International Bamboo
and Rattan Organisation(INBAR)

Desk Study on the Bamboo Sector in North-East India

An INBAR Study commissioned
and supported by GIZ / MoDoNER
Indo-German Development Project Climate Change Adaption
in the North Eastern Region









INBAR
INTERNATIONAL BAMBOO AND RATTAN ORGANISATION

german cooperation
DEUTSCHE ZUSAMMENARBEIT
giz

teri
The Energy and Resources Institute
...towards global sustainable development

Table of Contents

List of Tables

List of Figures

Key Findings and Messages

- Bamboo is an essential part of the natural environment and important part of the sociocultural and economic life in the North East Region (NER) of India. Bamboos cover about 3.1 million hectares of the area in NER and provide employment to 0.12 million people with a potential of generating 80 million person days of employment in the region.
- There is lack of consistent and reliable data on almost all aspects of bamboo i.e. area, production, consumption and trade. This gap has implications for planning and development of the sector in the region. Hence, it should be addressed on an urgent basis.
- An appropriate coordination of stakeholders in the bamboo sector at structural and implementation level is not in place. Various stakeholders ranging from national to local level working for the development of the bamboo sector in NER but hardly collaborate on their activities.
- Many extra sectorial and sectorial issues plague the growth of the bamboo sector in the region.
  Important extra sectorial issues are:
  - Infrastructure
  - Connectivity
  - Skilled labour
  - Credit facilities.

  Important sectorial issues are:
  - Low productivity
  - Discouraging policies and tax structure
  - Lack of technical know-how and innovation
  - Poor awareness and access to markets.
- Analysis of case studies indicate that
  - Urgency or need,
  - Compliance with market requirements,
  - Ease of the technology,
  - Appropriate institutional model and finance scheme,
  - Professional and strategic guidance and support, and
  - Access to information

  seem to be essential for initiatives to be successful and that the government can play a crucial role to kick-start and take bamboo entrepreneurship forward.
- Taking action to release the to date hardly tapped potential of smallholders, young entrepreneurs and women is seen as a key for inclusive and sustainable economic development of the bamboo sector in NER.

Chapter 1
Background

The north-eastern region (NER) of India covers eight states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (Figure 1.1). The region shares international border with Bhutan, China, Myanmar and Bangladesh. It covers 7.9% of the country's geographical area and 3.75% of the total population (NECS 2015).

The physiographical landscape of NER can be divided into hills, plateaus, and plains (World Bank 2007). The low-lying plains of Assam, Tripura and parts of Meghalaya, Manipur and Nagaland cover 27% of the area. These stretches of fertile land are highly useful for settled agriculture. The Brahmaputra valley accounts for 82% of the fertile plain land in the region. Hills and plateaus cover areas of 150,000 km^2 and 32,821 km^2 respectively, representing the geographical diversity of the region (Saikia 2014).

Figure 1.1: Map of Northeast Region

The region's climate varies and is a mixture of cold humid monsoonal climate in hills above 200 m asl, wet sub-tropical in southern Arunachal, Western Nagaland, Manipur and Mizoram, and humid mesothermal monsoon climate in the valley and plateau areas (Barthakur 1986).

NER receives heavy monsoon showers, particularly the Cherrapunji-Mawsynram-Pynursla belt of the southern part of Meghalaya, which borders Bangladesh. In the rest of the region, the average annual precipitation ranges from 1,000 to over 4,000 mm with about 60% being concentrated during the months of June to October. Heavy rains and moisture has led to a diverse vegetation and rich biodiversity.

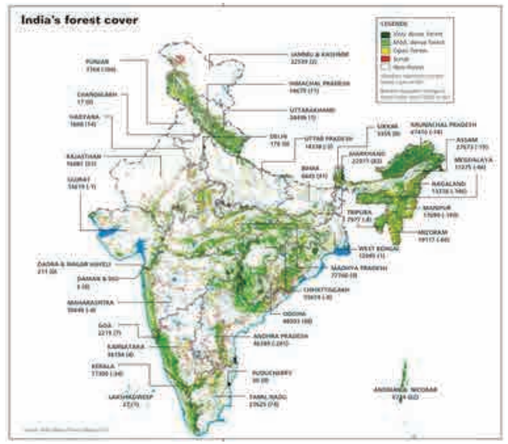

Figure 1.2: India's forest cover

The North East is rich with natural resources. Forest cover in NER constitutes 65% of its geographical area as compared to the national forest cover of 21% (FSI 2015) (Figure 1.2). Because of its biodiversity richness, the region has been identified as one of the 35 biodiversity hotspots of the world. At the confluence of the Indian-Malayan, Indo-Chinese and Indian bio-geographical realms, the north-eastern region provides a profusion of habitats, which feature diverse biota with a high level of endemism (ibid).

The region has a population of 45.5 million with a relatively low density of 174 individuals per km2 (NECS 2015). NER has more than 200 tribes and tribal population constitutes about one-fourth of the population. It ranges from 19.3% to 94.5% in Mizoram, is tribal across different states (MoDoNER and NEC 2008). Around 82% of the population from the region lives in rural areas that is higher than the country's average of 69%, which makes rural areas a focus for development (NECS 2015). The literacy rate in the region is 74.5%, which is slightly better than the country's average of 74% (NECS 2015) and reflects a significant improvement in education levels over the last decade.

NER lags behind the country on various developmental parameters especially in infrastructure, connectivity and income and employment opportunities (KPMG and FICCI 2015). The region shows a per capita income of INR 49,959 as compared to the country's per capita income of INR 68,747 (ibid).

Agriculture and allied activities constitute the predominant source of livelihoods. Around 65% of the population is dependent on agriculture for livelihood either as cultivators or as labourers (MoDoNER 2008). However, only 12% of the total geographical area is cropped, out of which only 20% is irrigated (NECS 2015).

Though NER is endowed with plenty of water resources, it has been difficult to tap these for development. Water scarcity and floods are recurring phenomenon. Floods lead to enormous loss of life, property and livelihood almost on yearly basis. Jhum or shifting cultivation is a striking feature and covers 30% of the total area under settled agriculture. The livestock and fishery sectors are very important for livelihoods, accounting for about 30% of the value of the output of the agriculture and allied sector and provide employment to 5.5% of the total working population especially women (MoDoNER and NEC 2008).

In NER, bamboo is a plentiful available natural resource with a huge economic potential (ICC and PWC 2013). The region has 28% of the bamboo area and 66% of the growing stock of the country (NBM, undated). Bamboo grows naturally in forests and is also cultivated on private lands in the region. It is an integral part of the socio- economic life and is widely used in social, cultural, and religious functions (MoDoNER and NEC 2008). For instance, the famous dance Cheraw is performed with the help of bamboo culms. Similarly, shoots are traditionally used in food at home and bamboo finds application for all important social occasions as well as for diverse other purposes such as construction of houses and for agriculture, food, energy, medicine, furniture and handicrafts (ibid). Bamboo cultivation, collection and processing provide employment opportunities to thousands of people and therefore play a significant economic role in the region.

It has been estimated that India produces only half of the bamboo required for household and industrial consumption. Hence, there is a supply deficit, which provides an immense opportunity for the region to foster growth and sustainable development. The Government of India (GOI) in collaboration with state governments and other agencies have initiated efforts through the National Bamboo Mission (NBM) and National Mission on Bamboo Applications (NMBA) to develop the sector. GOI has even declared Mizoram as the "Bamboo State" in 2015, emphasising its role in socio-economic development.

In this context, GIZ along with the Union Ministry of Development of North East Region (MoDoNER), GOI, has identified the bamboo sector as one area of intervention in the frame of the Indo-German Development Project Climate Change Adaption in the North Eastern Region (CCA-NER). Hence, CCA-NER commissioned the International Network for Bamboo and Rattan (INBAR) to undertake a "Study on the Bamboo Sector in Northeast India and Entry Points for Development in Mizoram State".

The objective of the first part of this study is to provide an overview of the bamboo sector for the region and best practices in the sector as given in this report. For this purpose, INBAR in cooperation with The Energy and Resources Institute (TERI) has undertaken an analysis of secondary data and interviews with resource persons to collate available information, identify gaps and highlight successful approaches in the region as well as the country.

Desk Study on the Bamboo Sector
in North-East India

It needs to be recognized upfront, that there are limitations to this part of the study. Firstly, as the focus of the study is on the development of the bamboo sector in Mizoram, this part of the study is limited in scope and expanse. Secondly, although it is generally known that information about the bamboo sector from secondary sources is quite limited in India, the study brought to light that there is a serious gap of consistent and reliable data for the North East especially on data relating to production, consumption, market size and trade, which urgently needs to be addressed by the institutions in charge.

The report consists of seven chapters. After the introduction, the second chapter details about the important stakeholders. The third chapter discusses various bamboo species and their uses across different sectors in the region. Fourth chapter details area, growing stock and trade size of bamboo based on the existing data. Fifth chapter discusses selected case studies of successful initiatives in the sector. The sixth chapter comprises a brief remark on gender issues in the region and the seventh chapter concludes the report.

Chapter 2
Stakeholders

There are various stakeholders ranging from national to local level working for the development of bamboo sector in the north-eastern region of the country (Figure 2.1). At national level, there are four ministries from Government of India viz. Ministry of Environment, Forests and Climate Change (MoEFCC), Ministry of Agriculture (MoA), Ministry of Development of North East Region (MoDoNER) and Ministry of Science and Technology (MoST), which are involved with the bamboo sector in the region. These ministries have specific mandates and programmes with different guidelines and implementation mechanisms that sometimes overlap but rarely converge for the effective growth of the sector.

The MoEFCC coordinates the policy and legal aspects related to forests and environment across the country. Indian Forest Act of 1927 and Forest Policy of 1988 govern and guide management and harvest of various timber and non-timber forest produce (NTFP) across public, community and private lands in the country. Based on these legislative instruments, every state government has drafted its own policy and legal instruments specific to its conditions. Bamboo is considered as one of the important NTFPs whose harvest, transport and sharing across different land ownership types is defined and governed by the legislative framework, which is often criticised for its policing approach (Aggarwal et.al. 2009).

Besides the policy and legal functions, MoEFCC supports the biggest plantation and capacity building programme i.e. National Afforestation Programme across the country (MoEFCC, undated). This programme promotes plantation of indigenous species which are important ecologically and economically. Bamboo is one of the main species that is promoted for plantations in suitable areas (ibid).

The Ministry of Agriculture (MoA) is a key stakeholder promoting bamboo plantation and development activities through the National Bamboo Mission (NBM) across India. NBM is a 100% centrally sponsored programme under Mission for Integrated Development of Horticulture (MIDH) in MoA. The emphasis of the National Bamboo Mission is on an area specific strategy to increase bamboo coverage through plantations in forest and non-forest areas, development and dissemination of appropriate technologies, promotion of bamboo markets along with the convergence and synergy amongst stakeholders (Salam 2013).

NBM was started in 2006 covering 28 states across the country, with special priority given to the NER. Guidelines for the scheme were prepared and circulated to all states and orientation workshops have been held in various states. The total budgetary allocation for the NBM is INR 5,680 million or approximately USD 142 million covering up to the 4th year of the 11th FYP (UNIDO 2014). Afforestation of bamboo in 0.24 million ha of forest and 0.14 million ha of non-forest land has been undertaken until March 2016 under the scheme (NBM 2016).

The North Eastern Regional Bamboo Mission (NERBaM) was launched by the North East Council (NEC) to coordinate the implementation of national policies on bamboo and to assist the 8 North East State Governments in formulating and implementing their respective policies of bamboo development (UNIDO 2014). NERBaM functions as the focal point for all aspects of bamboo development in the north-eastern region. The strategy of NERBaM is formulated in "Bamboo-2022" with a 15 year programme divided into 3 phases (ibid).

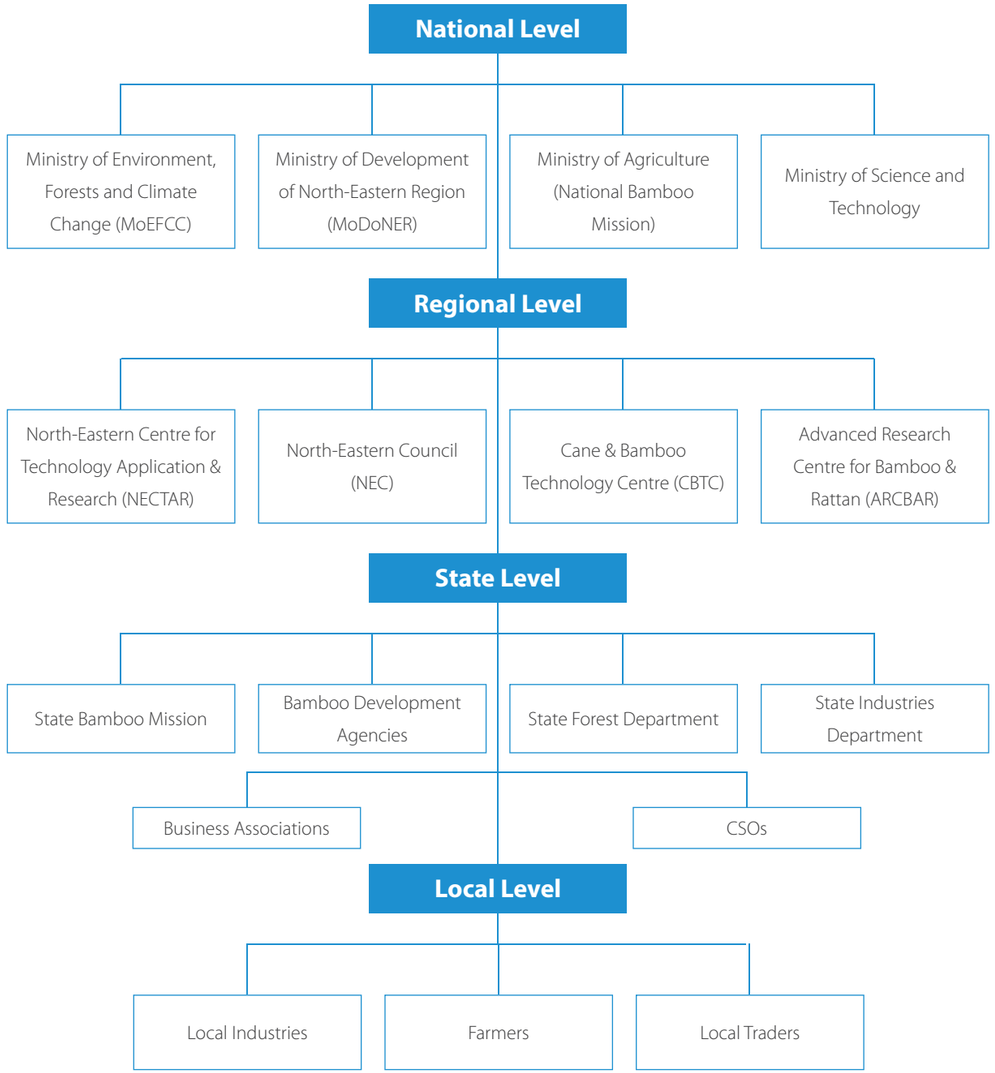

Figure 2.1: Bamboo stakeholders in north-eastern region

The Ministry of Development of North East Region (MoDoNER) is focused on the matters relating to the planning, execution and monitoring of development schemes and projects in the north-eastern region. Its vision is to accelerate the pace of socio-economic development so that it may enjoy growth parity with the rest of the country (MoDoNER, undated). Major development schemes in the regions are routed through the Ministry. In particular, it is responsible for the Hill Area Development Programme (HADP) and Border Areas Development Programme (BADP), as well as the Non-Lapsable Central Pool of Resources (NLCPR) of the region (UNIDO 2014).

The Ministry of Science and Technology coordinates some of the activities related to research, development and extension in the bamboo sector. Its two departments i.e. Department of Bio Technology (DBT) and Department of Science and Technology (DST) are linked to these activities. DBT promotes research on development of better yielding crops whereas DST is focussed more on application and extension activities of bamboo. The National Mission for Bamboo Applications (NMBA) was a technology mission under DST, which aimed to promoted new technologies in bamboo industry. It evolved into the North East Centre for Technology Application and Research (NECTAR) in 2012, which is focused on harnessing and leveraging niche frontier technologies available with central scientific departments and institutions for the north-eastern region (NECTAR, undated).

At the regional level, there are several organizations involved with planning, research and implementation activities. The North Eastern Council (NEC) is one of the most important stakeholders among them as all the government activities in the region are routed through them. NEC was constituted in 1971 to streamline and accelerate the development of the region. It has produced a vision document 2020 for the region, where bamboo development is one of the major livelihood improvement activities in the region (NEC, undated).

There are various centres related to bamboo, which are mandated to facilitate development and promotion of bamboo through research and extension in the region. These centres include the Advanced Research Centre for Bamboo and Rattan (ARCBAR), Aizawl, Cane and Bamboo Technology Centre (CBTC), Guwahati and the Rain Forest Research Institute (RFRI), Jorahat. The North East Centre for Technology Application and Research (NECTAR) has a regional centre in Shillong. RFRI and ARCBAR are involved in research activities related to biodiversity, productivity, and markets related to bamboo. CBTC is involved with development, training and extension of various products and technologies related to the cane and bamboo sectors. NECTAR is involved with development and marketing of user friendly technologies such as bamboo board initiative and furniture for the promotion of bamboo in NER. Again, discussion with staff at different centres suggests that these centres operate individually and hardly collaborate at institutional level.

At the state level, major stakeholders in the bamboo sector are the Forest department (SFD) and Industries department (SID). The National Bamboo Mission at respective states is implemented through State Bamboo Missions based at the SFDs. Certain north-eastern states such as Mizoram, Nagaland and Assam have Bamboo

Desk Study on the Bamboo Sector
in North-East India

Development Agencies (BDA) under the SIDs, which are engaged in promotion of businesses related to bamboo. These businesses include handicrafts, bamboo charcoal, furniture and various other products. BDAs help farmers with finance and technical support for the start of enterprises.

At the local level, farmers and micro to medium sized entrepreneurs are the most important stakeholders. Business associations and other civil society organizations (CSOs) are important players at the state as well as at the local level.

Despite the range of stakeholders working at different levels, there is only limited progress in the bamboo sector in North East due to the lack of coordination, credit facilities, skill development and appropriate extension (Baksy 2013).

Chapter 3 Bamboo Diversity and Uses

Bamboo diversity

Bamboo is among the perennial evergreens of the grass family *Poaceae*, subfamily *Bambusoideae*. Bamboos are perhaps the largest members of the grass family represented by 75 genera and 1,621 species across the world. They are distributed throughout the tropics and sub-tropics in the Asia, Americas, Africa and the Pacific. India has abundant bamboo resources of about 29 genera and 148 species (both wild and cultivated) (Sharma et.al. 2015). Of these, 3 genera are exotic and the others are indigenous. The major genera occurring in India include *Arundinaria, Bambusa, Cephalostachyum, Chimonobambusa, Dendrocalamus, Dinochloa, Gigantochloa, Indocalamus, Melocanna, Naohouseaua, Ochlandra, Oxytenanthera, Plaioblastus, Phyllostachys, Pseudostachyum, Schizostachyum, Semiarundinaria, Sinobambusa, Teinostachyum* and *Thamnocalamus*. Bamboos grow extensively in the Western Ghats and in the North Eastern States (Tripathi et.al. 2013).

Figure 3.1 represents the altitudinal distribution of bamboo species in the Himalaya. Bamboos are an integral part and keystone species of the natural forest ecosystems in the Himalaya, with bamboo forests occurring up to an altitude of about 1,500 m asl. While species of the genus *Bambusa* are limited to the tropical and subtropical zone, *Dendrocalamus* species also grow in oak and conifer forests of higher altitudes, and *Arundinaria spp.* can be found up to 3,500 m asl.

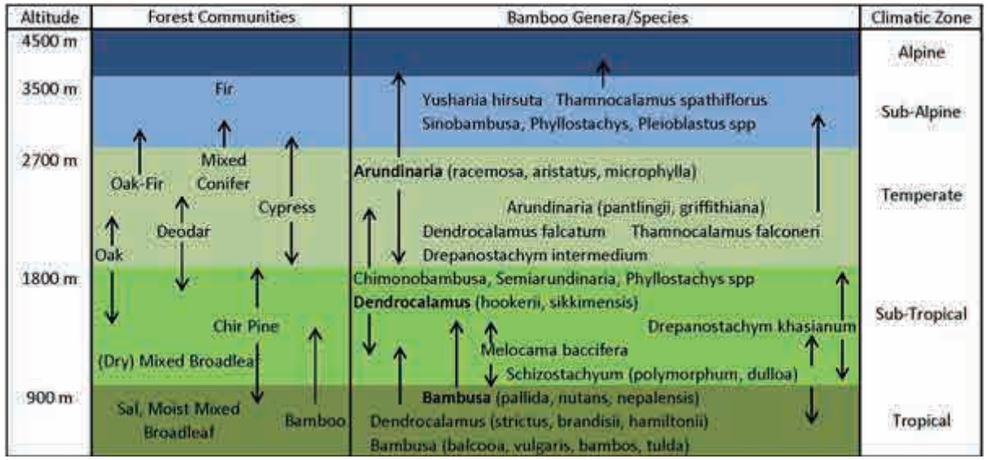

Figure 3.1: Altitudinal distribution of bamboo species in the Himalaya
Source: Kosemund 2015

About 28% of bamboo resources of the country are in the north-eastern region. Out of the total forest area, about 12.8% is under bamboo, and 2/3rd of the growing stock is located in the north-eastern states where bamboo is an important non-timber forest produce. About 89 species of bamboo grow in the natural forests and in the homestead plantations in plain rural areas (CBTB, 2008) (Table 3.1).

Table 3.1: Bamboo resources across the country and NER

	In the Country	In the NER
Number of genera	29	16
Number of species	148	89
Total area under bamboo	14.1 million hectares	3.10 million hectares

Source: ICFRE 2014, CBTB 2008 and Sharma et.al. 2015

The principal genera found in the North East are Arundinaria, Bambusa, Cephalostachyum, Chimonobambusa, Dendrocalamus, Dinochloa, Gigantochloa, Melocanna, Schizostachyum, Oxytenanthera, Phyllostachys, Pleioblastus, Sinarundinaria, Sinobambusa, Thamnocalamus and Thyrsostachys.

As far as bamboo species are concerned, the richest Indian state in regard to species diversity is Manipur with 53 species, followed by Arunachal Pradesh with 50 species. The most widely distributed and economically very important species are Bambusa bambusa and Dendrocalamus strictus. Bamboos find immense importance in every piece of life in the North East having great variable genetic resource of bamboo grown in almost every place of the region. Among them, six species viz., Bambusa balcooa, B. tulda, B. pallida, B. nutans, Dendrocalamus hamiltonii and Melocanna baccifera are being intensively used by the local population and hence, are economically very important. These species are widely distributed across the tropical and semi-tropical area in NER (RFRI 2013).

Species such as Arundinaria clarkei , A. debilis, A. kurzii, A. racemosa, A. rolloana , Bambusa arundinacea, B. auriculata, B. balcooa, B. burmanica, B. cacharensis, B. jaintiana, B. khasiana, B. kingiana, B. longispiculata, B. mastersii, B. nutans, B. oliveriana, B. pallida, B. polymorpha, B. pseudopallida, B. teres, B. tulda, Chimonobambusa callosa, C. griffithiana, Dendrocalamus calostachys, D. hamiltonii, D. hookeri, D. longispathus, D, patellaris, D. sikkimensis, Dinochloa compactiflora, D. gracilis, D. indica, D. maclellandii, Drepanostachyum kurzii, D. polystachyum, D. suberectum, Gigantochloaapus, G. hasskarliana, Melocanna baccifera, Neomicrocalamus clarkei, N. mannii, N. prainii, Oxytenanthera parvifolia, Phyllostachys mannii, Schizostachyum mannii, S. pallidum and S. wightii are predominantly found across various states of the north-eastern region (Biswas 1998).

Uses of bamboo

The National Bamboo Mission recognizes 13 commercial bamboo species in India of which in general the best quality is available in the NER: Bambusa balcooa, B.bambos, B.nutans, B.pallida, B tulda, B.vulgaris var. vulgaris, Dendrocalamus asper, D.giganteus, D. hamiltonii, D.strictus, Melocanna baccifera,Ochlandratra vancorica and O.parvifolia.

Literature regarding the multiple uses of bamboo highlights the utility of bamboo for house construction, bamboo ply, agricultural implements, handicraft, irrigation, brooms, medicine, food, fuel, fodder, paper and pulp, especially bamboo as a perfect substitute for some wood based products. An overview which bamboo species are used for the manufacture of different commodity groups is presented in figure 3.2.

Bamboo Species	Commodity Group	Size of Enterprise			
		Micro	Small	Medium	Large
All bamboos	Fuel (Charcoal/Energy)	■	■	■	
Bambusa balcooa, B. tulda, B. nepalensis, Dendrocla mus strictus, D. hamiltonii, Melocana baccifera	Food (Shoots)	■	■	■	
Bambusa vulgaris, B. tulda, B. nutans, B. pallida, Dendrocalamus brandisii, D. strictus, D. sikkimensis, Melocana baccifera, Schizostachyum polymorphum, S. dulloa, Thamnocalamus spathiflorus	Handicraft	■	■	■	
Bambusa balcooa, B. tulda, B. bambos, B. nepalensis, B. pallida, Dendrocalamus hamiltonii, D. hookerii, Arundinaria racemosa, Drepanostachym intermedium, D. khasianum, Melocana baccifera, Schizostachyum polymorphum, S. dulloa, Thamnocalamus spathiflorus, T. falconeri	Weaving Products	■	■	■	
Bambusa balcooa, B. vulgaris, B. tulda, B. nepalensis, B. nutans, B. pallida, Dendrocalamus strictus, D. hookerii, Arundinaria racemosa, Drepanostachyum khasiana, Melocana baccifera	Housing and Construction	■	■	■	
Bambusa balcooa, B. pallida, Melocana baccifera	Sticks/Agarbatti	■	■	■	
Bambusa bambos, B. balcooa, B. vulgaris, Dendrocalamus strictus, D. brandisii	Furniture		■	■	■
Bambusa bambos, B. tulda, B. balcooa, and various other	Boards and Flooring		■	■	■
Dendrocalamus strictus, D, hamiltonii, D. sikkimensis, Bambusa bacooa, B. vulgaris, B. bambos, B. tulda, B. nutans, Melocana baccifera	Paper and Pulp			■	■
Various bamboos	Textiles			■	■
	Other *	■	■	■	■
	* Medicines, Cosmetics, Beverages, Air and Water Purification, etc.				

Figure 3.2: Use of bamboo species and size of manufacturing enterprises
Source: Kosemund 2015

For a closer description, bamboo products may be grouped into:

- Wood Substitutes and Composites
- Industrial Use and Products
- Handicrafts
- Food Products
- Construction and Structural Applications.

• Wood substitutes and composites

This category of products essentially comprises of boards and sticks of varying descriptions and uses, and which can further be used to manufacture finished products like wooden floors or blinds or goes into another industry as an input like for incense sticks.

• Bamboo Based Panels and Flooring

China started producing bamboo panels in the early 19th century. Followed by the EU, with an export value of USD 30 million (26%), it exported some USD 65 million worth of bamboo plywood in 2012, accounting for 57% of the world export of bamboo plywood (INBAR 2014a). The largest importer of bamboo plywood is the EU, which contributed 30% of the world import of bamboo plywood in 2012, valued at USD 41 million (ibid). At present more than 20 different types of panels are produced in Asia (Lobovikov 2005). Bamboo fibre is longer than wood fibre, which gives bamboo some technological advantages. The panels are used in modern construction as structural elements or as forms for concrete mouldings. They are also used for flooring, roofing, partitions, doors and window frames. Bamboo panels have advantages over wooden board due to their rigidity and durability. Various types of bamboo veneers, panels and boards can be broadly classified as follows: veneers, strip boards, mat boards, fibreboards, particle boards, medium density boards, combinations of these, and combinations of these with wood and other lignocellulose materials and inorganic substances. Also composites of bamboo and jute are suitable to make panels (ibid).

Bamboo flooring is a premium product that has a large global consumer market. It has advantages over floors made of wood from trees due to its smoothness, brightness, stability, high resistance, insulation qualities and flexibility. Bamboo flooring has a soft natural lustre and maintains the natural gloss and elegance of the bamboo fibre.

China is the largest exporter of bamboo ¬flooring. The export of bamboo fl¬ooring from China to the world was valued at USD 333 million in 2012, about 91% of the world exports of bamboo ¬flooring (INBAR 2014a). The largest importer is the EU, with an import value of USD 47 million in 2012, accounting for 44% of the world import of bamboo fl-ooring (ibid). As per the survey conducted by the National Mission on Bamboo Application (NMBA), the real estate market in India was growing at the rate of 10% in year 2003-2004. Thus the potential for the bamboo flooring market is expected to be around 2.03 million square feet in India alone, which is equivalent to a value of INR 405 million (Brunner 2010).

• Bamboo Sticks for Blinds and Incense Industry

The art of making screens and blinds from bamboo is not new to India. For centuries, people have woven elegant screens from bamboo that have provided privacy, protection from the sun and added aesthetic appeal to living spaces.

Mechanised blind making units can be economically viable enterprises. Again, bamboo sticks making units can substitute the wood that is used in the incense stick (Photo 3.1). The production and market size of the sector is increasing tremendously in India and abroad.

Photo 3.1: Bamboo incense sticks

• Bamboo Furniture

The global export value of bamboo and rattan furniture products was USD 290.4 million in 2012, which accounted for 15% of the world export of bamboo and rattan products. Of this, Asia is the main exporting area of bamboo and rattan furniture products. In 2012, Asia exported a signi¬ficant amount of bamboo and rattan furniture products, accounting for 72% of the world export market, valued at USD 210.3 million (INBAR 2014a).

Photo 3.2: Traditional bamboo furniture

The category of bamboo furniture includes traditional products made of round or split bamboo (Photo 3.2) and also newer "pack-flat, knockdown" furniture, which retains physical, environmental and aesthetic qualities of bamboo while addressing shortcomings of variable quality, low productivity and high labour and transport costs.

• Industrial use and products

Traditionally the industrial use of bamboo was considered only for paper and pulp industry. However, in contemporary times bamboo has found multiple uses in industry such as generation of electricity, production of charcoal, oil and gas.

Several bamboo-producing countries, such as China and India, use bamboo for the production of paper and pulp. An advantage of paper made from bamboo is that its brightness and optical properties remain stable, while those of paper made from wood may deteriorate over time. The morphological characteristics of bamboo fibres yield paper with a high tear index, similar to that of hardwood paper. The tensile stiffness is somewhat lower compared with softwood paper. The strain strength is between that of hardwood and softwood papers.

Bamboo charcoal is used as a substitute for charcoal from trees or mineral coal. It can serve as a fuel, absorbent and conductor. The calorific value of bamboo charcoal reaches almost half of that of oil of the same weight and the absorption capacity of activated bamboo charcoal is six times that of charcoal from tress of the same weight (Gangopadhyay et.al. 2006). Bamboo charcoal is excellent for cooking and barbequing. Activated charcoal is used as purifier, disinfectant, medicine, in the pharmaceutical industry and in industrial processes for absorbing pollutants and excessive moisture.

• Handicrafts

A huge range of handicraft items are made from bamboo, many of which are woven from thin strips of bamboo. They include common objects for household use, such as baskets, bags, trays, vases, lamps and screens, as well as more decorative, creative pieces of art, such as models, toys, fans and carvings. As with most bamboo products, the market leader for bamboo handicrafts is China which exports 95% of the entire produce.

Data on the total export of bamboo handicrafts are difficult to determine, as few handicraft products have their own trading codes. However, according to the statistics of the Ministry of Textiles, India's exports of all handicrafts (excluding carpets and floor covering) averaged USD 2.0 billion during 2007- 2012 (MoT 2014). Estimates based on the population census, survey (NSSO), NCAER survey and other studies and information available for the unorganized cottage industry sector reveal that the annual growth rate of employment (both direct and indirect) in the handicrafts sector could be around 2.5% (MoT 2002). The sector is estimated to employ 68.86 lakhs artisans by 2014 and the export of handicrafts including handmade carpet up to October 2014 was INR 172,650 million (MoT 2014). According to INBAR, one important handicraft item that can provide an indicator of overall market trends is "bamboo and rattan baskets and wickerwork". In 2009, the total export value of bamboo and rattan baskets and wickerwork products was USD 435 million. Of this, bamboo articles accounted for just over half (USD 227 million) the amount.

• Food products

In the world, especially in developing countries, it is estimated that about 0.8 billion people do not have enough food to meet their daily requirements (FAO 2015) and further 2 billion people are deficient in one or more micronutrients (WHO 2015).

Photo 3.3: Bamboo shoots

Usually, food and nutritional insecurity to both rural and urban communities are due to farmer's dependence on few highly selective crops and loss of agrobiodiversity resulting in narrow food baskets. Bamboo shoots, if utilized properly, can contribute to alleviate this problem (Yengkopam 2013) (Photo 3.3).

Shoots refer to the young by a sheath covered bamboo plants that have newly emerged from the ground. They are usually 20-30 cm long with tapering at one end and weigh approximately a pound (Farelly 1984). The weight of bamboo shoots is dependent upon location, rainfall, watering and drainage conditions, soil fertility, depth of the soil, temperature, and pH (Choudhury et.al. 2011).

Bamboo shoots carry the potential of value added economic activity at the entrepreneurial and community level through cultivation, processing and packaging. Its use in food and cooking goes far back in history.

The shoots are rich in carbohydrate, proteins, minerals and moisture. Fresh shoots are nutritionally rich and healthy with very good organoleptic qualities (Choudhury et.al. 2012).

Bamboos with edible shoots in the north-eastern region include Bambusa balcooa, B. tulda, B. polymorpha, Chimonobambusa hookeriana, Dendrocalamus giganteus, D. hamiltonii, D. hookerii, D. asper, D. longispathus, D. sikkimensis, D. membranaceus, Gigantochloa rostrata, Melocanna baccifera, Phyllostachys bambusoides, Schizostachyum dullooa and Teinostachyum wightii (Bahar 2014).

Bamboo shoots are exported to Japan, USA, Germany, Saudi Arabia and Denmark by China and Taiwan, while in India the range of fresh and fermented products are prepared mainly for domestic consumption making curry after soaking in boiling water or to prepare pickles.

• Medicinal Value

Bamboo has for centuries been used in Ayurvedic and Chinese herbal medicine.

The shoots have a high nutritional value, low fat, and are good sources of fibre. Comparatively, the content of cholesterol is found less. Besides, bamboo shoots are rich in vitamins, cellulose, and amino acids. Presence of thiamine and niacin indicates that bamboo shoots are a good source of the vitamin B complex. They contain 17 different types of enzymes and mineral elements such as chromium, zinc, manganese, iron, cobalt, and copper (Bahar 2014).

Bamboo shoots are used to increase the appetite, decrease blood cholesterol, and can be regarded as a heart protective vegetable. The shoots of Bambusa arundinacea are pickled or steeped in oil for direct consumption or made into curries that are reported to promote appetite and help in digestion. The shoots and roots of Bambusa vulgaris possess diuretic, diaphoretic, and emollient properties. The young, tender shoots of Melocanna baccifera can be eaten raw and are considered an aphrodisiac. "Tabasheer" the powdered, hardened secretion from joints of this species is used to treat asthma and coughs (ibid).

• Construction and structural applications

Today, in India, bamboo is primarily used in construction as scaffolding and only to less extent for i.e. roofing or as composite material for walls.

In the north-eastern region, a large number of houses are made of timber and bamboo especially in the rural area (Sati et.al. 2014). After the great Assam earthquake of 1950, the traditional "Ekra" system, where woven bamboo is taken as in-fills for timber framed houses, has been improved and became a popular technique in NER as well as in Eastern Nepal and Bhutan (Photo 3.4).

Photo 3.4: Modern Ekra House in Shillong, Meghalaya
Source: Mohanty 2012

Many government buildings, hospitals, schools and private residences were constructed using this technique that proved to be earthquake resistant. Also other techniques like the Chitras of Meghalaya have lot of potential to provide solutions to the issues related to thermal comfort, affordability, security in the event of earthquakes and the sustainability of the environment. However, these are not encouraged and survive only as "poor man's housing", because of lack of building code, primitive tools and lack of professional interest (Mohanty et.al. 2012).

If appropriately leveraged, bamboo can be used to manufacture a multitude of products for the construction and infrastructure sector like corrugated roofs, trusses, wall composites, foot bridges, bus shelters, playground sets, granaries, storage sheds, water tanks and temporary shelters during natural disasters.

• Ecological benefits of bamboo

Role of bamboo in soil conservation and nutrient flux

There are numerous studies on the importance of bamboo forests in effective prevention of soil erosion, improvement in water retention capacity, and role in improving barren and semi-arid lands (Zhou et al. 2005; Ramakrishnan et al. 1993). In mountain areas of Japan, bamboo plays a significant role in preventing soil from acidification through returning the basic cations from the subsurface soil to the surface soils. Bamboo plays a key role in rehabilitation of degraded land by i.e. increasing organic matter, nitrogen, phosphorus and potassium in the soil nutrient pool through litter fall (Zhou et al. 2005).

The ability of the soil to supply nutrients and water depends on the interaction of a whole range of biotic factors and processes operating in the soil system (Ramakrishnan et al. 1993). Various studies have revealed the role of bamboos in soil nutrient conservation (Ramakrishnan 1989, Singh and Singh 1999, Arunachalam and Arunachalam 2002). Active nutrient cycling of vigorous bamboo growth and litter production improves soil fertility of habitats. Distinct requirements of soil conditions for different bamboo species could serve as a fairly reliable indicator of soil quality.

Bamboo also plays an important role in stabilizing nutrient and water cycling in the early successional fallows of slash and burn agricultural systems widespread in NER (Ramakrishnan 1989, Arunachalam and Arunachalam 2002). Nutrient supply from the mother plants to the young developing bamboo shoots decrease with the increase in age of parents due to the decline in physiological activities. While the moisture content in the bamboo culm decreases with age, the dry matter accumulation increases as a result of cell wall thickening, silica deposition and rapid lignification.

Role of Bamboo in carbon sequestration

Bamboo forests are an important carbon source and carbon sink (Li et.al. 2003). Through the mechanism of photosynthesis, bamboo turns CO2 into organic carbon and stores it in its shoot biomass, leaves and in soil. Bamboo has very vigorous growth. It is one of the fastest growing plants which reach its full height in two to four months.

Due to its rapid biomass accumulation and effective fixation of solar energy and CO2, bamboo can sequester carbon within a very short time (Lobovikov and Lou 2009). During degradation resulting from i.e. forest fires or pest attacks, it can become a source of carbon.

A recent life-cycle assessment of durable bamboo products made in China and sold in Europe found that they can be carbon negative. The credits through carbon sequestration and energy production in the end-of-life phase in an electrical power plant outweigh the emissions caused by production and transport. In other words, if production parameters are optimised, industrial bamboo products can have a negative carbon footprint over their full life cycle (Vogtländer and van der Lugt 2014).

Desk Study on the Bamboo Sector
in North-East India

However, on a global scale, bamboo keeps its negative carbon footprint only so long as the market for bamboo products continues to grow, placing more bamboo in long-lasting products such as construction materials, flooring and panels, and stimulating more bamboo plantation.

But also handicrafts (Photo 3.5) can help keeping bamboo's global negative carbon footprint if the products, when not any more fulfilling their designed function, are appropriately recycled or transformed into i.e. biochar that can persist over long time scales while ameliorating the soil (Woolf et.al. 2010).

Photo 3.5: Bamboo artisans in Aizwal, Mizoram

Chapter 4 Area, Growing Stock and Trade

Area and growing stock

India has 20% of the world's bamboo resources spreading across around 14 million ha of forest land (ICFRE 2014, Sarma 2014). The total growing stock of bamboo has been estimated to be 16.91 million metric tons, out of which 1.02 million metric tons of bamboo growing stock is available on areas outside designated forests (FSI 2011, FSI 2013).

There are differing estimates of the annual production of bamboo in the country. It ranges from 0.82 million tons per annum to 1.34 million tons (ICFRE 2011, FSI 2011). The average annual bamboo productivity in the country is less than one metric ton per hectare (ICFRE 2014).

The north-eastern region of the country, which comprises of eight states, is very rich in bamboo stock and diversity. About 3.1 million hectares of the area are covered by bamboo. In fact, 28% of the bamboo area lies in the region which has 66% of the total growing stock of the country (NBM, undated).

Figure 4.1 represents the bamboo bearing area across different states in NER. Arunachal Pradesh, Manipur and Mizoram are the states with the largest bamboo areas.

Density along with other factors can be a good indicator of the disturbance and degradation of vegetation. Table 4.1 represents the density of bamboo in various categories across different states.

Mizoram is the leading state with 226 km2 area of pure bamboo followed by Arunachal Pradesh. In the dense bamboo category, Arunachal has the largest area followed by Mizoram and Manipur. Arunachal also has largest area of scattered bamboos. Hacked bamboo clumps indicate degraded bamboo area, of which Assam has the largest area (ibid).

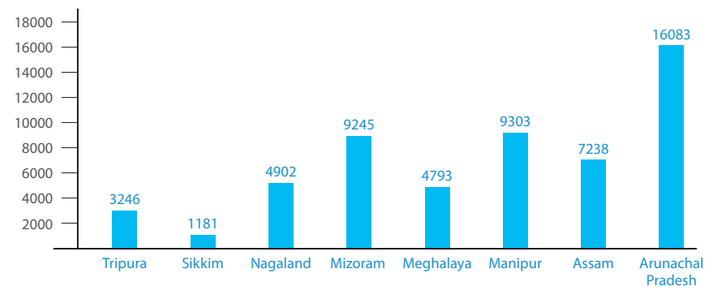

Figure 4.1: State-wise distribution of bamboo area in recorded forests (km^2)
Source: FSI 2011

Table 4.1: State-wise bamboo bearing area by density recorded in forests (km^2)

State	Pure Bamboo	Dense Bamboo	Scattered Bamboo	Bamboo present but clumps completed hacked	Bamboo re-generation
Arunachal Pradesh	217	8,681	6,953	144	88
Assam	105	4,049	2,878	166	40
Manipur	192	5,825	3,101	12	61
Meghalaya	63	2,815	1,830	68	17
Mizoram	226	6,116	2,757	104	42
Nagaland	101	3,064	1,644	65	28
Sikkim	0	481	684	8	8
Tripura	67	2,039	1,079	43	18
Total	971	33,070	20,926	610	302

Source: FSI 2011

Figure 4.2 represents the age and health of the bamboo culms. Green culms constitute a major share of all the culms across different states. Arunachal, Assam, Manipur and Mizoram have largest number of green culms across different states.

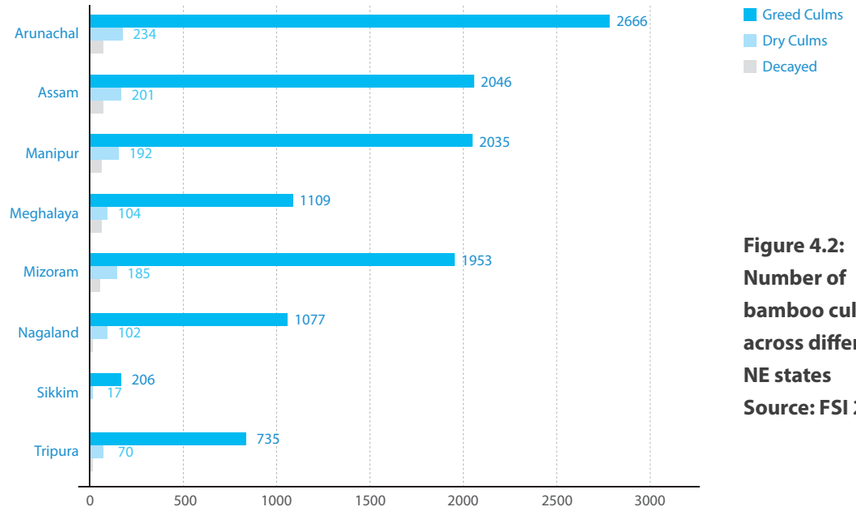

Figure 4.2: Number of bamboo culms across different NE states
Source: FSI 2011

Figure 4.3 represents the green weight of culms across various north eastern states. Arunachal, Manipur and Mizoram have the highest green weight of bamboo. It indicates growing stock and harvesting potential of bamboo across different states.

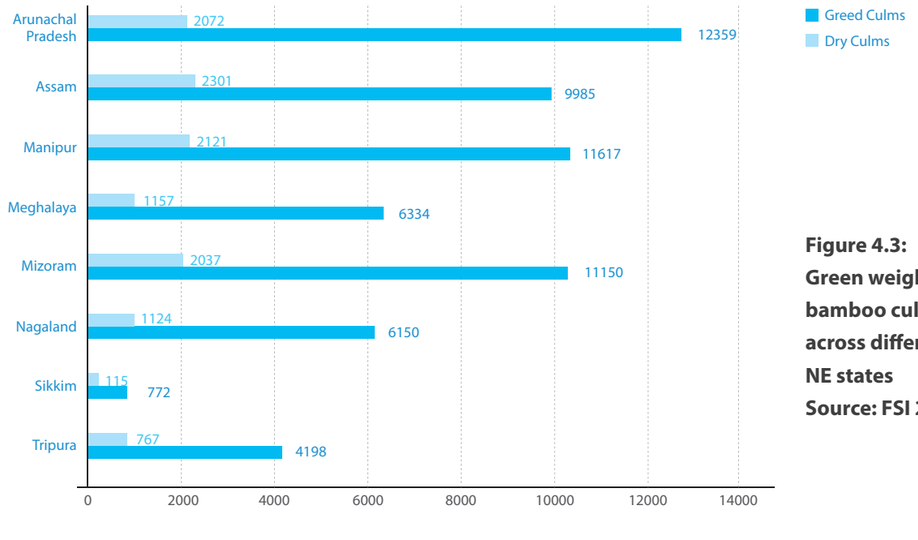

Figure 4.3: Green weight of bamboo culms across different NE states
Source: FSI 2011

Current use and trade

There are about 1,500 documented applications of bamboo, which include use as floor boards, bamboo mat corrugated sheets, bamboo mat boards, bamboo ply boards and bamboo particle boards. Various other products such as incense sticks, bamboo mats, bamboo slivers and strips are manufactured at the cluster level by the primary processors in the region (NEDFI, undated).

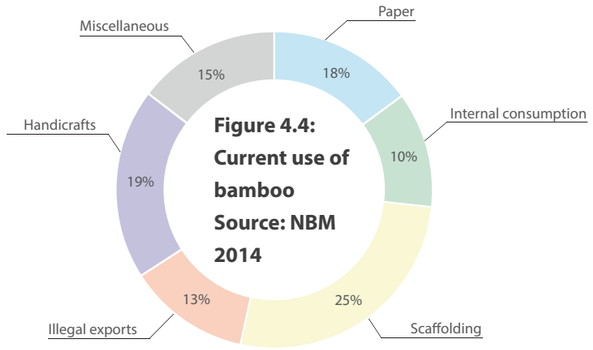

Figure 4.4: Current use of bamboo
Source: NBM 2014

Bamboo is universally utilized and traded in India and abroad. However, there is very limited recent data on these issues. Available data on use and trade vary widely which makes it difficult to rely on one source. Data from the National Bamboo Mission suggests that scaffolding, handicrafts and paper are the biggest uses. It is estimated that about 13% of the used bamboo is illegally exported (Figure 4.4).

There are different estimates of the size of the bamboo market in the country and the north east region. According to Sarma (2014) the global market of bamboo was INR 500 billion in 2001, which was expected to reach INR 1,000 billion in 2015. The size of the bamboo market in India was estimated to be INR 275 billion in the same year (ibid). Dhurga (2013) estimates bamboo trade in India worth INR 260 billion in 2015. The author further estimates that bamboo can reduce the import of timber by INR 300 billion by 2025 in the country (ibid). Salam (2013) estimates the bamboo market majorly consisting of wood substitute, processed bamboo shoots and industrial products to be worth INR 200 billion in 2015. INBAR (2002) also estimated the bamboo market in India to grow to INR 260 billion by 2015. Hence, estimates for bamboo market in India range from INR 200 to 275 billion for 2015.

In India, the total demand of various bamboo consuming sectors is estimated at 26.9 million tons. The estimated supply is 13.47 million tons, hence, only half of the total demands (Salam 2013). The pulp and paper industry, construction, cottage industry and handloom, food, fuel, fodder and medicine annually consume about 13.4 million tons of bamboo. The demand of bamboo for industrial use is met mainly from state owned forests, while for non- industrial purpose it comes from private as well as state owned resources (Salam 2013).

Table 4.2 and table 4.3 present the import and export data for bamboo and its products from the country. These data pertain to the year 2014 and have been sourced from the INBAR database. India imports around 250 million INR worth of bamboo and products and exports around INR 289 million which makes the net annual bamboo revenues from bamboo trade around INR 39 million.

One of the most predominant imported products is bamboo shoots which alone account for INR 131 million. Other important bamboo import items include mats, seats and flooring products (Table 4.2).

Table 4.2: Quantity and value of imported bamboo and its products

S.No	1	2	3	4	5	6	7	8	9	10	11	
Item	Raw bamboos	Bamboo shoots	Charcoal	Flooring/ shaped products	Panels	Mats/ matting/ screens	Plaits/ similar products	Basket works	Paper articles	Seats of bamboo/ rattan	Furniture	Total
Net weight (Qt)	418	11,024	15	599	263	1,531	62	496	59	859	443	15,770
Value (INR thousand)	3,661	131,128	341	18,969	1,412	32,587	4,041	18,693	2,448	24,968	11,827	250,075

Source: INBAR 2014b

India exports bamboo items worth INR 289 million. The most important export items are mats and screens followed by furniture and flooring products (Table 4.3).

Table 4.3: Quantity and value of exported bamboo and its products

S.No	1	2	3	4	5	6	7	8	9	10	11	
Item	Raw bamboos	Bamboo shoots	Charcoal	Flooring/ shaped products	Panels	Mats/ matting/ screens	Plaits/ similar products	Basket works	Paper articles	Seats of bamboo/ rattan	Furniture	Total
Net weight (Qt)	523	1,536	1,597	3,114	2,826	7,243	336	593	47	161	135	18,112
Value (INR thousand)	3,047	8,947	7,978	34,367	31,451	110,527	6,449	27,250	7,011	11,827	40,005	288,860

Source: INBAR 2014b

• North East market

It was estimated that harvest of bamboo from the north-east region was 8.11 million tons in 2002, which included harvest from all types of lands (INBAR 2002). Non forest areas contributed 5.7 million tons or 66% of the total produce, whereas forest areas contributed the rest of 34% (ibid).

The size of the bamboo market in NER is estimated to be INR 62.5 billion in 2015 (Sarma 2014). INBAR (2002) estimated that around 90 million tons of bamboo worth INR 50 billion was available from North East and that with value addition the bamboo market in the NER could be around INR 100 billion.

INBAR also carried out projections for investments, economic outputs, and employment generation in the bamboo industry in NER (Table 4.4).

Table 4.4: Economic output and projections of bamboo industry in NER

State	Total Direct Investment in Plant Machinery and Tools (INR million)	Other investment for infrastructure, coordinating body, lead district, bamboo processing zone (INR million)	Economic Output (INR million) (In addition to current generation)	Employment Generation (million person days) (In addition to current generation)
Arunachal Pradesh	170	750	1,610	9
Assam	270	750	2,110	12
Manipur	110	500	1,630	9
Meghalaya	220	500	2,030	11
Mizoram	140	500	1,890	11
Nagaland	100	500	1,990	11
Tripura	250	750	3,100	17
Total (NER)	1,260	4,250	14,360	80

Source: INBAR 2002

It has been estimated that with a total investment of INR 5.5 billion, an economic output of INR 14.36 billion can be attained (Table 4.4).

There are various sectors such as handicrafts, bamboo shoots, furniture, incense sticks and bamboo charcoal which can be explored and expanded in the region. It has been estimated that states such as Mizoram have huge bamboo potential and an industry worth INR 1,800 million could be created in the state (INBAR 2002). Some products such as bamboo shoots have great potential for development. The value of bamboo shoots on the international market is estimated INR 75,000 million where as in India the market size is still small (Borah et.al. 2008).

The bamboo sector has a high employment potential amongst the rural poor, especially women. It has been estimated that 432 million work days per annum are provided by the bamboo sector in India (Salam 2013). Around 0.12 million people are estimated to be employed in the bamboo related industry in NE India (Sarma 2014). INBAR (2002) estimated that the bamboo industry has the potential of generating 80 million person days of employment across different north-eastern states (Table 4.4).

Chapter 5 Best Practice Case Studies

Introduction

The National Bamboo Mission (NBM), National Mission on Bamboo Application (NMBA) and subsequently North East Centre for Technology Application and Research (NECTAR) and other government programmes have undertaken a number of initiatives to develop the bamboo sector in NER over the last decade. These initiatives range from productivity enhancement through plantations to development of new products. At the level of product development, efforts have been made to develop tools for processing, develop technology for conversion of bamboo and waste bamboo to activated carbon and refine processes for bamboo boards, furniture and other products (Madhab 2003). Efforts have also been made to finance through institutions such as the Technology Information Forecasting & Assessment Council (TIFAC), NMBA, North East Council, North Eastern Development Finance Corporation Ltd. (NEDFi) and various banks.

Despite these activities, the bamboo sector has achieved only a fraction of its potential due to several constraints like restrictions on bamboo use (Aggarwal 2014, The Times of India 2016) and partly unsound implementation practices of government development agencies (Kashyap 2016). However, there are promising traditional and new practices to be found in the region and country which have become sustainable and have the potential to further expand taking the bamboo sector forward. Some of these initiatives are presented in form of case studies in this chapter.

Case Study 1: Handicraft Production in Mizoram

• Background

Mizoram is a hilly state located in the southern part of north-east India (Figure 1.1). The northern part of the state is bordered by Cachar district of Assam and Churachandpur district of Manipur, whereas it is bounded by the Chin Hills and Arakan Hills of Myanmar from the east and south, respectively. Major part of the western side of the state is bounded by the Chittagong Hills of Bangladesh and few portions by Tripura state of India. The entire state is comprised of a terrain with steep slopes and gorges culminating into several streams and rivers. The forest cover of the state is the highest in the country with the majority of the area being covered by bamboo forests. The bamboo growing area in Mizoram is 924,500 hectares which is 44% of the State's geographical area. As per the ISFR report 2011, the growing stock of bamboo is estimated to be around 24 million metric tons (FSI 2011).

In order to sustainably harvest the bamboo stock and facilitate the economic value chains, a State Bamboo Policy was drafted in 2002. As per policy, the resource management is entrusted upon the Forest Department while the entrepreneurship development is being carried out by the Bamboo Development Agency under the Industries Department and NLUP.

• The story of Hnam Chhantu Pawl

Looking at the vast potential of the bamboo market inside and outside Mizoram, R. Ramhmangaiha, a resident and businessman of Aizwal, came up with the idea of initiating a society that would promote handloom and handicrafts goods and help artisans make a living through their skills. With this motto R. Ramhmangaiha together with four other people set on to establish a unit named Hnam Chhantu Pawl.

The NGO was established on 3rd March 1994 and commercially began operation in January 1997. With an initial contribution of INR 93,000 by the promoters, the project began on a small scale. The society had associations with another NGO called Hmeithai Association, based in Aizwal (NEDFi 2013).

With initial financial assistance of INR 37.00 lakhs from the North Eastern Development Finance Corporation (NEDFi), the Society started its production of handicraft and handloom items. Apart from NEDFi, the NGO also got a grant of INR 4.20 lakhs from the North Eastern Council (NEC) in 2003 and a cash credit limit of INR 5 lakhs from the Mizoram Co-operative apex bank. Initially, the NGO had only 7 members, but now it has over 50 regular members and over 1000 beneficiaries.

The NGO selects artisans from Below-Poverty-Line category and provides assistance to the income of these families. It offers micro-loans ranging from INR 10,000 to INR 50,000 to the members for making handicraft products.

Photo 5.1: Various handicrafts promoted by the NGO (Left), bamboo and cane furniture (Top right) and artisans being trained at the workshop (Bottom right)

The artisan members buy small machineries, raw material like bamboo and cane with this loan. The unit manufactures and sells handloom items, curtains, cushion covers, bed sheets, handicrafts, artefacts, upholsteries, photo frames and other products designed from bamboo (Photo 5.1).

Hnam Chhantu Pawl has its main workshop and showroom in Aizawl where residents of Lengpui and Sesawng villages are trained.

Hnam Chhantu Pawl has shown remarkable growth in the last couple of years with the opening of several handicraft stores in the city and exporting products to national and international markets.

The Bamboo broom promoted by Hnam Chhantu Pawl is fetching a good market both inside as well as outside the State (Photo 5.2). The production cost of these brooms is around INR 30 while they fetch a price of INR 50 locally and up to INR 100 in Delhi and other metropolitan markets. Bamboo brooms are likely to generate high levels of added value that are particularly important to the small family enterprises involved in its production.

Photo 5.2: Bamboo broom

Case Study 2: Bamboo Drip Irrigation in Meghalaya

For more than 200 years tribal farmers of the north-eastern part of India, in the state of Meghalaya, have been using an indigenous technique of bamboo drip irrigation to water their plantation crops. These farmers of the Jaintia and Khasi hill areas have developed a system of tapping springs and stream water to grow betel leaves, black pepper and areca-nut (Jeeva et.al. 2006).

The traditional technology uses locally available material like bamboo while harnessing the forces of gravity. An assortment of holed bamboo shoots zigzags downhill, diverting the natural flow of streams and springs across terraced cropland. The advantages of using bamboo are two-fold: it prevents leakage, increases crop yield with less water, and makes use of natural, local and inexpensive material (CSE India 2006).

• Terrain and water availability

The topology of the region is hilly with steep slopes and rock boulders. The soil depth on these hills is low and has poor water retention capacity. Though the region gets plenty of rain during the monsoon season, irrigation becomes a necessity during the dry season. The terrain imposes a challenge in bringing the water from distant water sources to the plantations. Diverting water through ground channels is not possible. Faced with this need for water and the challenges imposed by the terrain, the tribal farmers came up with a unique irrigation system (Singh et.al. 2001).

• Mechanism

The bamboo drip irrigation system is based on gravity and the steep slopes facilitate in implementing it (Photo 5.3). The sloped area should have at least 30 m in variation.

Water from an uphill source is tapped and brought to the plantation by a main bamboo channel.

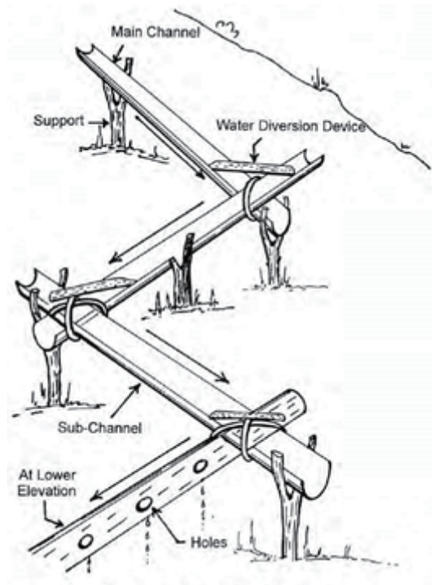

Photo 5.3: Construction sketch of bamboo drip irrigation system
Source: Singh et.al. 2002

Usually these water sources are far off from the plantations and the main bamboo channel runs hundreds of meters, in some cases even few kilometres. The water is then regulated through a complex bamboo network of secondary and tertiary channels to all the parts and corners of a plantation, right up to the bottom of the hill.

These bamboo networks usually have 4-5 diversion stages before water is delivered at base of the plant. 18-20 litres per minute of water from the main channel get reduced to 10-80 drops per minute at the end of the network. After a long journey, the water trickles or drips drop by drop at the base of the plant. Sometimes water is also diverted to distant houses for domestic use (Dabral 2002).

• Construction

Bamboos of varying diameters are used to build the channels, support structures, diversion pipes and strips (Photo 5.4). Channels are held above the ground by bamboo or wooden Y shaped sticks. One stretch of channel is lashed to another by thin bamboo strips. Indigenous tools like a "Dao", a type of local axe, and chisels of various shapes and design are used to build the bamboo network. Two labourers can construct a network covering 1 hectare of land in 15 days (CSE India 2006). They are built with such skill that water wastage by leakage is minimal. The construction is based on a simple rule of thumb; the ratio of diameter of primary channel to tertiary channel determines the quantity of water which will reach the trees. It is a subtle skill which comes with years of observation and experience.

Photo 5.4: Construction of bamboo channels
Source: Ministry of Agriculture, GOI

The cost involved in building the system is minimal. Bamboo is available freely in the area. Usually the farmer himself sets up the system in his plantation with the help from 1 or 2 labourers. The area gets heavy rain, so as a result each installation lasts for about 2-3 years. After the rainy season the undergrowth is cleared and reinforcements are provided. Old bamboo is left to rot, which over time returns to the soil as humus.

Cooperatives are formed and each farmer provides his skill and labour to build and maintain the system. The distribution of water from one plantation to another is done by diverting water at fixed timings. This avoids the occurrence of conflicts between various farmers. By this method the whole community works harmoniously, sharing the limited resources judiciously (CSE India 2006).

• Experiences of a farmer in Khasi Hills

Lan Pohtam, a farmer, owns 20 hectares of farmland in the Amlynpiang village in Khasi Hills near the Bangladesh border. His subsistence is dependent on cultivating areca nut, oranges, bayleaf and broomstick bamboo. Lan is using the age old technique of bamboo drip irrigation locally called "Shyngiar". He claims that Shyngiar is well-suited to the hills and their method of cultivating plantations. Lan earns around INR 2 lakhs a year. Maintenance of the system is limited to cleaning and reinforcement after seasonal monsoons, and labor can be carried out by farmers themselves (CSE India 2006).

Due to its easy availability across NER, bamboo can be extensively used for drip irrigation and can prove to be a boon for traditional agricultural practices (Krishnamurthy 2014).

Case Study 3: Bamboo for Production of Charcoal Briquettes in Nagaland

• Introduction

Nagaland is primarily an agrarian state where more than 80% of the population is dependent on agriculture and forest products. Bamboo is found extensively in Nagaland. It occurs as a predominant grass in parts of the districts of Dimapur, Peren, Mon and Mokokchung, and is found mixed with other forest species in all other districts. About 5% of the growing stock of bamboo of the country is in Nagaland which is about 448,000 hectares (NMBA 2009).

About 46 species of bamboo are known to occur in the state. The dominant species in Nagaland are Kako (Dendrocalamus hamiltonii), Dolo (Teinostachyum dulloa) and Jati (Bambusa tulda) (NBDA 2012).

Bamboo charcoal is traditionally used in Nagaland as a substitute for tree charcoal or mineral coal and is in demand during winter for warming houses, poultry farms and for barbeques during community and farming festivals. However, bamboo charcoal was not regarded as a livelihood option (Anand 2013).

• Institutional Development

The Nagaland Bamboo Policy was adopted in year 2004 seeking to develop bamboo as a resource and enterprise. In order to provide data to inform the State Bamboo Policy and to take action to mitigate youth migration and improve livelihood opportunities in bamboo flowering areas of Nagaland, a Nagaland Bamboo Development Board was established in 2005 (Anand 2013).

The Nagaland Bamboo Development Agency (NBDA) stresses on ways to convert the bamboo resource to charcoal, which can be used for energy and marketed to improve local livelihoods. In view of this NBDA initiated a plan to convert biomass into energy and at the same time promote bamboo plantation on a massive scale, mostly in areas where the bamboo had flowered, to help regenerate about 14,142 hectares of bamboo forests over a period of five years (2007–2012). The bamboo species planted were Bambusa tulda, Bambusa balcooa, Bambusa pallida, Dendrocalamus latiflorus, Dendrocalamus hamiltonii and Schyzostachyum dulloa. During this period approximately 0.31 million tons of biomass has been regenerated and about 0.17 tons of CO2/year has been sequestered by these measures.

Photo 5.5: Process of charcoal making
Source: Metha 2016

Institutions and associated stakeholders play an important role in improving local livelihoods by enhancing the value of bamboo through charcoal and briquette making, electricity generation, agroforestry, food and the associated activities like local enterprise development. With the assistance of the National Mission on Bamboo Application (NMBA), the NBDA has set up approximately 47 bamboo charcoal kilns, each with a capacity to produce 2,000 kg per cycle (operational time of five days) (Photo 5.5). NBDA set up two gasifier based 128 kWe and 35 kWe power plants and reinstated both when they failed, but lack of expertise and availability of mechanical parts has resulted in them becoming non-functional. During this period, Village Bamboo Development Committees (VBDC) were established across six districts which produced 23.5 tons of coal in each cycle and generated revenue of approximately USD 20,000 per annum.

Altogether this programme is helping around 142-250 persons. Indirectly, nearly twice as many people are working in the supply and distribution chain system for bamboo charcoal.

NBDA has been instrumental in securing best quantity prices for the community through appropriate support mechanisms, such as demand based collection point, training, incentives, and by facilitating local franchise for entrepreneurs (Anand 2013).

The agency is also actively focusing on existing bamboo resources, flowering areas and sorting of high and low cost bamboo species to help villagers access and utilise it in a sustainable manner. So far, 148 persons covering 28 villages have been trained and more than 60% of them are now charcoal entrepreneurs.

Recently, NBDA is marketing charcoal briquettes under the brand "Bam Grill" made from renewable bamboo wood, which is an ideal green fuel for barbeques or cooking as it is tasteless, smokeless, odourless, and substitutes conventional fuels such as coal. The current price of the product in the market is INR 200/3 Kg (Anand 2013).

Though NBDA activities are well received, the organisation faces several limitations in terms of financial and human resources and hence timely project execution.

Desk Study on the Bamboo Sector
in North-East India

Case Study 4: Tripura Agarbatti Sector

Agarbatti (Incense sticks or scented batti) have been used long since in religious prayers and have a special sanctity in the Hindu religion. They are also used largely at the household level as a room freshener or mosquito repellent. Agarbatti is a cottage industry, which can provide large-scale employment and increase the standard of living among the rural communities. Especially women can be beneficiaries as they are usually involved with primary processing of bamboo culms, i.e. producing slivers (incense stick core), although it constitutes only 2% of the final product value (Bordoloi et.al. 2009).

The demand for Agarbatti is increasing both in the domestic and export markets because of the improvement in quality and increase in the types of products. India is the largest producer of Agarbatti in the world. The current value of the Agarbatti industry is placed at INR 18,000 million with an annual growth rate of about 20%.

• Market potential of Agarbatti industry

In 2003, the annual domestic market for incense sticks was valued at USD 400 million with a yearly growth rate of 20% (Bordoloi et.al. 2009). In addition to this large domestic market, the international demand for incense sticks is growing rapidly. From 2001 to 2003, India's Agarbatti export increased from USD 36 million to USD 44 million.

Besides the Asian community shops, a number of fair trade shops and retailers in Australia, Europe and North America now stock extensive lines of incense sticks with India operating as a major supplier. Agarbatti is used by almost all communities in India, Sri Lanka, Burma and by Indians residing abroad. In addition to regular perfumed incense sticks, there is a great potential for products such as herbal incense sticks, air-fresheners, aromatherapy incense and mosquito repellent.

As of today about 90 foreign countries are using Agarbatti and the rising demand for the products has led the industry to orient itself increasingly towards exports. (Bordoloi et.al. 2009). The north-eastern region has huge potential of increasing the market by INR 300 million through mechanization of the splint making process and increasing the production (ibid).

• Value chain of Agarbatti sticks in Tripura

Chakmaghat is a point on the banks of the Khowai River which is around 5 km from Teliamara and around 55 km from Agartala. Here bamboo is lifted from the river on to the trucks that move to Agartala. The bamboos are brought from places like Ganganagar, Jalsara, Jigalsarai and Munasara, which are around 60-80 km from Chakamaghat. The tribal villagers make rafts of bamboo and take it to Chakmaghat. Normally it takes around three days to bring these bamboos from those faraway places to Chakmaghat. The procurement price at Chakmaghat is INR 350 -380 per 100 poles for small diameter bamboo and can reach up to INR 500 per 100 sticks. The procured bamboo from Chakmaghat is sold for INR 7/stick (Bordoloi et.al. 2009).

• TRIBAC's cluster-based sustainable enterprise development model

In 2003, the Tripura Bamboo and Cane Development Centre (TRIBAC), a former agency of INBAR, attempted to address problems of increasing costs of production for local artisans due to shortages of bamboo caused by the mass flowering in 2002. TRIBAC aimed to redress bamboo resource losses, generate employment and increase returns to women in the bamboo sector (Rao et.al. 2009).

TRIBAC is working in Tripura to promote cluster-based sustainable micro, small and medium enterprise development. It has also initiated to produce own branded hand rolled scented Agarbatti through developing the marketing capacity of self-help groups (SHGs). At Gandhigram Crafts Processing Centre, the finished scented Agarbatti is prepared and marketed locally under the brand names of Neermahal, Rangamati and Longtrai. TRIBAC is also producing mosquito herbal Batti through community SHGs members. Additionally, TRIBAC focused on micro finance need of the artisans (Bordoloi et.al. 2009).

The success of TRIBAC is attributed to its village extension system, wherein a network of 71 young men and women reached out to 4,600 households and 331 SHGs through projects including Batti-rolling. While the traditional value chain features only the stick being manufactured in Tripura with the remaining 99% of the value accruing to agencies and companies near production centres in South India (Bangalore and Mysore), TRIBAC helped to extend the local chain to Batti manufacture as a result of which now 10% of the value accrues to Tripura's villagers (Rao et.al. 2009).

TRIBAC has provided Agarbatti enterprise and livelihood training to over 3,200 men and women. In 2008, its operations covered 25 villages, benefiting 1,387 people, of whom almost 95% are women, and the interventions have raised incomes in the Agarbatti sector by 86-88%. Scenting and packaging processes contribute further to value addition, which together add 60% to the value of the product (the final 30% accruing from marketing) and ensure that locals are able to capitalise on more of the gains from value addition (ibid).

The model of a cluster-based enterprise has resulted in a significant increase of incomes from Agarbatti-related work and employment opportunities. Only the extension of the value chain to Batti rolling generates 11 jobs for every stick maker. The average monthly income from bamboo stick production of a new or inexperienced entrant, calculated on full-time basis, has gone up by 86% from monthly INR 700 in 2005 to INR 1,300 in 2008. Similarly, income from rolling batti has increased from INR 770 to INR 1,440 during the same period, an increase of 88%. Experienced persons, who currently constitute around 27% of producers, can earn up to INR 1,950 per month from stick making and INR 4,000 per month from Batti rolling on a full-time basis.

Considering that 80% of those participating did not earn any income before and the remaining 20% mostly had an average monthly income of just INR 25, the earnings represent a remarkable increase in income. For production of inputs used in Batti making, the monthly income realized is INR 130 for charcoal making and INR 1,980 for processing Jiggat (Rao et.al. 2009).

The experience of TRIBAC indicates the success of near-source value addition can help poor people earn better livelihoods. It further points out towards the potential of decentralised production and value chains, accompanied by appropriate marketing channels and finance schemes, and highlights the importance of extension at the community level.

Case Study 5: Bamboo School Furniture in Gujarat

• Background

The Centre for Indian Bamboo Resource and Development (CIBART) is an independent non-profit organization working for over a decade to foster livelihood development, ecological security and sustainable use of bamboo and rattan. CIBART is actively promoting furniture made out of bamboo to its domestic consumers, institutions, government departments, forest departments and schools.

Under its Bamboo Livelihoods Business Enterprise Project, CIBART is working towards strengthening bamboo production and processing by South Gujarat tribal community members, enabling commercial market linkages and achieve sustainable employment, enhanced income and improved quality of life. Tribal group members belonging to the Kotwalia community (basket weavers) are the target beneficiaries and have been trained intensively in the furniture making process since 2010. One of the furniture items promoted by CIBART is "School bench" as there is a large demand for school desks and benches.

• Public administration kick-starts bamboo sector development

In 2011, CIBART supplied school benches to the Ekalavya Model Residential School, a government run school in Songadh, Tapi district. Based on the positive feedback from the school authorities, CIBART targeted all government schools in the state.

After assessing the product quality and durability, in a governing body meeting of Gujarat State Tribal Development Residential Educational Institutions Society, it was decided that all Society managed schools will procure the school furniture through CIBART.

Photo 5.6: School bench, Gujarat

Comfort of the design and style were tested in workshops with students and school authorities, and on the basis of the feedback and inputs received the desk top has been changed by introducing bamboo ply (Photo 5.6).

Currently, 13 schools in 3 districts across the state of Gujarat house more than 515 bamboo furniture. The comfortable, strong yet lightweight bamboo furniture is in high demand in the schools in many districts in Gujarat. Increased school bench orders have brought about significant long term benefits to the rural communities by providing employment opportunity thus improving their life (Rathna 2016).

The initiative has been a major success in the sector as bamboo furniture has officially been mainstreamed for the first time in the country.

Case Study 6: Household Charcoal in Gujarat and Rajasthan

• Introduction

Every day, like 500 million women around the world, Keli Bai Reshma is using wood from trees and bamboo when preparing the two to three daily meals for her four children and her husband as daily part of the family life. But recently, cooking has become more than that, it has become an opportunity to make cash. An initiative has helped her realize that the firewood she was burning for cooking inadvertently became charcoal; if she removed it from the stove after cooking was done and sprinkled water on it on time to stop it turn into ash, she could produce up to 0.8 kg a day. In a week, that would be as much as 5.6 kg. At INR 8 per kg, INBAR and NGO partners CIBART (Gujarat) and Jan Chetna Sansthan (Rajasthan) made Keli Bai Reshma and many other women realize the income they can make from an activity they do twice or more a day, every single day of the year.

• Transforming consumers into producers and entrepreneurs

Instead of throwing the waste charcoal away like they used to, women collect the charcoal in a basket and carry it every week to her local collection centre (Photo 5.7). This brings them each an average of INR 180 per month; in a year over INR 2,000 without any additional work.

Photo 5.7: Women weighing household charcoal at collection centre
Source: Rao 2014

Once gathered at the collection points by a community-owned cooperative, the charcoal is brought to the briquetting factory that pulverizes the charcoal and densifies it into inexpensive, high calorific value briquettes for which demand is rapidly growing. The briquetting company itself is the result of a multi-investor equity through an NGO-Community-Private Sector Partnership. The money invested by the NGO goes into a revolving fund to be reinvested in development projects for replication and up-scaling. The community benefits directly and immediately from the profits. Rural community savings are presently reaching significant amounts and lack attractive opportunities for investment. In the case of Gujarat and Rajasthan, every participating woman has invested INR 100 (Rao 2014).

This new regular income opportunity makes households credit-worthy and empowers women economically.

Moreover, the power of collective thinking leading to more ideas for change within the community, "consumables for charcoal" is one of those: instead of buying products individually, they are now thinking of buying commodities in large quantities from the manufacturer and distributing them in exchange for charcoal – the value derived from charcoal would increase 3-fold.

But more than the economic profits, charcoal collection has become a festive outing for at present 8,000 women in Rajasthan and 4,000 women in Gujarat, and meals themselves have gained a new dimension. In Rajasthan, at an earlier stage of growth, the 6,500 women that were then gathering charcoal in their household collected 235,000 kg in the first 41 days with a daily collection of 5 tons.

Successful Joint Forest Management Community programmes provide a framework for collecting firewood sustainably without contributing to forest degradation. This is key for a supply chain that aims at being green and sustainable from supply to consumption and that needs to reach out to a minimum of 12,000 households to be viable with a strong potential to reach even larger scales. Records of charcoal collection are rigorously kept to ensure that the amounts produced are kept within the average amounts and that no firewood has been burnt solely for the purpose of producing more charcoal.

Even more, the initiative has become an incentive for growing trees and bamboo in homesteads and on farm boundaries. 30,000 bamboo plants have already been purchased in Rajasthan and training was provided on growing (INBAR 2016).

Chapter 6 Note on Gender in the North East

Defining gender equality

According to a UNESCO baseline definition, "Gender Equality is based on women and men being full partners in their home, their community and their society." (UNESCO, undated). The partnership does exist but not an equal one. Equality does not mean that women and men will become the same but that women's and men's rights, responsibilities and opportunities will not depend on whether they are born male or female.

Gender equality implies that the interests, needs and priorities of both women and men are taken into consideration, recognizing the diversity of different groups of women and men. On breaking the above down regarding partnership in home, community and society, and applying it in the regional context, a clear disregard for gender equality is evident.

Gender in North East

Women in the North East enjoy better status in the society as compared to the women in the rest of the country. And no new reforms can be given credit for this.

It is known that every society is a depiction of its cultural history, and it ascertains the role of men and women in the society. These roles have been cultivated over centuries and passed on for generations. As a result, there is a strict sexual division of labour in every household, which bars the men from worrying about the household related chores and prevents the women from taking the decisions related to their life or even the lives of others around them. This is the status that these "envied" women from the North East enjoy.

The north eastern women have been slightly more privileged as they did not have to face male dominance of the extent as faced by the more oppressed in the rest of India. They have been a prominent part of the daily landscape from farming, selling articles, weaving and other activities characterising life in the region. Overall the north eastern region has been free of any social sanctions, stigmas or taboos imposed on women (Malsawmdawngliana and Rohmingmawii 2015).

However, all is not as rosy as it appears. The large public opinion held is only on the basis of the socially visible roles played by women in the society. Even though the women are free to socialize, get education, work in factory and roam about unveiled, they are inconspicuous in any decision making roles or positions of administrative or societal power.

Overcoming the silence

It is suggested that the high potential women from the north eastern India should be mainstreamed and rewarded for their contribution by giving them the confidence and by building confidence in their decision making potential.

For this sensitization/ awareness drives discussing gender equality should be organized and local institutions should be encouraged to empower women and provide them the platform for participation in undertaking larger roles in the society and administration. Gender based evidences of success should also be widely circulated and communicated in order to motivate inclusion of more women for meaningful participation in decision making (Brara 2013).

Social attitudes and discriminatory cultural beliefs or stereotypes must not be perpetuated in the family, rather a neutral and healthy environment should be cultivated to ensure that the true potential of all its members, irrespective of their gender, can be tapped

Chapter 7
Conclusion

AThe north-eastern region (NER) is the "Bamboo hub" of India as it covers 28% of the geographical area and 66% of the growing stock of bamboo in the country. Arunachal Pradesh, Manipur and Mizoram are the leading bamboo states with large area under bamboo and substantial growing stock. Mizoram and Manipur have the largest area under pure bamboo brakes. The region has a stock of 62.5 million tons of green culms and 11.69 million tons of dry culms, and is rich in bamboo biodiversity as well. Out of the 29 genera and 148 species found in the country, 16 genera and 89 species are found in NER.

Bamboo constitutes an integral part of socio-cultural and economic life in NER. It is used for food, energy, house making, agriculture and various other purposes. There is no current reliable data available on the annual harvest of bamboo from the region. An INBAR study suggests that annual harvest from the region was 8.1 million tons in the early 2000s. However, other government sources put country's relatively recent annual production between 8.2 million to 13.47 million tons (FSI 2011, ICFRE 2011). Hence, it is difficult to reconcile these data. Based on these data and assuming a 60% of the harvest from NER, it can be estimated that the current annual production of the region may be between 5 and 8 million tons (dry weight).

There are a range of stakeholders from national to local level, which are engaged in the bamboo sector in the region. The National Bamboo Mission (NBM) under the Ministry of Agriculture is one of the main stakeholders promoting bamboo development activities across the country. Similarly, the Union Ministry of Environment, Forests and Climate Change (MoEFCC) and the Ministry of Development of North East Region (MoDoNER) are engaged in promotion of the sector through financial support and activities under different schemes.

At the regional level, the North Eastern Council is one of the most important stakeholders responsible for regional development, and research centres like the Advanced Research Centre for Bamboo and Rattan (ARCBR), Aizawl, the Rain Forest Research Institute (RFRI), Jorahat, and the North East Centre for Technology Application and Research (NECTAR), Shillong, provide support to the development of the bamboo sector.

At the state level, departments such as the Forest Department (SFD) and Industries Department (SID) are major stakeholders. SFDs are involved with plantation and productivity enhancement whereas SIDs are involved in the promotion of bamboo based industries. Stakeholders at local level are entrepreneurs, farmers and village institutions, and business associations are players at both local and state level.

Desk Study on the Bamboo Sector
in North-East India

The Government of India along with various regional and local stakeholders has been trying to promote bamboo production, its value addition and trade in the region. The market of bamboo and its products in NER is estimated to be INR 62.5 billion with a potential to grow up to INR 100 billion with value addition and further improvements.

There are some successful cases of bamboo use and entrepreneurship in the region such as the use of bamboo in drip irrigation in Meghalaya, manufacturing and trade of incense sticks in Tripura, and production of bamboo charcoal and briquettes in Nagaland. These and cases from Gujarat and Rajasthan like the production of school desks and household based charcoal production point toward some common factors such as urgency or need, ease of the technology, institutional model, financing, and guidance and support by competent or influential actors in the sector as well as access to information that seem to be essential for initiatives to be successful.

There are numerous issues constraining the growth and development of the sector. Some of these issues relate to the sector but many are lying outside it. Issues related to infrastructure, connectivity, skilled labour and limited labour force combined with increasing migration of young well educated people due to lack of livelihood opportunities (Kollmair and Hoermann 2011), credit facilities and difficulties to access credits are overarching issues that constrain development in NER.

Issues related to the bamboo sector in the region include low productivity, discouraging policies and tax structure, lack of technical know-how and innovation, lack of appropriate coordination, and poor awareness and access to markets encompassing dependence on local markets for selling products, sourcing, changing demand patterns, and branding and quality standards.

Though several especially extra-sectorial issues plaguing the bamboo sector in NER are long term with little prospect of being solved in reasonable time, issues that hamper development with good chance to be resolved in short or medium term need more attention and must be more effectively addressed through concerted action than it has been practised in the past.

The government can play a crucial role in bringing the bamboo sector forward by setting conducive framework conditions in consultation with other stakeholders and by supporting technical extension, creating information and trading centres and providing incentives for promising initiatives that serve private sector development and maintain or enrich the common resources.

Taking action to release the to date hardly tapped potential of smallholders, young entrepreneurs and women is, particularly for rural areas like NER with its plentiful resources of bamboo, seen as a key for inclusive and sustainable economic development.

References

Aggarwal, A, Paul V and Das S,2009: Forest resources: livelihoods, degradation and climate change in Green India 2047 renewed: looking back to change track, The Energy and Resources Institute, New Delhi , pp 91-108

Aggarwal, V.; 2014. Documenting state level restrictions in top 10 bamboo growing states in India. CCS Researching Reality Summer Internship 2014. Working paper: 329.

Anand, J. and Nambi, A.; 2013. Emerging institutional perspectives: A case study on managing bamboo resources for charcoal production in Nagaland, India. Issue 61: Climate Change: Adaptation, Resilience and Energy Security, Boiling Point, HEDON.

Arunachalam, A. and Arunachalam, K.; 2002. Evaluation of bamboos in ecorestoration of 'jhum' fallows in Arunachal Pradesh: ground vegetation, soil and microbial biomass. Forest Ecology Management. 159: 231–239.

Bahar, N.; 2014. Contribution of Bamboos in Livelihood of North-Eastern Region of India. Indian Forester, [S.l.], p. 674-678, jul. 2014. ISSN 2321-094X.

Baksy, A.; 2013. The bamboo industry in India supply chain structure, challenges and recommendations, CCS working Paper 283.

Benton, A., Cronin, T., Frith, O., Jonkhart, J. and Wu, J; 2011. Market potential of bamboo and rattan products. INBAR Working Paper 63. International Network for Bamboo and Rattan, Beijing.

Biswas Sas; 1988. Studies on bamboo distribution in North-Eastern region of India. Ind. For. 114(9):514-531.

Borah, E.D., Pathak, K., Deka, B., Neog, D., Borah, K.; 2008. Utilization aspects of Bamboo and its market value. The Indian Forester 423–427.

Bordoloi, B. and E. Sarmah; 2009. Project report on feasibility study for establishing agarbatti manufacturing units in north-east India and developing a comprehensive marketing strategy for CBTC- Basix Brand of Agarbatti.

Brara, V.; 2013. Gender Analysis for Climate Change Adaptation North East Region, Natural Resource Management Programme (GIZ), India.

Brunner, H-P. W. (Ed.); 2010. North East India – Local Economic Development and Global Markets. Sage Publications India.

CBTC; 2008. National Mission on Bamboo Application, One year of National Bamboo Mission in the states of NE Region, West Bengal, Orissa, Jharkhand, and Bihar 2007–2008, Cane and Bamboo Technology Centre (CBTB), Guwahati.

Choudhury, D., Sahu J.K., Sharma, G.D.; 2012. Value Addition to Bamboo Shoots: a review, J Food Science Technol. 49(4): 407- 414.

Choudhury, D., Sharma, G.P., Sahu, J.K.; 2011. Bamboo Shoot Based Fermented Food Products: A Review, J Sci Ind Res. 70: 199-203.

CSE India, undated. Bamboo Drip Irrigation. http://www.cseindia.org/node/2839 (Accessed 8 July 2016).

Dabral,.P.; 2002. Indigenous Techniques of Soil and Water Conservation in North Eastern Region of India", 12th ISCO Conference, Beijing 2002.

Dhas, S.R., Jeeva, N., Laloo, R.C., Mishra, B.P.; 2006. Traditional agricultural practices in Meghalaya, North East India, , Indian Journal of Traditional Knowledge, 5(1): 7-18.

Dhurga, S.; 2013. Indian Marketing of Bamboo, Indian Journal of Applied Research, 3(6): 388-389.

Farelly, D.; 1984. The Book of Bamboo, (Sierra Club Books), San Francisco, California.

FSI; 2015. India State of Forest Report 2015. Forest Survey of India, Government of India. http://fsi.nic.in/details.php?pgID=sb_62 (Accessed 14 July 2016).

Gangopadhyay, S., Khan, A.U., Hazra, A.; 2006. Industrialisation of the Bamboo Sector in India. Published by CII. 2006 Edition.

Government of India, Planning Commission, National Transport Development Policy Committee; 2012. Report of the Working Group on Improvement and Development of Transport Infrastructure in the North East for the National Transport Development Policy Committee.

ICC and PWC; 2013. India's North-East Diversifying Growth Opportunities.

ICFRE; 2014. Proceeding of National Seminar "Bamboo Productivity in Forest and Non – Forest Areas", 30 to 31 January, 2014, Indian Council for Forest Research and Education, Dehradun.

INBAR; 2016. An Innovative, Scalable, Pro-poor Home Cooking-based Charcoal Production Value Chain For Women. IFAD Grant Fact Sheet.

INBAR; 2014a. International Trade of Bamboo and Rattan 2012.

INBAR; 2014b. INBAR Bamboo And Rattan Trade Database: http://trade.inbar.int/ (Accessed 10 July 16).

INBAR; 2002. Country Report India. Bamboo Value-Added Industry. Market opportunity Assessment and Entry strategy. International Network for Bamboo and Rattan.

Jalyatra, undated. Exploring India's Traditional Water Management Systems, Chapter 5 Shillong: Betelnuts and bamboos, http://www.jalyatra.com/chapters/shillong_final.pdf (Accessed 10 July 2016).

Kashyap, S.G.; 2016. Left in lurch by 'failed' Bamboo Mission, units now face suits for loan recovery. http://indianexpress.com/article/india/india-news-india/left-in-lurch-by-failed-bamboo-mission-units-now-face-suits-for-loan-recovery-2939928/ (Published July 28, 2016).

Kollmair, M. and Hoermann, B.; 2011. Labour Migration in the Himalayas. ICIMOD.

Kosemund, W.; 2015. Woody Grasses in the Himalaya: Opportunities for Fostering Development and Resilience. Presentation at the International Mountain Forestry Symposium, Dehradun, 18 to 22 January 2015.

Kotecha, P.V.; 2008. Micronutrient Malnutrition in India. Let us say "no" to it now, J Commun Med. 33: 9-10.

KPMG and FICCI; 2015. Emerging North East India: Economically and Socially Inclusive Development Strategies. https://www.kpmg.com/IN/en/IssuesAndInsights/ArticlesPublications/Documents/KPMG-FICCI-North-East-India-2015.pdf (Accessed 14 July 2016).

Krishnamurthy, R.; 2014. http://permaculturenews.org/2014/02/28/bamboo-drip-irrigation/ (Accessed 14 July 2016).

Li, Z.C., Fu, M.Y., Xu, D.Y.; 2003. Bamboo ecosystem and carbon dioxide sequestration, Journal of bamboo Research. 4: 1-6. (In Chinese with English summary).

Lobovikov, M. and Lou, Y.P.; 2009. The poor man's carbon sink. Bamboo in climate change and poverty alleviation. Non-wood Forest products. Working document (FAO), Rome (Italy). Forestry department. 68p.

Lobovikov M, Paudel S, Marco P, Hong R and Junqi W., 2005. World bamboo resources: A thematic study prepared in the framework of the Global Forest Resources Assessment. http://www.fao.org/docrep/010/a1243e/a1243e00.htm (Accessed 18 August 2016).

Madhab, J.; 2003. National Bamboo Mission, Ministry of Agriculture, Government of India; The Bamboo Policy of Mizoram, 2002.

Malsawmdawngliana and Rohmingmawii; 2015. Mizo Narratives: Accounts from Mizoram, (Scientific Book Centre), Guwahati, India.

Metha Tolto; 2016. "Nagaland Bamboo Development Agency". Presentation.

MOA, undated. Let Green Reign Forever- A film of Bamboo Drip Irrigation in Meghalaya, Ministry of Agriculture, Government of India.

MoDoNER, undated: About the Ministry, Ministry of Development of North East Region, http://mdoner.gov.in/ (Accessed 15 June 2016).

MoDoNER; 2008. Report on Poverty Eradication 2008. Ministry of Development of North Eastern Region, Government of India. http://mdoner.gov.in/content/report-poverty-eradication-2008 (Accessed 15 June 2016).

MoDoNER and NEC; 2008. North Eastern Region Vision 2020. Ministry of Development of North Eastern Region and North East Council, Government of India. http://mdoner.gov.in/content/vision-document (Accessed 15 June 2016).

MoEFCC, undated: National Afforestation Programme. http://naeb.nic.in/documents/NAP_intro.htm (Accessed 20 June 2016).

Mohanty, S. et. al.; 2012. Bamboo as a Green Engineering Material in Rural Housing and Agricultural Structures for Sustainable Economic Growth. Indian Council of Agricultural Research, National Agricultural Innovation Project Component 4.

MoT; 2002-03. Handicrafts Annual Report. http://texmin.nic.in/pdf/ar03_c09.pdf (Accessed 18 August 2016).

Nagaland Bamboo Development Agency; 2009. http://www.nagalandbamboo.com/NagaBamboo/policy.php (Accessed 10 July 2016).

National Mission on Bamboo Applications; 2009. http://www.bambootech.org/subsubTOP.asp?subsubid=105&subid=37&sname=#bm_activities (Accessed 10 July 2016).

NBM; 2014. Bamboo growing areas in India.http://nbm.nic.in/grow_bamboo.html (Accessed 10 July 2016).

NBM, 2016: Total physical target of major components during 2006-07 to 2015-16 under NABM-MIDH: http://nbm.nic.in/PDF/Targets&Achievements.pdf (Accessed 10 July 2016).

NEC, undated. About the North Eastern council. http://necouncil.gov.in/index1.asp?linkid=53 (Accessed 15 June 2016).

NECS; 2015. Basic Statistics of North Eastern Region 2015. North East Council Secretariat, Government of India. http://necouncil.gov.in/writereaddata/mainlinkFile/BasicStatistic2015.pdf (Accessed 15 June 2016).

NECTAR, undated: Genesis and overview, North East Centre for Technology Application and Research, Department of Science and Technology, Government of India: http://www.nectar.org.in/page.php?sid=8 (Accessed 12 July 2016).

NEDFi, undated. Hnam Chhantu Pawl- Success story, North Eastern Development Finance Corporation Ltd (NEDFi) http://www.nedfi.com/sites/default/files/files/success_stories/mizoram.pdf (Accessed 15 July 2016).

NID: 2012. Report of Bairabi Bamboo Cluster. http://designclinicsmsme.org/Design%20Awareness%20Programme%20Reports/NAS_IIE_Bairabi-Bamboo.pdf (Accessed 18 August 2016).

Ramakrishnan, P.S., Saxena, K.G., Swift, M.J. & Seward, P.D. (Eds.); 1993. Tropical Soil Biology and Fertility Research: South Asian Context. Himasvikas Publication 4, Oriental Enterprises, Dehradun. pp 147.

Rao, I.V.R.; 2014. Lessons & Results from Pro-Poor Bamboo Technologies. Presentation at the International Workshop on State and Perspectives for Bamboo Value Chain Development in South Asia. INBAR. New Delhi, 25 to 26 September 2014.

Rao, I.V.R., Kumar, A., Reza, S., Motokuri, B.; 2009. A Pathway Out Of Poverty - Bamboo Incense Sticks Production as a Livelihood Option For Rural Women In Tripura, India, INBAR, Beijing, and CIBART, New Delhi.

Rao, M. Govinda and Hans-Peter Brunner: 2010. Economic Governance in the North East in (ed.) Hans-Peter Brunner, North East India: Local Economic Development and Global Markets. New Delhi: Sage Publication; 83-105

Rathna, K.; 2016. Bamboo School Furniture: An Expanding and Large Market. Unpublished case study.

Saikia, A.; 2014. Over-Exploitation of Forests: A Case Study from North East India, Springer Briefs in Geography, DOI: 10.1007/978-3-319-01408-1_1.

Salam, D.; 2014. Physico chemical properties of soils and nutrient content in the culms during pre-flowering and post flowering phases of Dendrocalamus hamiltonii in Arunachal Pradesh and Melocanna baccifera in Mizoram. PhD Thesis. Submitted in NERIST.

Salam, K.; 2013. Connecting the poor: Bamboo, Problems and Prospect. South Asia Bamboo Foundation (SABF) retrieved 17.

Sarma, S.; 2014. Bamboo industry of North East India, Employment News, 39(17):40.

Sati, V. P. et. al.; 2014. Diversity, Use pattern and Management of Forest Resources in the Eastern Himalaya: A Case Study of Mizoram, India .Journal of Forests, 2014, 1(1): 1-10.

Shanmughavel, P. and Francis, K.; 1997. Balance and turnover of nutrients in a bamboo plantation (Bambusa bambos) of different ages. Biol. Fert. Soils. 25: 69-74.

Sharma M, Nirmala C., 2015. Bamboo Diversity of India: An update presented at 10th World Bamboo Congress, Korea 2015. http://www.worldbamboo.net/wbcx/Sessions/Theme%20Biology%20Morphology%20Taxonomy/Sharma,%20M.%20L.,%20Nirmala%20C.pdf (Accessed 18 August 2016)

Singh, R.A. and Gupta, R.C.; 2002. Traditional land and water management systems of North-East hill region, Indian Journal of Traditional Knowledge, Vol.1(1): 32-39.

Singh, A.N. and Singh, J.S.; 1999. Biomass, net primary production and impact of bamboo plantation on soil redevelopment in a dry tropical region. For. Ecol. Manag. 119: 195-207.

Tewari, D.N.; 19 92. A Monograph on Bamboo. International Book Distributors, Dehradun.

The Times of India; 2016. Tripura forest department bans trading of bamboo shoots. http://timesofindia.indiatimes.com/city/agartala/Tripura-forest-department-bans-trading-of-bamboo-shoots/articleshow/53389613.cms (Published: July 26, 2016).

Tripathi Y. C., Kaushik, P. K., Bhuyan, T.C.; 2013. Sustainable development of quality bamboo resource for employment generation and socio-economic development in NE India. Rain Forest Research Institute. Jorhat, Assam, India.

UNESCO's Gender Mainstreaming Implementation Framework. Baseline definitions of key concepts and terms. http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/BSP/GENDER/PDF/1.%20Baseline%20Definitions%20of%20key%20gender-related%20concepts.pdf (Accessed 27 July 2016)

UNIDO; 2014. Promoting livelihoods in North Eastern India: The cane and bamboo networking project, UNIDO Report.

Vogtländer, J.G. and van der Lugt, P.; 2014. The Environmental Impact of Industrial Bamboo Products: Life-cycle Assessment and Carbon Sequestration. INBAR Technical Report No. 35.

Woolf, D. et. al.; 2010. Sustainable biochar to mitigate global climate change. Nature Communications, DOI: 10.1038/ncomms1053.

World Bank; 2007. India - Development and Growth in Northeast India : The Natural Resources, Water, and Environment Nexus (No. 36397).

WHO; 2015. Micronutrient deficiencies. http://www.who.int/nutrition/topics/ida/en/ (Accessed 18 August 2016)

WFP; 2015, Hunger Statistics. https://www.wfp.org/hunger/stats (Accessed 18 August 2016)

Yengkopam, R.D.; 2013. Bamboo Forest Resources of India and its Role in Food Security- A Review, Agricult Rev. 34(3): 236-241.

Zhang Guang- Zhu; 1987. Studies on choromosome number of bamboo species with clump rhizomes. In A.N.Rao, G. Dhanarajan and C.B. Sastiy (Eds.): Recent Research on Bamboos. Chinese Academy of Forestry, China and International Development Research Centre, Canada, pp. 154-155.

Zhou, B. et. al.; 2005. Ecological functions of bamboo forest: Research and Application. Journal of Forestry Research, 16(2): 143-147.

Study Team

INBAR
Mr. Werner Kosemund (Ed.)
Ms. Baya Agarwal

TERI
Dr. Ashish Aggarwal
Mr. Siddharth Edake
Mr. Mradul Choubey
Mr. Suresh Chauhan

For further information

T.P. SUBRAMONY
Director & Regional Coordinator for South Asia
INBAR South Asia Regional Office
41, 2nd fl., Zamrudpur Community Centre
Kailash Colony Extension
New Delhi – 110 048
India

Tel. 11-4101 5489/90
E-mail subramony@inbar.int
Fax 11-2923 5115
Web www.inbar.int