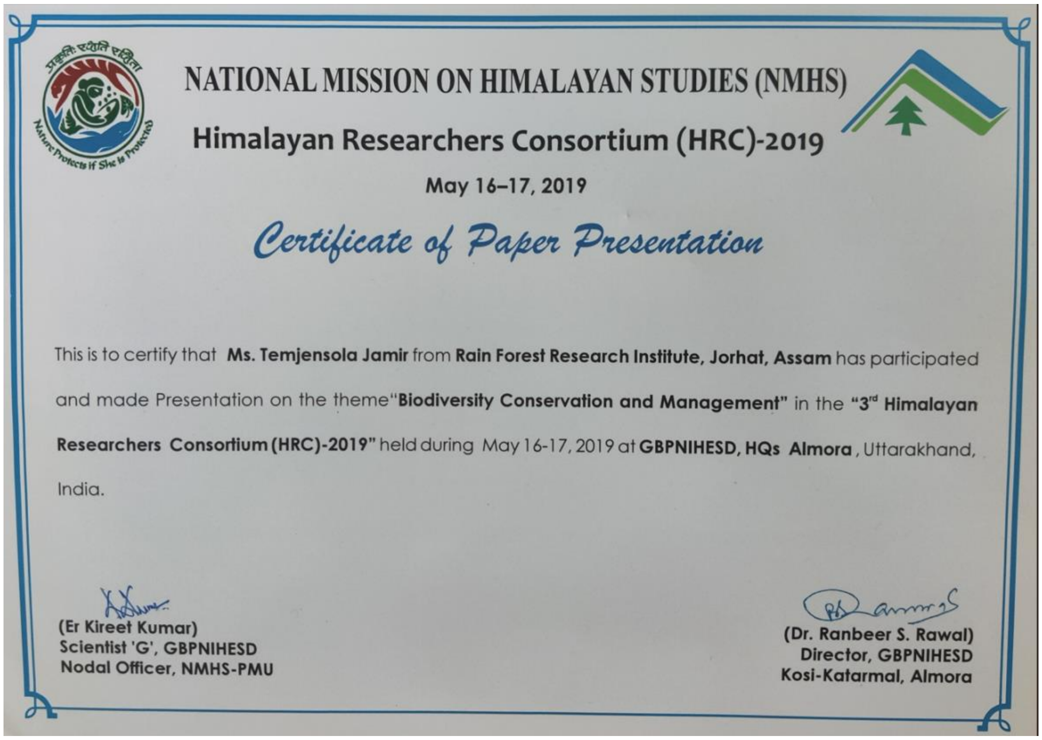
Fig: A

Fig: B

Fig: C

(Fig: A-C: Meeting with the local bodies disseminating knowledge on sustainable utilization of bamboo resources, information on scientific harvesting and its ecological significance).

PARTICIPATION CERTIFICATES



NATIONAL MISSION ON HIMALAYAN STUDIES (NMHS)

Himalayan Researchers Consortium (HRC)-2019

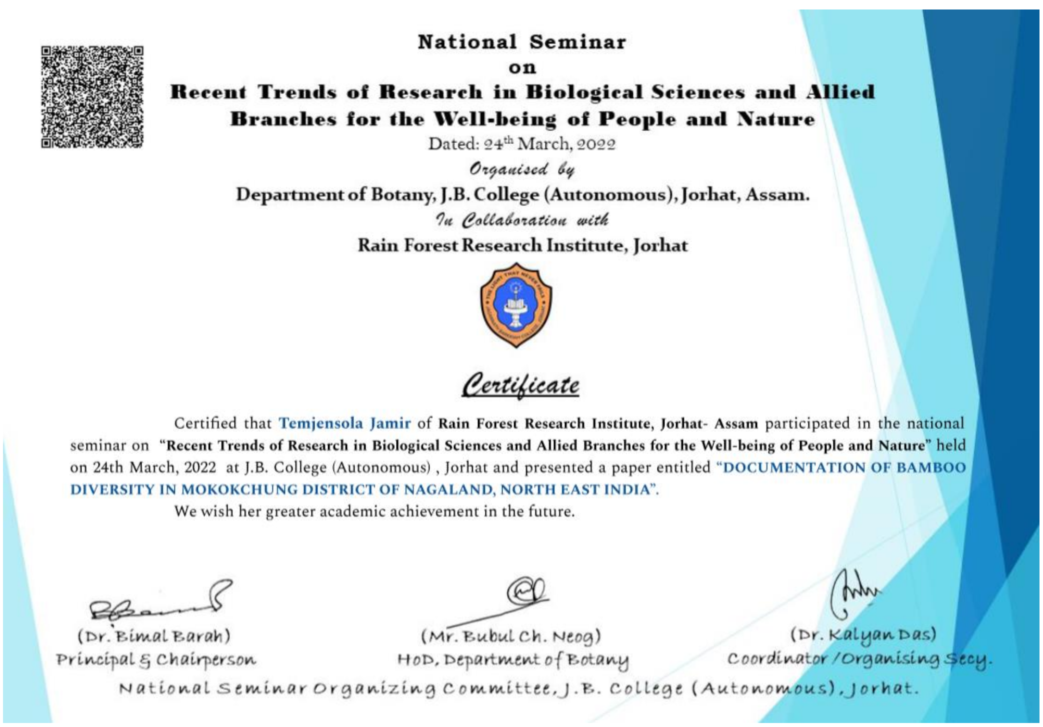
May 16–17, 2019

Certificate of Paper Presentation

This is to certify that **Ms. Temjensola Jamir** from **Rain Forest Research Institute, Jorhat, Assam** has participated and made Presentation on the theme"**Biodiversity Conservation and Management"** in the **"3rd Himalayan Researchers Consortium (HRC)-2019"** held during May 16-17, 2019 at **GBPNIHESD, HQs Almora**, Uttarakhand, India.

(Er Kireet Kumar)
Scientist 'G', GBPNIHESD
Nodal Officer, NMHS-PMU

(Dr. Ranbeer S. Rawal)
Director, GBPNIHESD
Kosi-Katarmal, Almora



National Seminar
on
Recent Trends of Research in Biological Sciences and Allied Branches for the Well-being of People and Nature

Dated: 24th March, 2022

Organised by

Department of Botany, J.B. College (Autonomous), Jorhat, Assam.

In Collaboration with

Rain Forest Research Institute, Jorhat

Certificate

Certified that Temjensola Jamir of **Rain Forest Research Institute, Jorhat- Assam** participated in the national seminar on **"Recent Trends of Research in Biological Sciences and Allied Branches for the Well-being of People and Nature"** held on 24th March, 2022 at J.B. College (Autonomous) , Jorhat and presented a paper entitled **"DOCUMENTATION OF BAMBOO DIVERSITY IN MOKOKCHUNG DISTRICT OF NAGALAND, NORTH EAST INDIA".**

We wish her greater academic achievement in the future.

(Dr. Bimal Barah)
Principal & Chairperson

(Mr. Bubul Ch. Neog)
HoD, Department of Botany

(Dr. Kalyan Das)
Coordinator /Organising Secy.

National Seminar Organizing Committee, J.B. College (Autonomous), Jorhat.

ARUNACHAL UNIVERSITY OF STUDIES

NRMSA 2020

WCM WORLD EDUCATION MISSION विश्व शिक्षा अभियान

NATIONAL CONFERENCE ON

NATURAL RESOURCES MANAGEMENT AND SUSTAINABLE AGRICULTURE

WITH REFERENCE TO NORTH-EAST INDIA

28 & 29 January 2020

CERTIFICATE OF PRESENTATION

Certified that

Prof./Dr./Mr./Ms. Temjensol A. Jamir of Rain Forest Research Institute has presented a paper (Oral/Poster) entitled "Bamboo Diversity .... North-East India" in the National Conference on "Natural Resources Management & Sustainable Agriculture With Reference to North-East India" during 28 & 29 January, 2020, Organized by Faculty of Agriculture Sciences, Arunachal University of Studies, Namsai, Arunachal Pradesh.

Dr. Chowlani Manpoong, Convener — Prof. K. Vasanthakumar, Chairperson — Prof. O.P. Sharma, Vice Chancellor

NABARD

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जवाहरनगर, खानापारा, गुवाहाटी -781022 (भारत)

NATIONAL INSTITUTE OF RURAL DEVELOPMENT & PANCHAYATI RAJ
NORTH EASTERN REGIONAL CENTRE
Ministry of Rural Development, Govt. of India
Jawaharnagar, Khanapara, Guwahati—781022, (INDIA)

This is to certify that

TEMJENSOLA JAMIR

has completed the Online International Training on

Bamboo for Rural Livelihood

conducted by

NIRDPR-NERC, GUWAHATI

in Collaboration with

INTERNATIONAL BAMBOO & RATTAN ORGANIZATION, CHINA

from 26.05.2020 to 29.05.2020

पाठ्यक्रम निदेशक / Course Director — CERTIFICATE ID: 9MDPHE-CE000084 — निदेशक / Director

Appendix 4 – List of New Products (utilizing the local produce like NTFPs, wild edibles, bamboo, etc.)- **NA**

Appendix 5 – Copies of the Manual of Standard Operating Procedures (SOPs) developed- **NA**

Appendix 6 – Details of Technology Developed/ Patents filed- **NA**

APPENDIX- 7

JOINING ORDER FOR JUNIOR PROJECT FELLOW (JPF) & EXPERIENCE CERTIFICATE OF THE PROJECT

वर्षा वन अनुसंधान संस्थान
RAIN FOREST RESEARCH INSTITUTE
भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद्
Indian Council of Forestry Research & Education
(पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय, भारत सरकार के अधीनस्थ एक स्वायत्त परिषद्)
(An Autonomous body under Ministry of Environment, Forest & Climate Change, Govt. of India)

No. GCR/2022/2-184/Vol.IX 1642 **Date: 18.08.2022**

TO WHOM IT MAY CONCERN

This is to certify that Ms. Temjensola Jamir worked as a Junior Project Fellow (JPF) in the NMHS funded project titled "Estimation of species wise bamboo resources using remote sensing and GIS and assessment of utilization pattern in Mokokchung District, Nagaland" under Dr. Dhruba Jyoti Das, Scientist-E of Rain Forest Research Institute, Jorhat from 04.07.2018 to 31.03.2021.

During the aforesaid period, Ms. Temjensola Jamir had performed tours to various places of Mokokchung district of Nagaland to collect field data. She was also engaged in preparing of various project related reports including analysis of field data.

She was found to be sincere, energetic and honest to her duties. She bears a good moral character and I wish her every success in future endeavors.

(Dr. Rajib Kumar Borah)
Group Coordinator (Research)

पोस्ट बॉक्स नं./ Post Box No. 126, जोरहाट (असम) / Jorhat (Assam)-785010, ई-मेल / E-mail: dir_rfri@icfre.org
फ़ोन/ Phone: +91-376-2305101 (कार्या./W), +91-376-2305102 (नि./R), +91-376-2305130 (फैक्स / Fax)

NMHS- BAM 1072 04/07/18

To,

The Director
Rain Forest Research Institute
Jorhat, Assam

Dated: 04/07/2018

Subject: **Application for joining NHMS project**

Respected Sir,

With reference to the letter No. GCR/2018/2-184/Vol.III/418, dated 22nd June, 2018. I would like to inform you sir that with effect from today i.e. 4th of July 2018, I am hereby joining the above mentioned project entitled "Estimation of species wise Bamboo Resources and Assessment of their utilization pattern in Mokokchung district of Nagaland, India" as Junior Project Fellow (JPF) in the Forest Ecology and Climate Change Division of Rain Forest Research Institute under the supervision of principal investigator Dr. Dhruba Jyoti Das, Scientist-E.

Therefore, I do accept this offer and would abide all the terms and conditions required for this project, kindly, accept my application for which I shall remain ever grateful to you.

Thanking You

Yours Obediently,
Temjensola Jamir

Copy to:

- Group Coordinator Research (GCR), RFRI
- Head of Forest Ecology and Climate Change Division, RFRI
- Dr. Dhruba Jyoti Das, RFRI, Principal Investigator

******

(Signature of HRA/HJRF/HPF)

(**NMHS FELLOWSHIP COORDINATOR**)
(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)
(Signed and Stamped)

Place: ………………..
Date: ……../……/……

APPENDIX-8

BAMBOO ENUMERATION & ANALYSIS FORM (CLUMP FORMING)

Sl.No.	Species	Clump Sl.No.	Clump diameter (cm)/ m	Clump size class	**Green Sound culm**										**Remarks**	**Green damaged culm**										Dry sound culms			Dry damage culms			Decayed culms	Total no. of culms
	Name				Current year' s	1-2 yr			2-3 yr			>3yr				Current year' s	1-2 yr			yr			>3yr										
						2<5 dbh/**6.28-15.7 girth**	5<8 dbh /**15.7-25.12 girth**	8+ dbh />**25.12 girth**	2<5 dbh	5<8 dbh	8+ dbh	2<5 dbh	5<8 dbh	8+ dbh			2<5 dbh	5<8 dbh	8+ dbh	2<5 dbh	5<8 dbh	8+ dbh	2<5 dbh	5<8 dbh	8+ dbh	2<5 dbh	5<8 dbh	8+ dbh	2<5 dbh	5<8 dbh	8+ dbh		
1.																																	
2.																																	
3.																																	
4.																																	
5.																																	
6.																																	

Date: / /

Signature of the surveyor

Name of the surveyor ……………………………

Date- / /

Bamboo diversity and its utilization pattern in Mokokchung district, Nagaland
Rain Forest Research Institute, Jorhat, Assam (ICFRE)

VILLAGE PROFILE

1. GENERAL INFORMATION:

Date of Survey	**Name of Village**		**Name of Range**
	Latitude(dd/mm/ss)	**Longitude**(dd/mm/ss)	**Altitude** (m)
GPS Data			

2.Village road:
( ) Kuccha ( ) Pucca ( ) Foot trail

3. Name of headman: ____________________________________ Age: _____

4. Contact no: _____________________________

5. Estimated number of households: ______________

6. Total land area currently under use by the community, other than homestead (in ha/bigha): _________
   6.1. Privately owned: ________
   6.2. Community owned: _________
   6.3. Open access: ___________

7. Total land area under bamboo resource (in ha/bigha) in the village: _____________________
   7.1. Estimated land area under wild/natural bamboo (in ha): ______________
   7.2. Estimated land area under cultivated/private bamboo (in ha): __________

8. Any charges or fees established by the community for collection of bamboo from wild: _______________

9. Season of bamboo collection: _______________

10. Bamboo species available earlier but very rare/not found nowadays: ______________________

Date-   /   /

QUESTIONNAIRE: ______________

Bamboo diversity and its utilization pattern in Mokokchung district, Nagaland

Rain Forest Research Institute, Jorhat, Assam (ICFRE)

---

2. GENERAL INFORMATION:

Date of Survey	Name of Village		Name of Range
	Latitude(dd/mm/ss)	**Longitude**(dd/mm/ss)	**Altitude** (m)
GPS Data			

3. SOCIO-ECONOMIC INFORMATION:

1. Name of Respondent:____________________________________ Gender: _____Age:_____

2. Contact no: _____________________________

3. Occupation/ Primary livelihood:

<table>
<tr><td colspan="3">1. Farmer</td><td rowspan="2">2. Livestock rearing</td><td rowspan="2">3. Govt. job</td><td rowspan="2">4. Craftsmen</td><td rowspan="2">5. Wage labour</td></tr>
<tr><td rowspan="2">Shifting cultivation</td><td rowspan="2">Terrace cultivation</td><td rowspan="2">Other agriculture</td></tr>
<tr><td rowspan="2">6. Business</td><td rowspan="2">7. Collection of Forest products</td><td rowspan="2">8. Private job</td><td rowspan="2">9. Others</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

4. Name of Head of household: _______________Relation with Respondent: ______________

5. Type of house (√):   Kachcha   Semi Pucca   Pucca

6. Type of family (√):   Nuclear   Joint

7. No. of family members :Adult Male _____ Adult Female _____ Children: Male _____ Female _____ Total _____

8. (i) Religion: _____________________________ (ii) Tribe _________________________

9. Average monthly income of family (Rs):

   ☐Less than 1000☐Less than 2,500☐2,500-5,000☐5,000-10,000☐10,000-15,000

   ☐15,000-20,000 ☐20,000-30,000☐30,000 or above

10. Livestock profile (Nos):

    (i) Cow______ (ii) Buffalo_____ (iii) Goats_____ (iv) Pigs_____ (V) Poultry: Chicken_____ Ducks _____

4. INFORMATION ON BAMBOO:

1. Bamboo species available in and around the house: ______________________

2. Mostly used bamboo: ______________________

7. Source of bamboo (√): ( ) Wild ( ) Home garden ( ) Plantation( ) other ________________

8. If purchased: Rate of each bamboo/culm:

Species	Present rate	Off season	5years back	10 years back

9. For what purpose the bamboo is collected? (Own use/sale/both own use and sale).

10. On an average, how many bamboo culms does a household member collect in a month/year? _________ culms. Culms collected during season _________ and during off-season __________

11. What is the maximum and minimum distance usually travelled to collect bamboo?
Minimum: __________km, Maximum: __________km.

12. Whether bamboo has increased/reduced in number: Increased/ decreased/ steady/ don't know.

4. INFORMATION ON COLLECTION, TRANSPORTATION FOR SALE AND SELLING PRODUCTS:

1. Where do you usually sell bamboo? (Door-to-door, by the street side/market place/more than one outlet).

2. How many bamboo culms did you sell? (Last) year.

3. How was bamboo transported from collection site to selling point? (Back/head load /animals/small truck/heavy truck).

4. What was the marketing cost of bamboo for:
   4.1 Transport __________
   4.2 Labour__________
   4.3 Other cost __________
   4.4 Total cost __________

5. If selling: Rate of each bamboo/culm:

Species	Present rate	Off season

6. Is bamboo trading a profitable business compared to other sources of income: (Y/N).

7. Bamboo products are produced by HH (partly/entirely/not at all) for sale.

8. If produced for sale:
   8.1 To whom were the products mainly sold? (Consumers directly/wholesalers/retailers).
   8.2 How much does the HH earn from sale of bamboo products?_____________(Month/year).

9. Do you produce more than the demand? (Y/N)

5. UTILISATION PATTERN:

1. Use and rate of extraction

Use	**Bamboo spp.**	**Species wise quantity/year ***	**Age**	**Use**	**Bamboo spp.**	**Species wise quantity/year**	**Age**
Agarbatii sticks				Fishing			
Furniture				Pulp and paper			
Handicrafts				Medicinal Uses			
Constructions				Fodder			
Fencing				Charcoal			
Fuel wood				Erosion control			
Cutlery				Other			
Edible shoots							
Mats							
Ornamental purposes							

***Species wise quantity (in no. of poles)**

2. Have you ever bought bamboo products? (Y/N)

3. If yes, what are the bamboo products:

4. What bamboo products do you have in your home?

5. How do you compare bamboo product to similar product made from other materials?
   - 5.1. Attractiveness: Inferior/comparable/superior.
   - 5.2. Durability: Less/comparable/more.
   - 5.3. Price: Less/comparable/more.
   - 5.4. Others:

6. What is the durability of bamboo in different uses:
   - i. Construction _________
   - ii. Handicrafts_________
   - iii. Furniture _________
   - iv. Fencing _________
   - v. Mats _________

7. Do you treat bamboo before use? Y/N

8. If so, what kind of treatments?

9. Ranking of major bamboo species based on utilization:

Rank	**Species**
1	
2	
3	
4	
5	
6	
7	

6. GOVT. INTERVENTION:

1. **What kind of Govt. intervention you want for bamboo sector in your area**

Remark: **Sign. of investigator**
