Scoping and Feasibility Studies of Bamboo Plantation for Implementation of REDD+ Activities in the North Eastern States of India

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On behalf of
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
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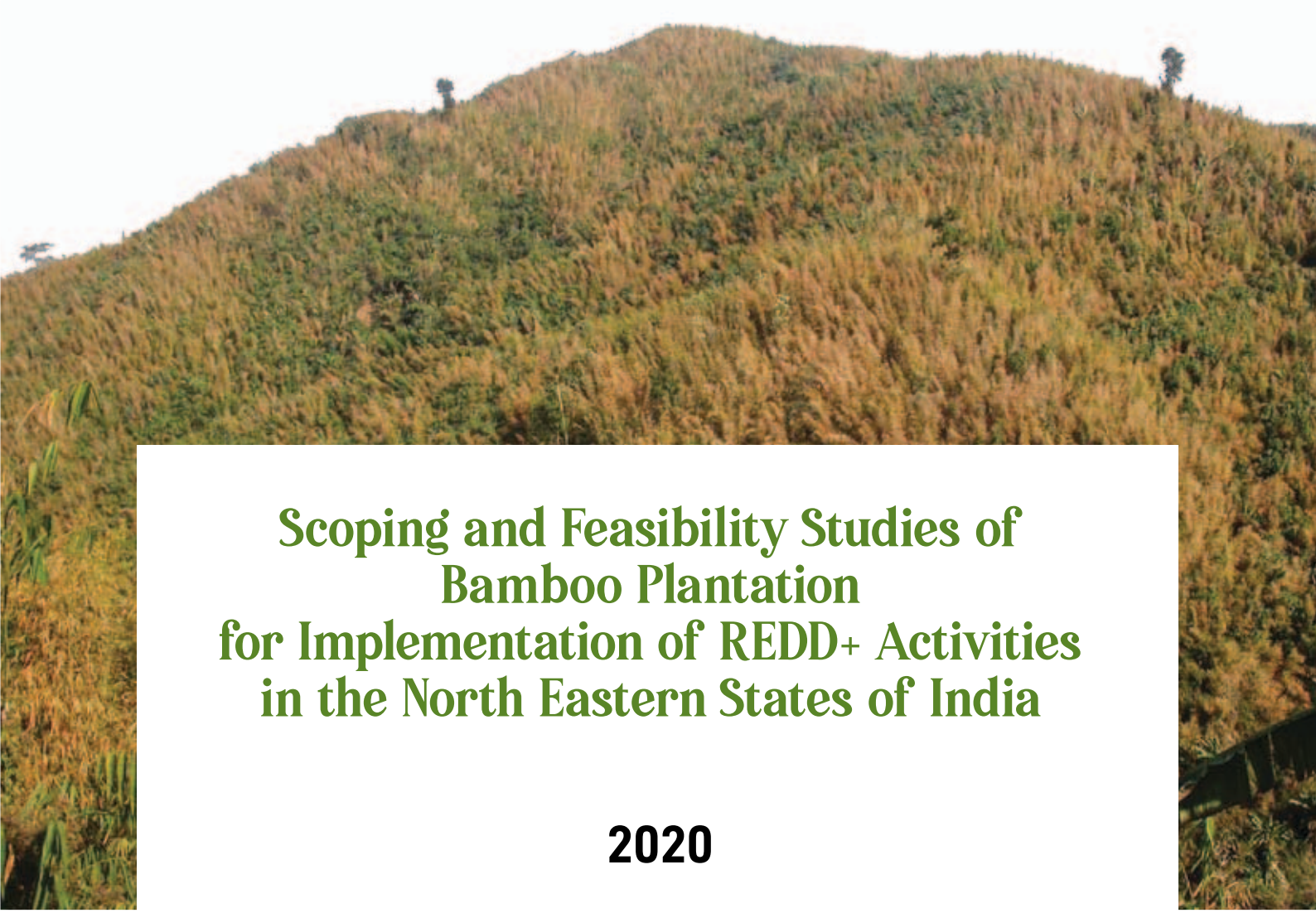

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Indian Council of Forestry Research and Education

(An Autonomous Body of Ministry of Environment, Forest and Climate Change, Government of India)

P.O. New Forest, Dehradun – 248006 (INDIA)

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CONTENTS

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EXECUTIVE SUMMARY

Land is source and sink of carbon dioxide due to anthropogenic and natural drivers. Global models estimate net carbon dioxide emissions of 5.2 ± 2.6 $GtCO_2eq\ yr^{-1}$ (likely range) from land use and land-use change during 2007–2016. Agriculture, Forestry and Other Land Use (AFOLU) activities accounted 23% (12.0 ± 2.9 $GtCO_2eq\ yr^{-1}$) of total net anthropogenic emissions of greenhouse gases (IPCC, 2019). Reduction in the emissions from the forest and land use sector is an efficient way out to stabilize and reduce the further increase of the atmospheric concentration of CO_2 to mitigate the impacts of climate change. REDD+ is an important climate change mitigation mechanism in developing countries agreed to the Country Parties of UNFCCC. Implementation of REDD+ activities will provide financial incentives in the form of result-based payments to the developing countries.

Bamboo is one of the key non-timber forest produces which has huge potential to provide ecological and socio-economic benefits. It is also known as "poor man's timber" which is an impending substitute of expensive woods. The engineered product of bamboo is a change agent for poverty alleviation and simultaneously bringing biodiversity conservation, land restoration apart from carbon sequestration.

Surveys were conducted in the Mamit and Aizawl districts of Mizoram for understanding the horizon of bamboo functions in terms of its scope and feasibility in implementation of REDD+ activities. SWOT analysis has elucidated the scoping of bamboo and feasibility of bamboo plantations for implementation of REDD+ activities in North Eastern states of India and emphasized different aspects to bridge the gap between expected and observed potential of bamboo and realize the opportunity to be derived from implementation of REDD+ activities. During the survey, it was found that *Melocanna baccifera* (locally known as Mautak) is the most preferred and important bamboo species by villagers of the Mamit District of Mizoram due to its excellent properties and its availability. The most common traditional usages of bamboo are flooring in house construction, mizo hut, reinforced concrete construction, bamboo hut, drained water harvesting pipe etc. *Melocanna baccifera* (Mautak), *Melocalamus compactiflorus* (Sairil), *Dendrocalamus hamiltonii* (Phulrua), *Dendrocalamus longispathus* (Rawnal) and *Bambusa tulda* (Rawthing) are the most preferred species by the artisans in Mizoram and are commercially important. Moreover, a bamboo policy at national level needs to be formulated to strengthen the bamboo sector in India. Among North Eastern States of India, four states viz Assam, Mizoram, Nagaland and Tripura have formulated their state bamboo policies in

2019, 2002, 2004, 2001 respectively for development of bamboo and enhances the conservation of bamboo plantations. In North Eastern states of India, as per three categories of forest cover, the open forest category covers 67771 sq km and contributes 40.53% in total forest cover of North Eastern states of India. The scrub (forest land <10 % canopy density) is 3155 sq km. The degraded area has shown a cumulative increase of 0.53 million hectare of degradation in seven sister states between two time periods (2003-05 and 2011-13) as per Desertification and Land Degradation Atlas of India, 2016. This brings a good opportunity to increase the area under bamboo plantations. The state policies have a common vision with the objective of realizing the potential of bamboo in terms of economic, social and environmental benefits. The utilization of bamboo resources along with its sustainable development using scientific management practices encouraged in all the state policies of the four states. This is in well alignment with REDD+ mechanism to address the drivers of deforestation and forest degradation and parallelly provide green employment with enhanced green skills. On the basis of scoping and feasibility studies, it can be concluded that bamboo plantations have wide scope in implementation of REDD+ activities in the North Eastern states as bamboo species have potential to sequester atmospheric carbon dioxide at the faster rate besides providing the livelihood opportunities to the local communities.

1

INTRODUCTION

Role of forests is irrefutable in climate change mitigation. The growth of forest resources is an indicator of socio-economic conditions of forest dependent communities. The design of REDD+ programme has an influential role to play holistically in forest sector of developing countries. It is considered as an important mechanism under the United Nations Framework Convention on Climate Change (UNFCCC) aimed at mitigating climate change. Forest is known to be an important sector to contribute in climate change mitigation by four ways such as (i) increase in forest area through reforestation (ii) increase in carbon density of existing forests at both stand and landscape levels (iii) sustainably managing forests for harvesting forest products and (iv) reducing emissions from deforestation and forest degradation (GOFC-GOLD, 2010).

Bamboo is a widely distributed grass in the tropical, subtropical and temperate climatic domains. According to FAO (2020), 23 countries indicated that they had bamboo resources out of 132 countries and total estimated bamboo resources in these countries is estimated to be 35.0 million hectare, of which 24.9 million hectare (71 percent of the total bamboo area) is found in Asia. It is not only recognized as an ideal economic investment but also has an enormous potential of providing solutions to environmental and socio-economic problems. It is also known to be fastest growing plant in the world and covers 16 million hectare in India, and North Eastern states of India constitutes 32.71% bamboo bearing area (FSI, 2019). Its biological characteristics make it a perfect tool for solving many environmental problems, such as erosion control (Austin *et al*., 1970) and carbon dioxide sequestration. It has an extensive shallow rhizome-root system and accumulates leaf mulch which serves as an efficient agent in preventing soil erosion and conserving moisture, reinforcement of embankments and drainage channels, etc. Due to its mechanical properties like strength, light weight and flexibility, it is preferred as a viable alternative to tropical timbers that typically supply for the furniture and building materials industries (Ben-zhi *et al*., 2005). There are nearly 1500 species under 87 genera of bamboos growing worldwide, and India is home of about 125 indigenous species and 11 exotic species of bamboo from 23 genera and is abundantly found in deciduous and semi-evergreen forests of North Eastern states of India and tropical moist deciduous forests of Northern and Southern India. The major bamboo genera found in

India are *Arundinaria*, *Bambusa*, *Chimonobambusa*, *Dendrocalamus*, *Dinochola*, *Gigantochola* etc. North Eastern states and West Bengal accounts for more than 50% of bamboo resources of the country (ICFRE, 2017).

Bamboo holds a fundamental part for the livelihoods of people from North Eastern states of India. Its usage varies from home consumption, as a raw material for household utensils and farm tools to building material for shelters, fences, bridges, fish pens, or even water pipes. The products of bamboo have high value in use.

REDD+ mechanism has been underlined as an effective solution for climate change and widely known for providing mitigation actions. The concept of deforestation and forest degradation was focused more with the development of REDD+ mechanism. Addressing the drivers of deforestation and forest degradation are necessary to support the emission reducation from deforestation and forest degradation. REDD+ mechanism also offers incentives for developing countries to reduce emissions from forested lands and invest in low carbon paths to sustainable development (CFI, 2006). An emerging issue for developing countries is addressing the drivers of the forest degradation than deforestation. Moreover, during forest degradation there is no change in land use but has a high chance of conversion or getting deforested and has a high tendency to be converted into another land use. In view of this, bamboo presents a quintessential alternative to achieve first two activities of REDD+. Bamboo presents a promising alternative to products produced by silvicultural forestry (Hunter, 2002). Bamboos have socio-economic and ecological values and its management can provide benefits on a local, national and global level through livelihood, economic and environmental security for many millions of the rural people (Nath *et al*., 2009). Bamboo is considered as fastest growing and high yielding plant natural resource. Bamboo provides multiple applications such as vessels, fences, poles, and musical instruments like flute to food and fodder. In addition to this, bamboo ropes, mats, baskets, fishing nets, ladders, fans, brooms, lamps, thatching and roofing, bows and arrows, handicrafts, and toys are quite common among rural communities. Moreover, chemical products like beer, energy drink, air freshener, and deodorizer add value to bamboo culms. Bamboo has a potential to diversify the income of smallholder farmers particularly women and provide value addition to bamboo products for its export at a global level. This can bring resilience in the livelihoods and ecosystems in India against the adverse effects of uncertainty generated due to anthropogenic activities and climate change.

Role of Bamboo Plantation in achieving SDGs

Bamboo plantation has a potential in providing success towards achieving Sustainable Development Goals (SDGs). The contribution of bamboo in achieving Sustainable Development Goals can be highlighted for Goal 1 (No Poverty), Goal 7 (Affordable and Clean Energy), Goal 8 (Decent Work and Economic Growth), Goal 11 (Sustainable Cities and Communities), Goal 12 (Responsible Consumption and Production), Goal 13 (Climate Action) and Goal 15 (Life on Land).

In India, bamboos are widely distributed, especially in semi-dry and dry zone along plains and hilly tracts, usually up to an altitude of 4500 meters. China, and Myanmar together constitute ~ 80% world's bamboo forest. Although 45% of the world's bamboo production is shared by India, its share in global market is only about 4.5% (Mehra and Mehra, 2007). North Eastern states of India covering a major portion and diversity of bamboo species, and are popularly also known as "Bamboo Paradise of India" (Goyal and Brahma, 2014). Policy based approach is the initiating step to identify and break the barrier to uptake the utilization of bamboo and realize the benefits derived from REDD+ mechanism. Ministry of Environment, Forests and Climate Change, Government of India on 5th January 2018 has amended the Indian Forest Act, 1927 and introduced the Indian Forest (Amendment) Act, 2017. The act amends section 2, clause (7) of the Indian Forest Act, 1927 by omitting the word 'bamboos' (belonging to grass family *Poaceae*) from the earlier definition of trees which included palms, stumps, bamboos, brush-wood and canes, thereby dispensing with the requirement of felling/ transit permit for its economic use by farmers in non-forest areas.

This amendment will help to encourage bamboo plantation and domestic production among farmers which will eventually contribute to enhanced economic growth, increased green cover as well as bring reforms in bamboo sector. This act will help to use 12.6 million hectares of cultivable waste lands by planting suitable bamboo species and hence will promote income generating opportunities among people especially in north-eastern parts and central parts of the country. It has also stated that bamboo grown in the forest areas shall continue to be governed by the provisions of Indian Forest Act, 1927.

The major objective behind the amendment is to promote cultivation of bamboo in non-forest areas to achieve twin objectives of increasing the income of farmers and also increasing the green cover of the country. The act consolidates the laws relating to forests, transportation of forest-produce and the duty to be imposed on them.

In view of the importance of bamboo sector in India, National Bamboo Mission was launched in 2006-07

by the Department of Agriculture and Co-operation, Government of India with the objective to uplift the socio-economic condition of the poor villagers by introducing large scale bamboo production in rural areas so that poor villagers would get direct benefits of using the bamboo and its products. Later it was subsumed under Mission for Integrated Development of Horticulture during 2014-15 and continued till 2015-16. In 2018, a restructured National Agroforestry and Bamboo Mission was approved by the Government of India and currently is under implementation. The main aim is to support the development of the entire value chain of the bamboo sector starting from planting material, plantation, creation of facilities for collection, aggregation, processing marketing, micro, small & medium enterprises, skill development and brand building initiative in a cluster approach mode. This will contribute to doubling of farmers' income and also generate more employment opportunities for skilled and unskilled workers, especially youths in rural areas. It aims to provide supplement farm incomes to farmers and help to build strong linkage between farmers (producers) and industry. For sustainable management of bamboo with all forward and backward linkages, National Bamboo Policy as an inclusive framework need to be framed on a national basis.

2

OVERVIEW OF BAMBOO RESOURCES OF NORTH EASTERN STATES

North Eastern states mainly consists of the so-called seven sister states of India viz Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. Agriculture is the main occupation of the local community in North Eastern states and practices 'Jhum or shifting' cultivation in which they grow cereals, vegetables, and fruits etc. The forest cover of North Eastern States of India is 1,67,199 sq km and contributes 65.54% forest cover to geographical area (FSI, 2019). The open forest category covers 67771 sq km of North Eastern States and contributes 40.53% in total forest cover of North Eastern states of India. The scrub (forest land <10 % canopy density) covers an area of 2848 sq km.

North Eastern states of India is geographically nestled in one of the most biodiversity rich regions of the world and is included in 18 global biodiversity hotspots. Bamboo is valuable renewable resource which is referred as 'Green Gold' rather than 'Poor Man's Timber and is found in plenty with a huge economic potential. North Eastern states of India are known for its high diversity of bamboo resources. High diversity of bamboo resource plays a significant role in the food and nutritional security of the tribal population of North Eastern states of the country (Solanki *et al*., 2003).

Bamboo species are fast-growing woody grasses with an extensive underground network of rhizomes and fibrous roots. The growth form of bamboo varies from a few centimeters to 35 m height with large, medium sized to thick, sometimes thin-walled culms. The high growth rate (30-100 cm daily during the season of growth), which can grow as tall as 36 m and diameter between 1 and 30 cm, makes it a highly renewable resource. Due to its high growth rate, it can achieve its full height in a period of only 2 months with low weight and high strength properties (Ribeiro *et al*., 2017). The broad shallow rhizome-root system and its accumulated leaf mulch make it a splendid material to conserve soil and retain moisture. It is found to be an excellent source as carbon sink and effective solution for mitigating climate change (Bhalla *et al*., 2008).

More than 50% of the bamboo species occur in North Eastern states of India (Rai and Chauhan, 1998). The maximum number of bamboo species are found in the deciduous and semi-evergreen forests of the North Eastern states and the tropical moist deciduous forests of Northern and Southern India (Loushambam *et al*., 2017). The North Eastern states of India harbour nearly 90 species of bamboos out of which 41 species are endemic (Loushambam *et al*., 2017). In India, 26 bamboo species are reported as rare and endangered, out of which 12 species are reported from North Eastern states (Bahadur and Jain, 1981; Biswas, 1988).

North East India is known as Bamboo Queen of India. The bamboo species widely found in the tropical forests of North Eastern states are from the genera of *Bambusa*, *Dendrocalamus*, *Melocana* and *Neohouzeaua*. In the subtropical forests, the bamboo species found belong to the genera of *Chimonobambusa*, *Dendrocalamus*, *Neohouzeaua*, *Pseudostachyum*, *Teinostachyum* and *Thamnocalamus*. In temperate type of vegetation genera like *Arundinaria*, *Chimonobambusa*, *Semiarundinaria* and *Thamnocalamus* are found. Whereas in alpine zone very few genera like *Arundinaria*, *Pleioblastus* and *Thamnocalamus* are found. In the higher altitudes, bamboos are usually found in the moist valleys, sheltered depressions, along streams, moist deciduous forests, wet temperature forests and alpine coniferous forests. Under different bio-climatic regions bamboo species is found naturally as well as in cultivated form. Bamboo dwindles into under shrubs in temperate regions and at greater altitudes, some species look almost like grasses (Cajee, 2018).

North Eastern states has 20.52% of the bamboo bearing area of its geographical area and 38.80% equivalent green weight of culms in recorded forest area of the country (FSI, 2019). However, the area covered by bamboo in North Eastern states has decreased from 2011 to 2019 (Figure 1). The status of bamboo bearing area of North Eastern states for the year of 2011, 2017 and 2019 are depicted in Figure 2. The details of bamboo bearing area in the North Eastern states under different classes are given in Table 1.

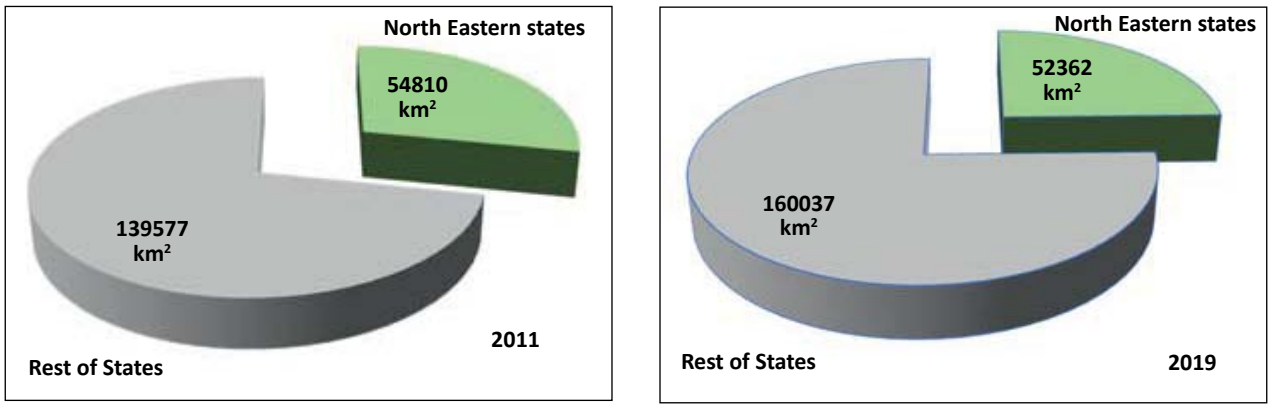
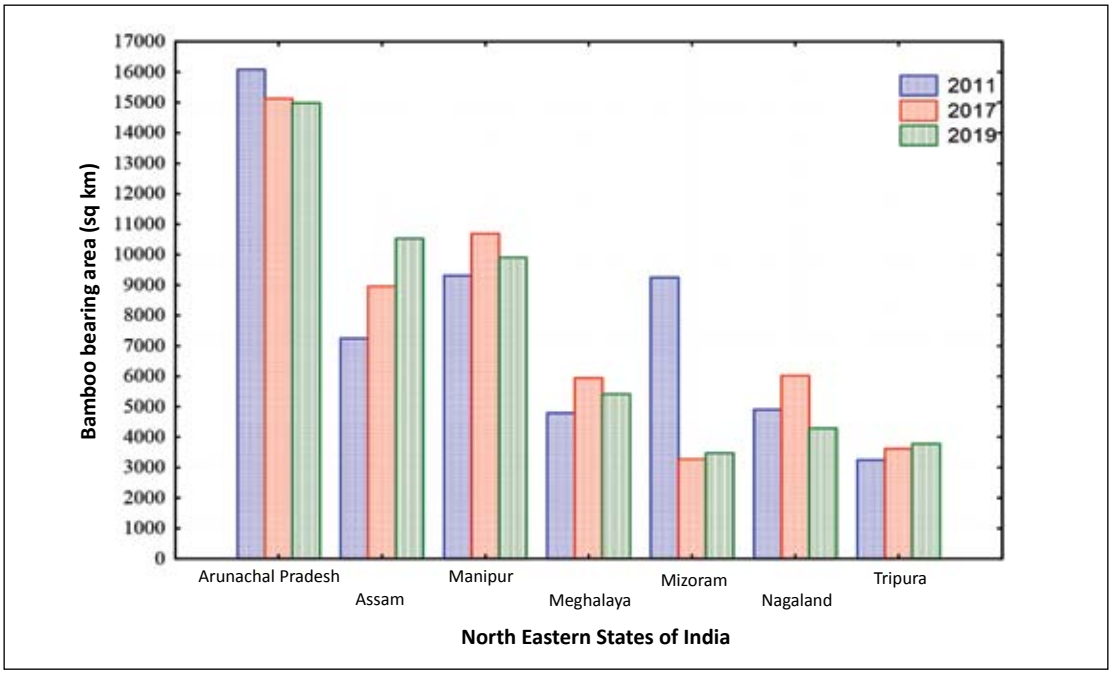


Figure 1. Bamboo bearing area of North Eastern States



(Source: FSI, 2011, 2017, 2019)

Figure 2. Status of bamboo area for the period of 2011, 2017 and 2019

Table 1. Bamboo bearing area (sq km) under different classes for North Eastern states

S.No.	States	Pure bamboo	Dense	Scattered	Bamboo present but clumps completely hacked	Regeneration crop	Total bamboo bearing area
1	Arunachal Pradesh	417	3389	10904	0	271	14981
2	Assam	204	2350	7664	0	307	10525
3	Manipur	0	1383	6862	995	663	9903
4	Meghalaya	140	467	4803	0	0	5410
5	Mizoram	0	1370	2106	0	0	3476
6	Nagaland	227	1137	2730	75	115	4284
7	Tripura	20	617	3146	0	0	3783
	Country's total	**4332**	**30575**	**102139**	**8260**	**14731**	**166037**

(Source: FSI, 2019)

Among North Eastern States, Arunachal Pradesh (14981 sq km) has the maximum bamboo bearing area followed by Assam (10525 sq km) and minimum is found in Mizoram (3476 sq km) in Mizoram (FSI, 2019). There was decrease in 1257 sq km observed between two time period from 2017 to 2019. The annual production of bamboo in India about 14.6 million tonnes and annual yield varies from 1 to 3 tonnes per ha (ICFRE, 2017). As per India State of Forest Report (FSI, 2019), state wise number of estimated culms in recorded forest area of north east states is given in Table 2.

Table 2. Estimated culms (in million) in recorded forest area of north east states of India

S.No.	States	Green culms		Dry culms		Decayed culms		Total		Total equivalent green weight (000' tonnes)
		2017	2019	2017	2019	2017	2019	2017	2019	
1	Arunachal Pradesh	3121	4869	637	512	290	388	4048	5769	27932
2	Assam	1848	3082	387	466	217	281	2452	3829	24064
3	Manipur	1772	843	338	205	230	78	2340	1126	7754
4	Meghalaya	1002	1148	191	188	130	185	1323	1521	12323
5	Mizoram	543	863	103	134	70	77	716	1074	8812
6	Nagaland	985	2289	188	98	128	157	1301	2544	20547
7	Tripura	604	963	115	88	78	59	797	1110	6295
Total of North Eastern States		**9875**	**14057**	**1959**	**1691**	**1143**	**1225**	**12977**	**16973**	**107727**
India's total		**20711**	**29358**	**5374**	**6761**	**2018**	**3335**	**28103**	**39454**	**277587**

(Source: FSI, 2019)

Utilisation of bamboo as a resource: Bamboo is a versatile plant group in adaptability and utility. Bamboo can be used as young as 30 days old bamboo shoots are used as food, shoots between 6-9 months are suitable for basketry, 2-3 years old culms are useful for laminates and boards and 3-6 years old culms are used for construction (Pandey and Shyamasundar, 2008). It is also used as a raw material for pulp and paper industries, besides providing subsistence and livelihood to a vast rural population. Bamboos are used for manufacturing a wide range of items like furniture, trays, baskets, winnows, lampshades, fishnets, flutes, fans, mats, hats, flooring, lanterns, decoration items, pulp, plywood, activated charcoal, etc. More than 1,500 products exist, which are known to be made of bamboo. This brings the demand of bamboo raw material in small and medium scale enterprises due to ease of production. Utilization of bamboo in North Eastern states of India is given in Table 3.

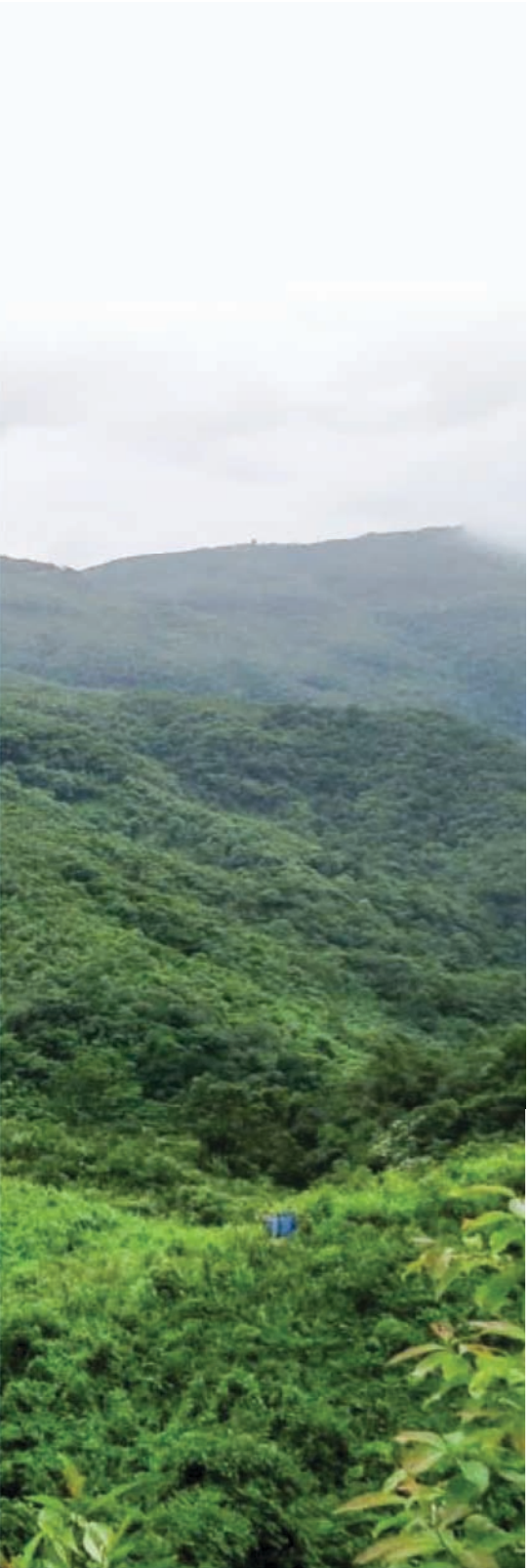
Table 3. Utilisation of bamboo in North Eastern states of India

S.No.	States	Common uses of bamboo species
1.	Arunachal Pradesh	Construction, scaffolding, fencing, flooring, walling etc, raw material for pulp and paper, food item, handicrafts, musical instruments furniture, baskets, mats, agricultural implements, weapons.
2.	Assam	Construction, scaffolding, fencing, flooring, walling, ornamentals, raw material for pulp and paper, food item, handicrafts, musical instruments furniture, etc.
3.	Manipur	Construction, scaffolding, fencing, flooring, walling, raw material for pulp and paper, food item, handicrafts, musical instruments furniture, etc.
4.	Meghalaya	Construction, scaffolding, fencing, flooring, walling, ornamentals, raw material for pulp and paper, food item, handicrafts, musical instruments furniture, baskets, mats, water pipes, water pitchers, food containers.
5.	Mizoram	Construction, scaffolding, fencing, flooring, walling, raw material for pulp and paper, food item, handicrafts, musical instruments furniture, etc.
6.	Nagaland	Construction, scaffolding, fencing, flooring, walling, ornamentals, raw material for pulp and paper, food item, etc.
7.	Tripura	Handicrafts, musical instruments furniture, baskets, mats, etc.

(Source: Cajee, 2018)

3

SCOPING OF BAMBOO FOR IMPLEMENTATION OF REDD+ ACTIVITIES IN NORTH EASTERN STATES



Bamboo has an extensive commercial use due to its versatile natural resource. It is used to produce a wide variety of household products and is also used in construction, agricultural applications, packing industry, etc. Utilizing bamboo as a source of raw material provide opportunities for income generation and employment. Apart from this, bamboo sector has also added up a new dimension through carbon mitigation process and plays an important role in carbon cycle other than providing food security. Bamboo-based land use system provides nature-based solutions to promote judicious land management practices and bring resilience from climate change impacts. The high annual carbon accumulation rates (2–14 Mg ha^{-1} yr^{-1}) suggest the potential for successful carbon farming using bamboo (Sileshi and Nath, 2017).

Scoping study is designed to understand the potentialities of bamboo plantations in implementation of REDD+ activities. Field surveys were conducted in the Mamit district of Mizoram (project area under REDD+ Himalaya Project) which consists of 12 villages. Demographic details of the project area are given in Table 4.

Table 4. Demographic details of the project area

S.No.	Name of Village	No. of Households	Total Population	Male Population	Female Population
1	Reiek	360	1627	786	841
2	W.Lungdar	109	668	340	328
3	Lengte	88	406	211	195
4	Nghalchawm	60	302	161	141
5	Rulpuihlim	78	392	233	159
6	Chungtlang	54	327	174	153
7	N. Kanghmun	166	858	432	426
8	Khawrihnim	128	789	401	388
9	Ailawng	104	510	267	243
10	Rawpuichhip	241	1244	620	624
11	Tuahzawl	80	381	198	183
12	Hruiduk	115	670	356	314
	Total	**1583**	**8174**	**4179**	**3995**

(Source: Rawat et al., 2017))

3.1 Methodology

Scoping study was conducted to determine the scope of bamboo plantations/ forests in implementation of REDD+ activities in project area under Mamit district of Mizoram. All the relevant data were collected on the pre-tested questionnaire (Annex I) which covered all the data needed to identify the extent of bamboo in implementation of REDD+ activities. Twelve villages of the project area were sampled with 100 percent sampling and village was taken as sampling unit. This included the personal responses of Village Council on behalf of whole village. Village Council allots land for shifting cultivation, for construction of houses and for taking up other farming practices etc. to the villagers. They act as a local body which works under the guidance of local administration and facilitates to take the voice of the communities to the government. Microsoft excel and Statistical Package for the Social Sciences (SPSS) software have been used for the analysis of the collected data. Strengths, Weekness, Opportunities and Threats (SWOT) analysis has also been done to know the scope of bamboo for implementation of REDD+ activities in North Eastern states.

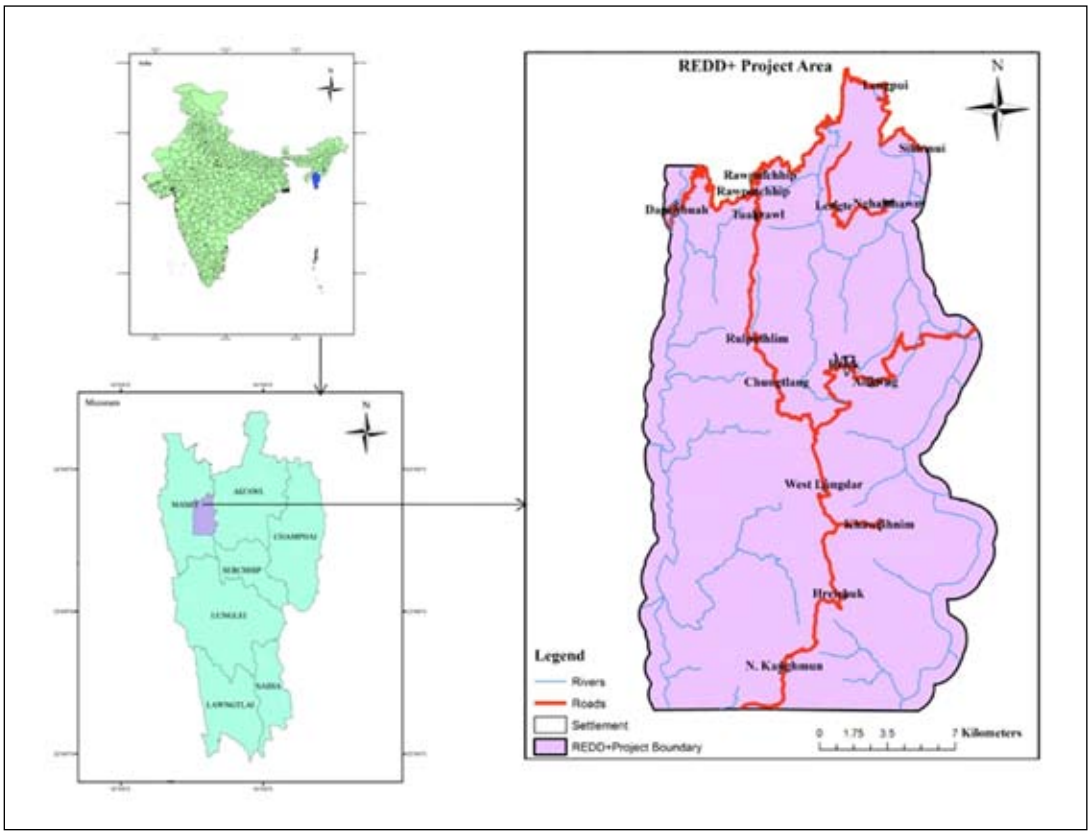


Figure 3. Map of REDD+ project area highlighting all the villages of Mamit district

3.2 Results

Large extent of Mizoram is covered under bamboo forests. Around 57% of the geographical area of Mizoram is under bamboo cover. The State possesses the maximum percentage of its geographical area under bamboo forests as compared to other states of the country. There are 35 different bamboo species found in Mizoram (Table 5).

Table 5. Bamboo species of Mizoram

Bambusa balcooa	*B. vulgaris*	*D. longispathus*	*Schizostachyum dullooa*
B. bambos	*B. vulgaris* var. *vittata*	*D. sikkimensis*	*S. fuchsianum*
B. dampeana	*B. vulgaris* var. *waminii*	*D. strictus*	*S. mannii*

B. mizorameana	*Dendrocalamus asper*	*Melocalamus compactiflorus*	*S. munroii*
B. multiplex	*D. giganteus*	*Melocanna baccifera*	*S. pergracile*
B. nagalandiana	*D. hamiltonii*	*Neomicrocalamus mannii*	
B. nutans	*D. hookeri*	*Phyllostachys edulis*	
B. tulda	*D. laetiflorus*	*P. mannii*	

(Source: http://mizobamboo.nic.in/bambooinmizoram.html, accessed on 25-07-2020)

Out of 35 bamboo species, the survey showed that *Melocanna baccifera* (locally known as Mautak) is the most preferred and important bamboo species and favored by 9 villages out of 12 villages. Details of bamboo resources development and its demand is given in Table 6. Bamboo is one of the oldest building materials used by mankind in tropical and subtropical regions. It has been also processed into an extended diversity of products ranging from domestic household products such as food containers, skewers, chopsticks, handicrafts, toys, furniture, flooring, boats, charcoal, musical instruments etc. Traditional backpack (Em) is the common bamboo made product which is high in demand. *M. baccifera* is abundantly found in all villages and is the largest material used for varied purposes like in preparation of different types of baskets with different shapes and sizes especially oval, square, flat etc. People in all villages prefers this species in preparation of different household items and carries an economic importance.

Apart from its most common traditional usage as traditional backpack, other different uses in villages are also practiced viz., bamboo flooring in Nhngalchawm village, house construction in Khawrihnim, N. Kanghmun and Rulpuihlim village, Mizo hut in Ailawng village, reinforced concrete construction in Ailawng village, bamboo hut in Tuahzawl village, drained water harvesting pipe in W. Lungdar village.

Table 6. List of bamboo species used as a resource in twelve villages of Mamit district

S. No	Village name	Bamboo species grown	Most preferable bamboo species to grow	Main products from bamboo	Bamboo products high in demand
1.	Nhngalchawm	*Melocanna baccifera* (Mautak) *Dendrocalamus longispathus* (Rawnal) *Bambusa longispiculata* (Rawthing) *Schizostachyum dullooa* (Rawthla)	*Melocanna baccifera* (Mautak) *Dendrocalamus longispathus* (Rawnal)	Bamboo hut (Thlam) Traditional back pack (Em)	Traditional back pack (Em)
2.	Hruiduk	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Dendrocalamus sikkimensis* (Rawmi), *Pseudostachyum polymorphum* (Chal), *Melocalamus compactiflorus* (Sairi)	*Melocanna baccifera* (Mautak)	Traditional back pack (Em), boundary wall (Pal), Partition wall, House ceiling	Mizo and traditional back pack
3.	Khawrihnim	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Bambusa longispiculata* (Rawthing), *Melocalamus compactiflorus* (Sairi), *Dendrocalamus hamiltonii* (phulrua)	*Melocanna baccifera* (Mautak)	Traditional back pack (Em), winnowing tray (Thlangra), basket (Kho)	Traditional back pack (Em)
4.	Lengte	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Bambusa longispiculata* (Rawthing)	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Bambusa longispiculita* (Rawthing)	Traditional back pack (Em), winnowing tray (Thlangra), rain water harvesting (tuidawn)	Traditional back pack (Em)

S. No	Village name	Bamboo species grown	Most preferable bamboo species to grow	Main products from bamboo	Bamboo products high in demand
5.	N. Kanghmun	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Dendrocalamus hamiltonii* (phulrua), *Melocalamus compactiflorus* (Sairi), *Dendrocalamus sikkimensis* (Rawmi), *Schizostachyum dulloa* (Raw-thla)	*Melocanna bacciferra* (mautak)	Traditional back pack (Em), winnowing tray (Thlangra), basket (Kho), boundary wall, partition ceiling	Traditional back pack (Em), winnowing tray (Thlangra), basket (Kho)
6.	Rawpuichhip	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Dendrocalamus hamiltonii* (phulrua), *Bambusa longispiculata* (Rawthing), *Melocalamus compactiflorus* (sairil)	*Melocanna bacciferra* (mautak)	Traditional back pack (Em), crap trap (Ai-wat), Flooring mat (Pher)	Traditional back pack (Em)
7.	Tuahzawl	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Dendrocalamus hamiltonii* (phulrua), *Bambusa longispiculata* (Rawthing), *Melocalamus compactiflorus* (sairil)	*Melocanna bacciferra* (mautak)	Traditional back pack (Em), crap trap (Ai-wat), winnowing tray (Thlangra)	Traditional back pack in both big and small sizes
8.	Ailawng	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal)	-	Stools	Bamboo mat ply
9.	Chungtlang	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Dendrocalamus, hamiltonii* (phulrua),	-	Traditional back pack (Em), carp trap (Aiwat), Winnowing tray (Thlangra)	-
10.	Reiek	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Dendrocalamus hamiltonii* (phulrua), *Bambusa tulda* (Raw thing), *Cephalostachyum latifolium*	-	Stools	Bamboo hat, rice cleaner tray (Thlangra), traditional mizo back pack (Em)
11.	Rulpuihlim	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Dendrocalamus hamiltonii* (phulrua), *Bambusa tulda* (Raw thing)	*Melocanna bacciferra* (mautak)	Traditional back pack (Em), carp trap (Aiwat), Winnowing tray (Thlangra)	Traditional back pack (Em)
12.	W.Lungdar	*Melocanna baccifera* (Mautak), *Dendrocalamus longispathus* (Rawnal), *Dendrocalamus hamiltonii* (phulrua), *Bambusa tulda* (Raw thing)	*Melocanna baccifera* (Mautak), *Dendrocalamus hamiltonii* (phulrua)	Traditional back pack (Em), Winnowing tray (Thlangra), boundary wall (Pal), rain water harvesting (Tuidwan)	Traditional back pack (Em)

In the 12 villages of Mamit district, the bamboo is utilized in two forms i.e. shoots and culms or poles. The common practice of villagers is to utilize bamboo poles/culms for construction material, bamboo flooring, Mizo huts, bamboo huts etc. Bamboo as shoots has also been recognized as a valuable and essential commodity by three villages namely Reiek, Ailawng and Nhngalchawm. Bamboo shoots are the young, immature and tender culms of the bamboo used for preparing various food items after being harvested. During the field survey, it was recorded that annual income generated from shoots are high in comparison to poles/culms. The annual income earned from selling bamboo shoots in Ailawng village and Reiek village are INR 3 million and INR 5 million, respectively. Cumulative selling of both bamboo shoots and culms have led the annual earnings to INR 3.2 million in Ailawng village and INR 5.3 million in Reiek village. Moreover, the harvesting of bamboos is done when demanded personally and commercially. Bamboo grows much faster than any timber species and requires less intensive management, therefore, it is most suitable species after shifting cultivation. In seven villages harvesting is mainly done when bamboo required for personal utilization and remaining villages are dependent upon the market demand for its harvesting. The villages which are dependent upon market for their bamboo produce are Nhngalchawm, Lengte, N. Kanghmun, Rawpuichhip, Ailawng and Reiek village. Manual labour are required to harvest culms at the rate of 50-100 culms per day.

SWOT Analysis has also been done to know the weaknesses and threats to realize and bridge the gap between expected and observed potential of bamboo to derive the opportunity from REDD+ result based financial incentive (Table 7). Mizoram is part of North Eastern states and shares the same physiographic zone. The benefits and critical knowledge gaps identified from the results of the study is important to extract the ability of bamboo ecological and economic importance. This includes species specific verifiable data for quantifying emission reductions, baseline scenarios and reference levels for monitoring and evaluation of bamboo plantations for implementation of REDD+ activities. Moreover, the state level bamboo specific policy might bring optimal utilization of bamboo resources and also provide the upliftment of livelihood of people.

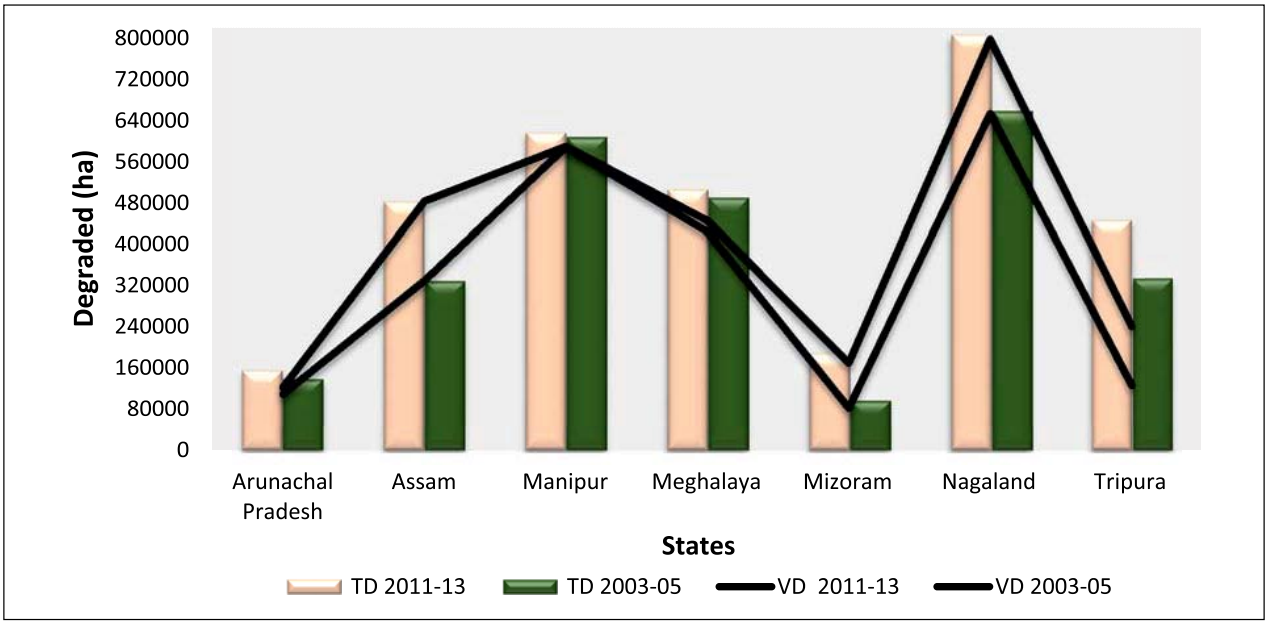
Table 7. SWOT Analysis for scoping of bamboo for REDD+ in North Eastern states

STRENGTHS	WEAKNESSES
• High diversity of bamboo species • Favorable environment for bamboo growth and development • Fastest growing woody grass with less production cost and more employment • Food and nutritional security • Strong indigenous knowledge in production and consumption of bamboo • It is renewable and sustainable substitute • Low cost option to meet mitigation targets	• No Bamboo Policy envisaged at national level • Low productivity due to lack of scientific management (package of practices) of different bamboo species • Limited availability of seed and flowering of bamboo species and increase in rodent population • Lack of proper channel of production especially presence of nurseries, processing and marketing of bamboo species • Lack of skilled manpower • Lack of capacity building in post-harvest management including storage and processing facilities and industries • Improper roads and high transportation cost
OPPORTUNITIES	**THREATS**
• Carbon sequestration potential, biodiversity conservation and land restoration along with enhanced state economy • High market potential including exports • Varied uses of bamboo products to improve the socio-economic conditions of people involved • Bamboo based agroforestry system especially for jhum lands • Scientific management for low cost quality raw material for its proliferation	• Shifting cultivation • Poor linkages between production and marketing of bamboo products • Imbalance between forward and backward linkages in bamboo market • Illegal trading • Costly micro propagation techniques to multiply

Scope of bamboo plantations in addressing the drivers of deforestation and forest degradation in North Eastern states

According to Desertification and Land Degradation Atlas of India, 2016, changes in desertification and land degradation classes were brought out for the time frames 2011-13 and 2003-05. Out of 12 categories of degradation defined in the atlas, vegetation degradation contributes around 88 percent in total degradation for North Eastern states. An increment of 0.52 mha in vegetation degradation by seven sister states has been analyzed revealing that the contribution has increased to 88.87% in 2011-2013 from 87.21% in 2003-05 in total degradation consisting of all 12 categories. The contribution of vegetation degradation in total degradation in two time periods for seven sister states is given in Figure 4.

Bamboo is known to grow in nutrient poor soils and has prolific nature in biomass production which is ideal for regenerating poor soil (Ben-zhi *et al.*, 2005). Adaptive capability, nutrient and water conservation of bamboos, enables it as fore-runner species in the restoration of degraded land. The biological characteristics like fast growing nature with dense foliage of bamboos and abundant litter fall makes bamboo suitable for rehabilitation of land. Due to the presence of intensive root system, bamboos are known for rapid colonization in degraded lands and able to control the runoff and soil erosion especially on the hilly slopes of degraded jhum lands. Land degradation is a complex process and pressure on land to attain food security and sustain the increasing population pressure. Venkatesh *et al*., 2005 reported that *Dendrocalamus giganteus*, *D. hookerii* and *Bambusa nutans* found to be the better species for improving and maintaining the fertility status of acid soils in the North Eastern Himalayan region.



(TD= Total Degradation, VD= Vegetation Degradation)

Figure 4. Contribution of vegetation degradation in total degradation in two time periods (201-13 to 2003-05) for seven sister states

Shifting cultivation is one of the common land use system and is known for its indigenous and primitive practice of cultivation in the states of North Eastern India. Initially the shifting cycle was 20 to 30 years (Singh and Bag, 2002) but due to increase in human population and increasing pressure on land, shifting cycle reduced progressively (4-5 years) causing problems of land degradation and threat to ecology of the region (Ramakrishnan, 2003). This has also been reported as one of the major drivers of deforestation and forest degradation in Mizoram (Rawat *et al*., 2017 and ICFRE, 2018). The details of shifting cultivation practiced area under each North Eastern states of India are given in Table 8. Serious depletion of forest resources has occurred in North Eastern States of India and are under tremendous pressure due to shifting cultivation. Bamboo will pave way for alternatives in the form of bamboo-based agroforestry system. To extract the full potential of land and maintain it on sustainable level requires quality planting material

in order to maintain the productivity of land. Since the viability of bamboo seeds are poor and flowers gregariously. This demands for mass macro and micro propagation of bamboo species, establishment of modern nurseries of bamboo species, conservation of natural genetic resources of bamboo species and development of suitable silvicultural interventions for productivity enhancement.

Bamboo based agroforestry has an immense potential for resource conservation. It could be categorised under different agroforestry systems like homesteads, block plantations, wide row intercropping, wind breaks and miscellaneous systems. However, a standard package of practices for cultivation of commercially important bamboo species are unavailable (ICFRE, 2017). National Mission on Bamboo Application, Government of India has identified 19 species as industrially important (ICFRE, 2017). Focus need to be done on research and development in availability of quality planting stocks with trade and transit issues to popularize bamboo agroforestry at sustainable level.

Table 8. Changes in the extent of shifting cultivation in India (2000-2010)

States	Shifting Cultivation (2000)	Shifting Cultivation (2010)	Change (km^2)	Percent Decadal change
Arunachal Pradesh	3088.08	1531.46	-1556.62	-50.41
Assam	8391.48	239.56	-8151.92	-97.15
Manipur	12014.06	852.20	-11161.86	-92.91
Meghalaya	2086.77	448.99	-1637.78	-78.48
Mizoram	3761.23	2617.56	-1143.67	-30.41
Nagaland	5224.65	2827.74	-2396.91	-45.88
Tripura	400.88	254.11	-146.77	-36.61

(Source: MoSPI, 2014)

Due to the rapid growth rate and its wide distribution, bamboos have high potential to store substantial amounts of carbon. Bamboo species has a pivotal role as a carbon sink and thus contributing to climate change mitigation (Singnar *et al*., 2017). Therefore, bamboos play an important part in biomass production and terrestrial carbon capture in different climate at a faster rate than other timber species (ICFRE, 2017). Focusing on the relationship between bamboo and its potential in mitigating climate crisis through biomass production, study was conducted in Forest Research Centre for Bamboo and Rattan (FRCBR), Aizawl, Mizoram for three species namely *Bambusa mizorameana*, *Dendrocalamus longispathus* and *Dendrocalamus strictus* in 2017. These species were planted under two treatments *i.e.,* organic manure and control treatment. The variables like collar diameter (cm) height (m), number of culms and number of shoots were measured for these bamboo species. The mean value of collar diameter ranged from 0.83-2.24 cm in *Bambusa mizorameana,* 1.10-3.83 cm in *D. longispathus* and 0.35-3.20 cm in *D. strictus.* Height ranged from 8.33-17.83 ft. in *B. mizorameana,* 10.72-20.13 ft. in *D. longispathus* and 4.75-15.50 ft. in *D. strictus.* Number of culms ranged from 11.00-18.00 in *B. mizorameana,* 13-22 in *D. longispathus,* 4-9 in *D. strictus.* Number of shoots varied from 0-4 by three spp. in all treatments. Under both the treatments, variables like collar diameter, height of culms and number of shoots is found maximum in *Dendrocalamus longispathus* whereas the maximum number of culms was observed by *Bambusa mizorameana*. Between two treatments, organic manure had shown significantly ($P<0.05$) higher performance in all the variables among all the species than the control treatment.

3.3 Conclusion

Bamboo is a conglomerate of both natural resource and enterprise that builds a strong relationship in effective REDD+ design. It is known for its short gestation period with high ecological adaptability. Bamboo is also known for its versatility and can be grown on boundary plantation and forms vital agroforestry component in jhum lands. Shifting cultivation is an indigenous and primitive practice and forms a prominent land use system in North Eastern states of India. This land use system occupies more than 84% (0.76 mha) of land out of 0.94 mha of India which includes both current *jhum* (53%) and abandoned *jhum* (47%) (MoRD, 2011) and

about 0.44 million tribal families are dependent on this for their livelihood (Yadav 2013) and the forest area affected is 92853 km^2 (Verma *et al*., 2017). This is recognized and categorized as wasteland category (MoRD, 2011). Bamboos are preferred on jhum lands as it requires low management practices. The proper technique followed for its cultivation, management practices and harvesting regimes are lacking. This requires a proper institutional arrangement along with research intervention at every level to attain sustainable management of bamboos to obtain maximum productivity. This can be achieved by strategic regulation of bamboo as a resource utilization and maintain its market especially in jhum areas by collaborating with Village Councils to get boom in bamboo-based industries, enterprises, handicraft sector and also for trade and commerce other than ecological importance.

An appropriate policy needs to identify communities as an important place in encouraging forward and backward linkages and help in accelerating the growth of bamboo sector in India other than private investors. SWOT Analysis performed based on questionnaire clearly states that capacity building of various stakeholders in management of micro-enterprise which includes nursery technologies for cultivation of various species to value addition bamboo processing and design technologies is required.

The developed State REDD+ Action Plan (SRAP) of Mizoram has recognized adoption and expansion of hillside settled farming systems. Bamboo based agroforestry system exemplifies and promotes "sustainable cropping pattern and land management" intervention package documented in SRAP of Mizoram to implement National REDD+ Strategy at sub national level. This will enhance the implementation of REDD+ activities and incentivize communities not only for reducing deforestation but also for conservation, sustainable management of forests, and enhancement of forest carbon stocks. Bamboo plays an important role and integrates well with REDD+ mechanism and provide both social and environmental benefits.

4

FEASIBILITY OF BAMBOO PLANTATION IN IMPLEMENTATION OF REDD+ ACTIVITIES IN NORTH-EASTERN STATES

Bamboo plays an important role both economically and ecologically. It is one such raw material which has a tremendous potential to give income generating activities and helps to improve the livelihood of people and improve rural economy. Therefore, this study is designed to understand the feasibility of bamboo plantations in implementation of REDD+ activities in the North Eastern states of India.

4.1 Methodology

The study was conducted to determine the feasibility of bamboo plantations in Aizawl district, Mizoram. All the relevant data collected on the pre-tested questionnaire (Annex II) which covered all the data needed to identify the extent of bamboo to integrate in REDD+ activities. The data was collected from primary sources by visiting the ten randomly selected artisan/ entrepreneurs families and analyzed in Microsoft excel and Statistical Package for the Social Sciences (SPSS) software.

Secondary data was also collected from different sources like previous related research works, statistical data, world bamboo resource reports and other relevant reports and bamboo resource studies were also consulted, reviewed and compiled. Strengths, Weekness, Opportunities and Threats (SWOT) analysis has also been done to determine the feasibility of bamboo plantations for implementation of REDD+ activities in North Eastern states

4.2 Results

Bamboos have their multifarious uses which includes poles, paper, pulp, housing and material for handicrafts besides minor uses such as leaves for medicinal purposes. Shifting cultivation is a traditional practice and is passed on generation to generation. It had a deep influence in socio-culture of Mizo society. Shifting cultivation typically creates a mosaic of remnant primary forests and successional vegetation ranging from recently abandoned weedy- herbaceous fallows and bamboo forests to mixed tree and bamboo late-successional secondary forests (Raman, 1996). The area under shifting cultivation behaves as source area for bamboo plantations. District wise distribution of bamboo in Mizoram is given in Table 8.

Table 8. District wise distribution of bamboo in Mizoram

District	Area	Bamboo Area	% bamboo area to the district area	% bamboo area to total area
Aizawl	3576.31	927.69	25.94	13.08
Champhai	3185.83	345.68	10.85	4.87
Kolasib	1382.51	661.80	47.87	9.33
Lawngtlai	2557.10	730.79	28.58	10.30
Lunglei	4538.00	1956.59	43.12	27.59
Mamit	3025.75	1598.00	52.81	22.53
Saiha	1399.90	432.04	30.86	6.09
Serchhip	1421.60	439.08	30.89	6.19
Total	**21087.00**	**7091.66**	**33.63**	**100**

(Source: http://mizobamboo.nic.in/bambooinmizoram.html, accessed on 25-07-2020)

Among 35 bamboo species found in Mizoram, *Melocanna baccifera* (Mautak), *Melocalamus compactiflorus* (Sairil), *Dendrocalamus hamiltonii* (Phulrua), *Dendrocalamus longispathus* (Rawnal) and *Bambusa tulda* (Rawthing) are the most preferred species by the artisans and are recognized as one of the commercially important bamboo species. The price of the finished products varies and depends upon bamboo species, processing of bamboo to make final product and demand of the product. Market price along with its cost of production of the different finished products made from preferred bamboo species are given in Table 9.

Table 9. Finished product with the market price from various bamboo species

S.No.	Bamboo species	Name of the products	Cost of the product (INR)	Cost of production (INR)
1	*Melocanna baccifera*	Decorative head gear (Vakiria)	400-600	900-1100
		Partition wall	3000-4500	7500-8500
		Laminated board	3000-5000	8000-10000
		Mat	1000-1100	2500-3500
		Hand bag	100-200	500-600
2	*Dendrocalamus longispathus*	Traditional earring (bengbeh)	50-70	150-200
		Charcoal	300-400 per bag of charcoal	160-250 per bag
		Basket (Thul)	300-500	500-800
		Flower vase	100-300	500-1000
		Dustbin	200-300	500-600
		Traditional backpack (Em)	100-200	600-700
		Bamboo flooring	150-250	3000-4000
3	*Melocalamus compactiflorus*	Bracelet (ban-hun)	50-100	100-200
		Rice cooker stand	40-80	400-450
		Vinegar	200-300	700-1000
		Fridge Magnet	50-100	150-250
		Plate and bowl	50-100	300-500
		Broom sticks	20-30	100-200

S.No.	Bamboo species	Name of the products	Cost of the product (INR)	Cost of production (INR)
4	*Bambusa longispiculata*	Vinegar	18000-17000	3500-4500
5	*Bambusa tulda*	Basket (Kho)	30-50	150-200
		Tray	80-135	500-750
		Coffee cup	5	30
		Bamboo vase	400	1500
		Bamboo container with trolley	800-1000	4500-6000
		Miniature set of Mizo tool	200-350	1500-1700
6	*Cephalostachyum latifolium*	Traditional earring (bengbeh)	5-10	60-70
		Traditional hat (khumbeu)	300-500	1000-1250
7	*Dendrocalamus hamiltonii*	Vinegar	17500-19000	3500-4500
		Mat	1000-1700	2500-3500
		Traditional hat gear	80-100	1000-1200
		Traditional back pack	100-120	1200-1300
		Winnowing tray	50-70	500-750
		Traditional earring	5-10	50-75
		Flower pot	100-200	350-450

Due to varied finished products & its usage and demand of raw material of different species, the harvesting age tends to vary which was observed from one to five years of age. The harvesting of bamboo culms is preferred to be a matured bamboo during dry season i.e. from the month of October to March when the habitat is comparatively drier. The artisans are engaged from two months to round the year for carving a raw material to final product. Artisans from villages like Tuikual, Upper Republic, Mission Venge hires 2-10 persons on year-round basis for making several bamboo products whereas artisans from village like Chaltlang engages 4-6 persons (generally family members) for only two months in a year for making bamboo products.

In bamboo sector, the people engaged in commercial activity at a small scale are mostly family members. The cost of raw material depends upon the availability of volume and value of bamboo species, market size of each species including the finished product, time and energy involved in processing of bamboo etc. In Aizawl district, the cost of bamboo culm varied from INR 16-25 per culm. Due to number of active working months of artisans in a year in Aizawl district, the demand of raw material had shown a lot of variation which varied from 100-500 culms on monthly basis and 80-100 quintal on yearly basis. Highly variable market structure of finished bamboo products also influences the amount of raw material purchased by artisans and number of active working months in a year. The annual income of artisans from selling the finished bamboo products had shown high variability i.e., INR 40,000 to 100,000 per artisan.

The consistency of demand and supply of bamboo raw material depends upon the stable market structure for bamboo products both at national and international level. The major strategy is to achieve the production of bamboo products with quality standards/ assurance and branding of supply of quality raw material. This will provide both ecological and economic gain as well as maintain the consistency of the supply of bamboo raw material. Further the strength and weaknesses has been elucidated through SWOT analysis and given in Table 10.

Table 10. SWOT Analysis for feasibility of bamboo plantations for REDD+ in North Eastern states

STRENGTHS	WEAKNESSES
• High diversity of bamboo species • Naturally favorable environment for bamboo growth and development • Fastest growing woody grass with less production cost and more employment • Strong indigenous knowledge in production and consumption of bamboo • It is renewable and sustainable substitute • Low cost option to meet mitigation targets • Food and nutritional security	• Absence of nurseries and consequently good planting stock • No Bamboo Policy envisaged at national level • Lack of standard package of practices for each bamboo species • Limited availability of seed due to gregarious flowering and less viability of seed • Lack of quality planting material of commercial species • Lack of skilled man power and capacity building in post-harvest management including storage and processing facilities • Poor road connectivity with villages and high transportation cost and therefore lack of access to market • Very little equipments present for bamboo processing and lack of capital intensity
OPPORTUNITIES	**THREATS**
• Carbon sequestration, biodiversity conservation and land restoration along with enhanced state economy • High market potential including exports • Improvement in socio-economic conditions of people due to its versatility • Bamboo based agroforestry system especially for jhum lands • Scientific management for low cost quality raw material for its proliferation	• Shifting cultivation • Poor and imbalance between forward and backward linkages • Illegal trading • Costly micro propagation techniques to multiply • Insufficient baseline data • Unstable market structure • Bamboo flowering

4.3 Conclusion

Bamboo species are an integral part of forests and carries a huge potential in carbon sequestration and storage offering tremendous opportunity for enhancing the ecosystem goods and services including climate change mitigation. Large scale plantations of bamboo species can ensure sustainable supply of the raw material for industrial requirement and other uses. Improving silvicultural interventions in both government owned and private lands by assisted natural regeneration and enrichment planting with nursery grown quality planting stocks are also required. Moreover, genetic interventions to obtain promising productive stock by both clonal origin and seed origin which flowers sporadically and provide ensured supply of quality seeds. Apart from technical interventions, basic infrastructure to raise bamboo plantations and processing of raw material to attain finished product are also necessary. Moreover, National Bamboo Policy needs to be formulated for the sustainable development of bamboo sector. The ownership structure, tenure system, plantation area and annual production as a raw material for bamboo-based industries need to be studied simultaneously while formulating the policy. During policy making process recognition of bamboo need to be considered as a relevant part to achieve successful implementation of REDD+ activities.

To promote bamboo cultivation, supply, processing and value addition, products manufacturing as well as utilization and marketing in a balanced manner necessitates policy interventions. In view of this, four states in seven sister states of India have envisaged a policy and several provisions have been made under the policy which is stated in figure 5.

Bamboo can play an important role in implementation of REDD+ activities. Use of bamboo in agroforestry system is one of the climate effective land use which requires a more structured approach to overcome the challenges faced by the North Eastern states of India.

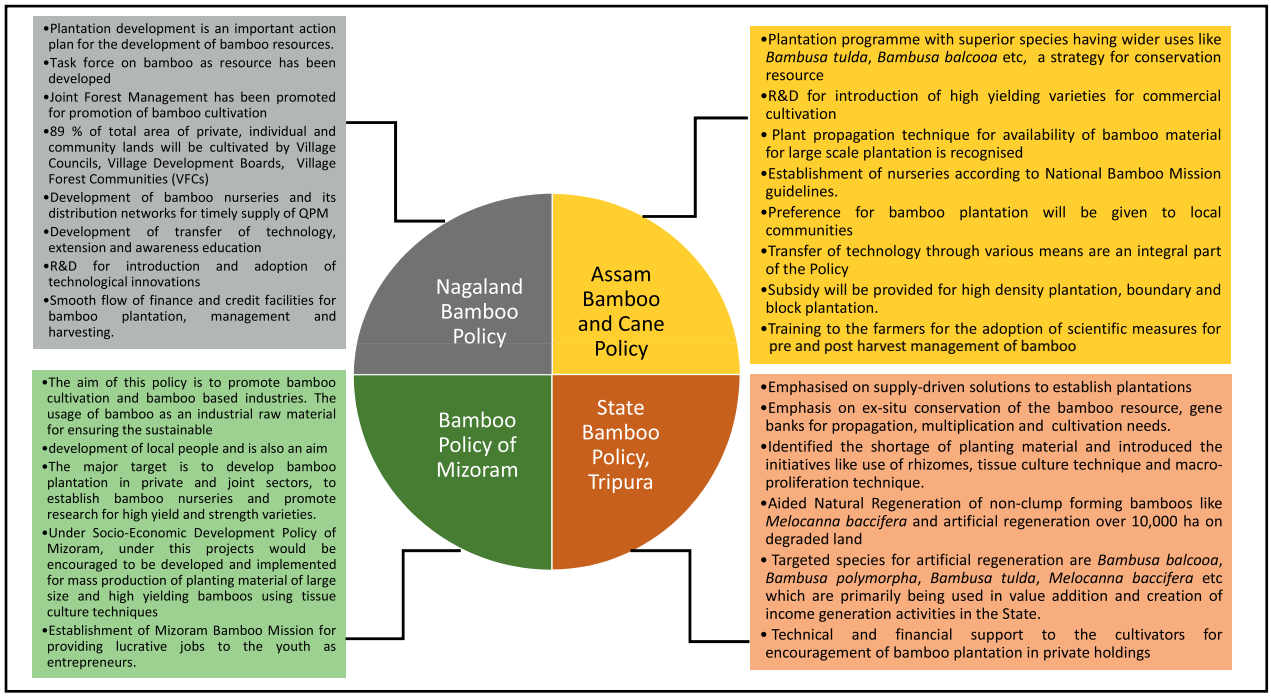


Figure 5. Provisions of bamboo plantations in State Bamboo Policies of seven sister states

In addition to this, bamboos also have several benefits including firewood, construction materials and raw materials for handicrafts. If positioned correctly, bamboos also play participatory approach in conservation and restoration through integrated landscape approach and helps in rehabilitation of degraded land, protection of watersheds and contribute to conservation of biodiversity etc. It is one of the innovative and upcoming sectors which needs to be included in implementation of REDD+ programmes. Integration of bamboo plantation in implementation of REDD+ activities is an important aspect in understanding the role of bamboos in climate change mitigation and adaptation. The important role of bamboo within REDD+ mechanism is not only its ability to act as a substitute for non-renewable forest products but also to enhance the livelihood of local communities.

REFERENCES

Austin, R., Levy, D. and Ueda, K. (1970). Bamboo [M]. New York: John Weatherhill Inc.

Bahadur, K.N. and Jain. S.S. (1981). Rare Bamboo of India. *Indian Journal of Forestry*, 4 :280-286.

Ben-zhi, Z., Mao-yi, F., Jin-zhong, X., Xiao-sheng, Y. and Zheng-cai, L. (2005) Ecological functions of bamboo forest: Research and Application. *Journal of Forestry Research*, 16(2): 143-147.

Bhalla, S., Gupta, S., Gudhakar, P. and Suresh, P. (2008) Bamboo as green alternative to concrete and steel for modern structures. *Journal of Environment Research and Development*, 3(2):362–370.

Biswas, S. (1988). Studies on bamboo distribution in North-Eastern region of India. *Indian Forester*, 114 (9):514-531.

Cajee, L. (2018). Diversity of Bamboo Species and its Utilization in the North-Eastern Region of India. *International Journal for Research in Applied Science & Engineering Technology*, 6 (3): 3286-3299.

CFI (2006). Community Forest International. Proceedings of the Non-Timber Forest Product (NTFP) Workshop and Seminar, Cambodia, 7-8 December 2006. CFI, Phnom Penh.

FAO (2020). Global Forest Assessment 2020. Food and Agriculture Organization, Rome.

FSI (2011). India State of Forest Report 2011.Forest Survey of India, Ministry of Environment, Forest and Climate Change, Dehradun.

FSI (2017). India State of Forest Report 2017.Forest Survey of India, Ministry of Environment, Forest and Climate Change, Dehradun.

FSI (2019). India State of Forest Report 2019.Forest Survey of India, Ministry of Environment, Forest and Climate Change, Dehradun.

GOFC-GOLD (2010). A sourcebook of methods and procedures for monitoring, measuring and reporting anthropogenic greenhousegas emissions and removals caused by deforestation, gains and losses of carbon stocks in forest remaining forests, and forestation(eds Achard, F. *et al.*), GOFC-GOLD Report version COP15, GOFC-GOLD Project Office, Natural Resources Canada, Alberta,Canada, 2010, p. 197.

Goyal, A.K. and Brahma, B.K. (2014). Antioxidant and nutraceutical potential of Bamboo: an overview. *International Journal Fund Applied Sciences*, 3(1):2–10.

Hunter, I.R. (2002). Bamboo—Solution to problems. *Journal of Bamboo and Rattan*, 1(2): 101–107.

ICFRE (2017). Bamboo conservation, management and utilization: A status report. Indian Council of Forestry Research and Education, Dehradun, India.

ICFRE (2018). Mizoram State REDD+ Action Plan. Indian Council of Forestry Research and Education, Dehradun, India.

IPCC (2019). IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Loushambam, R.S., Singh, N.R., Taloh, A. and Mayanglambam, S. (2017). Bamboo in North East India. *Indian Journal of Hill Farming*, 30(2): 181-185.

Mehra, S.P. and Mehra, L.K. (2007). Bamboo cultivation – potential and prospects. *Technical Digest*, 10:26–36.

SAC (2016). Desertification and Land Degradation Atlas of India. Ministry of Environment, Forest and Climate Change. New Delhi, India.

Singnar, P., Das, M.C., Gudeta, W., Sileshi, W.B., Brahma, B., Nath, A.J. and Das, A.K. (2017). Allometric scaling, biomass accumulation and carbon stocks in different aged stands of thin-walled bamboos *Schizostachyum dullooa*, *Pseudostachyum polymorphum* and *Melocanna baccifera*. *Forest Ecology and Management*, 395: 81–91.

Nath, A.J. and Das, A.K. (2009). Carbon farming through village bamboos in rural landscape of North East India as affected by traditional harvest regimes. In: Proceedings of VIII World Bamboo Congress: Community and Economic Development, Vol. 7, pp. 7-23.

MoRD (2011). Wasteland Atlas of India, Ministry of Rural Development, Department of Land Resources. dolr.nic..in/dolr/ wasteland_atlas.asp.

Pandey, C.N. and Shyamsundar, K. (2008). Post-harvest management and storage of bamboo culms. In: Proceedings of the International Conference on Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood. 15-17 April, 2008, New Delhi, pp.47-58.

Rai, S.N. and Chauhan, K.V.S. (1998) Distribution and growing stock of bamboos in India. *Indian Forester*, 124 (2): 89 -98.

Ramakrishnan, P.S. (2003). Linking natural resource management with sustainable development of traditional mountain societies. *Tropical Ecology*, 44: 54-63.

Raman, T.R.S. (1996). Impact of shifting cultivation on diurnal squirrels and primates in Mizoram, northeast India] a preliminary study. *Current Science*, 69 : 747-750.

Rawat, V.R.S., Rawat, R.S., Verma, N. (2017). Drivers of Deforestation and Forest Degradation in Mizoram. Indian Council of Forestry Research and Education, Dehradun (India).

Ribeiro, R.A.S., Ribeiro, M.G.S. and Miranda, I.P.A. (2017) Bending strength and nondestructive evaluation of structural bamboo. *Construction and Building Materials*, 146: 38–42.

Sileshi, G.W. and Nath, A.J. (2017). Carbon farming with bamboos in Africa: a call for action. Working Paper.

Singh, K.A and Bag, T.K. (2002). Indigenous technical knowhow relevant to farming systems of Arunachal Pradesh. (In) Resource Management Perspective of Arunachal Agriculture, K A Singh (Ed.). ICAR Research Complex for NEH Region, pp. 234-67. Arunachal Pradesh, Basar.

Solanki, K.R., Bujarbarauah, K.M. and Bhatt, B.P. (2003). Bamboo: A potential Resource for Agroforestry and Social Forestry with Special reference to N.E.H. Region. Technical Bulletin, ICAR, Meghalaya, India. pp. 70.

Venkatesh, M.S., Bhatt, B.P., Kumar, K., Majumdar, B. and Singh, K. (2005). Soil properties influenced by some important edible bamboo species in the North Eastern Himalayan region, India. *Journal of Bamboo and Rattan*, 4(3): 221-230.

Yadav, P. K. (2013). Slash-and-Burn Agriculture in North-East India. *Expert Opinion on Environmental Biololgy*, **2**(1):1-4.

ANNEX I

Questionnaire for Collection of Data from Bamboo Cultivators/Growers

Questionnaire No: ..... Date:.....

Village Name:.....

Location: Latitude:.....º.....'.....” N Longitude.....º.....'.....” E Altitude.....

1) Name of the respondent: .....Mobile No.....

2) Qualification:.....

3) Age.....

4) Gender: M ☐ F ☐

5) Professional occupation:

Agriculture/ Farming ☐ Business ☐ Government Service ☐ Other ☐

Information about bamboo cultivation

1. Number and name of bamboo species cultivated/ grown.....
2. Area under bamboo cultivation.....
3. Harvesting age of bamboo and time of harvesting.....
4. Most preferable bamboo species for cultivation is.....
5. Why.....
6. Is quality planting material of bamboo available? Yes ☐ No ☐
7. Are there any bamboo nurseries present near by? Yes ☐ No ☐
8. If yes, Name of the Nursery .....
9. Have you attended any training on bamboo cultivation or bamboo products making?

   Yes ☐ No ☐
10. How many small scale/cottage industries are present in the village .....
11. Which is the main product made from bamboo (made round the year) .....
12. Which bamboo product is in high demand in the market?.....
13. Quantity (in tonnes) of bamboo is sold as a raw product .....
14. Annual income from sale of bamboo .....
15. Man days required per year for growing and harvesting of bamboo.....
16. Any problems faced in bamboo cultivation.....
17. Suggestions for overcoming the problems faced in bamboo cultivation.....

Name of the Data Collector ..... Mobile No. .....

ANNEX II

Questionnaire for Collection of Data from Bamboo Artisans or Small Scale/Cottage Industry

Questionnaire No: ..... Date:.....

Village Name:.....Latitude:.....º....'.....” N

Longitude.....º.....'.....” E Altitude.....

1) Name of the respondent: .....Mobile No. .....

2) Qualification:.....

3) Age.....

4) How many artisans or small scale/cottage industries are present in the area.....

5) Number and name(s) of bamboo species are used for making product .....

.....

6) Harvesting age of the bamboo used for the product making .....

.....

7) Name of the Bamboo species in highest demand .....

.....

8) How much (in Quintal) bamboo is purchased from cultivators/ growers annually?.....

.....

9) Price of bamboo culms on weight basis.....

10) Price of different finished products from bamboo.....

Bamboo species	Name of the Products	Cost of the product	Cost of production

11) Annual income from selling finished product.....

12) How many months in a year engaged in bamboo products making .....

13) Number of people engaged .....

14) Any problems faced by artisans or industry in the market.....

.....

15) If yes, specify reason.....

.....

Name of the Data Collector ..... Mobile No. .....