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Research and policy framework for conservation and utilization of edible bamboo in northeast India

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India harbours large bamboo germplasm and most bamboo growth in the country are through human interventions, particularly in the hilly environment. The local communities' associate greater sense of ethics towards this group of plants and are also consumed on a day-to-day basis in different forms. Thus, edible bamboo species gains significance both culturally as well as on economic terms. The strengths and weaknesses of cultivating edible bamboo as a livelihood option in the north-eastern hill (NEH) region has been elucidated through a SWOT analysis in this paper. Over all, a research and policy framework is warranted and integrates the backward and forward linkages of bamboo resource management with the marketing linkages of edible bamboo for sustainable socio-economic development of the hill communities, particularly in the biodiversity rich north-east hill region of India.

Key words: Edible bamboo, conservation, utilization, Northeast India, policy.

INTRODUCTION

India ranks third next to China (300) and Japan (237) in bamboo diversity (Tewari, 1992) and ranks second only to China in bamboo production with 3.23 million tons per year. From a total area of 10.03 million hectares (Sharma, 1980; Biswas, 1988), this constitutes arbout 12.8% of the total area of forest cover in the Country. Out of 125 plant species (represents 23 genera) recorded so far in India, nearly 78 are available in the north-eastern region. Amongst six states of the north-eastern hill (NEH) region, Mizoram occupies largest forest area (30.8%) under different bamboo species (Table 1), followed by Meghalaya with 26.0% (Trivedi and Tripathi, 1984). Environmentally, bamboos have been found to be the best for restoration and short-rotation forestry (Arunachalam and Arunachalam, 2002). On an average, living and litter biomass of bamboo has significantly higher concentration of potassium than dicot trees (Rao and Ramakrishnan, 1989). Owing to their gregariousness and fast growing nature, bamboo form complete colony within 4-5 years of plantation with production of young shoots after 3 year of plantation (Pynskhem et al., 2010). Mature culms are used to make house, flooring, roofing, fencing, for carrying water from long distances and various other day-to-day requirements. Most importantly, the bamboo shoots

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Table 1. Area and distribution of major edible bamboo species in hilly states of the NE region.

State	Geographical area (km^2)	Total forest cover (km^2)	Actual area under bamboo cultivation (km^2)	Potential availability (lakh tons)
Arunachal Pradesh	87,743	51500	7770 (9.50)	2.23
Manipur	22,327	6020	3263 (14.62)	14.48
Meghalaya	22,429	9490	5863 (26.00)	8.25
Mizoram	21,081	13030	6047 (30.81)	6.34
Nagaland	16,579	8620	2405 (22.19)	4.90
Tripura	10,486	6060	2849 (27.13)	5.50

Source: Anonymous, 1999; percentage of area under bamboo species are given in parentheses.

being an intercontinental edible delicacy are typical secondary products exported to Japan, USA, Germany, Saudi Arabia and Denmark by China and Taiwan. In the NEH region, an array of fresh and fragmented bamboo products are prepared for internal consumption. But the biochemistry of edible bamboos has not been given due attention (Bhatt et al., 2001). Nevertheless, the edible species are quite frequently cultivated in home gardens, besides their occurrence in the natural forests. If scientifically explored and validated, the NEH region can share the global export of steamed and canned bamboo shoot to European countries. As this region is the largest reservoir of bamboo resource in India (Table 2), screening is required to find most delicate bamboo species and develop package of practices for their mass multiplication. This paper attempts to evolve a research and policy framework for conservation and utilization of edible bamboo in the country and NEH region in particular.

METHODS

In order to evolve a research and policy framework for edible bamboo utilization and conservation, relevant information from published information with special reference to northeast India were analyzed, based on which, important research and policy issues attributing to management and marketing have been appraised thereof. For holistic analysis of the framework, a SWOT analysis was also exercised, and institutional arrangements were suggested in this paper.

RESULTS AND DISCUSSION

Management of bamboo resources

Being a versatile and renewable resource, bamboo has been over-exploited to the extent that concern is being expressed over erosion of this gene-pool (Renuka, 1996). Over-exploitation affects regeneration of bamboo in their wilderness, apart from mundane flowering. As far as edible species of bamboo are concerned, there are seven genera (Table 2) whose tender shoots are consumed over a prolonged period (Hore, 1998). Such continued extractions could also be limited to the natural regeneration potential, perhaps threatening their survival. This region has witnessed mass flowering of *Melocanna baccifera* during 2005-2007 (Pynskhem et al., 2010). Absence of quality planting material and continued supply of bamboo to paper and pulp industry has significantly affected the livelihood of the humans. Therefore, conservation of this valuable gene pool is warranted for sustainable utilization and profitability. Furthermore, given the climate change scenario, bamboo could contribute tremendously to the carbon sequestration process. Evidently, the recent report on State of Forests in India (FSI, 2011) indicates the role of bamboos and trees outside forest (TOF) in carbon budgeting.

Appreciable research has been carried out on bamboo germplasm collection and resource conservation by various prominent agencies like Forest Departments, Kerala Forest Research Institute (KFRI), State Forest Research Institute (Itanagar), Indian Grassland and Fodder Research Institute (IGFRI), Indian Council of Forestry Research and Education (ICFRE), National Bureau of Plant Genetic Resources (NBPGR), Forest Research Institute (FRI) among several amongst others. Nonetheless, independent research highlighted the importance of bamboo-based agroforestry systems in increasing soil moisture and nutrients, while reducing water run-off and soil erosion (Sharma et al., 1992; Ramakrishnan and Toky, 1981). Due to the shrinking bamboo resources, careful determined and consistently chalked out programme for plantation in farm and forest sector is very much essential.

Being a cross-pollinated species, bamboo exhibits greater variation in wild, which can be utilized in genetic improvement of this species, although bamboo could be successfully grown by sowing of seeds. Nonetheless, most bamboo improvement programmes is based on phenotypic selection, followed by clonal multiplication of superior clumps. Since all the characters of mother clumps are inherited in the progenies, their performance is very much predictable. This is the only method of crop improvement in the case of *Bambusa balcooa*, *Bambusa vulgaris* and *Dendrocalamus strictus* which however do not set seed after flowering. Moreover, the seeds of other bamboo species are short-lived (viability of 1-2 months).

Table 2. Bamboo species in north-eastern states of India.

	Species	Arunachal Pradesh	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
	Edible Bamboo							
1	*B. balcooa* Roxb.	+	+	-	+	-	+	+
2	*B. bambos* (L.) Voss	+	-	+	-	-	-	-
3	*B. khasiana* Munro	-	-	+	+	-	-	-
4	*B. longispiculata* Gamble ex Brandis	-	-	-	-	+	-	-
5	*B. nutans* Wall. ex Munro	+	+	-	-	-	-	-
6	*B. pallida* Munro	+	+	-	+	+	+	+
7	*B. polymorpha* Munro	+	-	+	+	-	-	+
8	*B. teres Buch*.- Ham. ex Munro	+	+	-	+	-	+	+
9	*B. tulda* Roxb	-	+	-	+	+	+	+
10	*B. vulgaris Schrad*. ex Wendl	-	-	+	-	-	-	-
11	*Chimonobambusa hookeriana* (Munro) Nakai. Synonym *Himalayacalamus hookerianus* (Munro) Stapleton	-	-	-	+	+	-	-
12	*Dendrocalamus brandisii* (Munro) Kurz	-	-	+	-	-	-	-
13	*D. giganteus* Munro	+	+	+	-	-	+	-
14	*D. hamiltonii* Nees et Arn. ex Munro	+	+	+	+	+	+	+
15	*D. hookeri* Munro	+	-	+	+	+	+	-
16	*D. longisphathus* Kurz	-	-	-	-	+	-	+
17	*D. sikkimensis* Gamble	+	-	-	+	-	+	-
18	*D. strictus* (Roxb.) Nees	-	-	-	-	-	-	+
19	*Gigantochloa albociliata* (Munro) Kurz	+	+	-	+	-	-	-
20	*G. apus* (Bl. ex schult. f.) Kurz	-	-	-	+	-	-	-
21	*G. macrostachya* Kurz	-	+	-	+	+	-	-
22	*Himalayacalamus falconeri* (Hook. f. ex. Munro) Keng	+	-	-	-	-	-	-
23	*Melocanna baccifera* (Roxb.) Kurz	-	+	+	+	+	-	+
24	*P. bambusoides* Sieb. and Zucc.	+	-	-	-	-	-	-
	Others							
25	*Arundinaria gracilis* Blanch	+	-	-	-	-	-	-
26	*A. hirsute* munro	+	-	-	-	-	-	-
27	*A. microphylla* Munro	-	-	-	+	-	-	-
28	*A. racemosa* Munro	+	-	-	-	-	-	-
29	*A. rolloana* Gamble	-	-	-	-	-	+	-
30	*Bambusa affinis* Munro	-	-	-	-	-	-	+
31	*B. auriculata* Kurz	-	+	-	-	-	-	-
32	*B. cacharensis* R. Majum	-	+	-	-	-	-	-
33	*B. griffithiana* Munro	-	-	+	-	-	-	-
34	*B. jainthiana* R. Majum	+	+	-	-	-	-	-
35	*B. kingiana* Gamble	-	-	+	-	-	-	-
36	*B. masiersii* Munro	-	+	-	-	-	-	-
37	*B. multiplex* (Lour) Raeusch	+	-	-	-	-	-	-
38	*B. oliveriana* Gamble	-	-	-	-	+	-	-
39	*B. pseudopallida* R. Majum	-	+	-	+	-	-	-
40	*Butania pantlingii* (Gamble) Keng	+	-	-	-	-	-	-
41	*Chimonobambusa callosa* (Munro) Nakai	+	-	+	+	+	+	-
42	*C. griffithiana* (Munro) Nakai	+	-	-	+	+	+	-

Table 2. Contd.

	Species	Arunachal Pradesh	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
43	*D. catastachyus* (Kurz) Kurz	-	-	-	+	-	+	-
44	*D. patellaris* Gamble	+	+	-	-	-	+	-
45	*D. sachni*i Naithani and Bahadur	+	-	-	-	-	-	-
46	*Dinochloa maclellandii* (Munro) Kurz	-	+	-	-	-	-	-
47	*D. indica* (Majumdar) Bennet	-	+	+	-	-	-	-
48	D. gracilis (Majumdar) Bennet & Jain	-	+	-	-	-	-	-
49	*D. compactiflora* (Kurz) McClure	-	+	-	-	+	-	-
50	*Drepanostachyum hookerearianum* (Munro) Keng	+	-	-	+	+	-	-
51	*D. intermedium* (Munro) Keng	+	-	-	-	-	-	-
52	*D. khasiananum* (Munro) Keng	-	+	+	+	-	-	-
53	*D. kurzii* (Gamble) Pandey	-	-	+	+	-	-	-
54	*D. polystachyum* (King ex Gamble) Pandey	-	-	-	+	-	-	-
55	*D. suberectum* (Munro) Majumdar	+	-	-	+	-	-	-
56	*G. rostrata* Wong	-	+	-	+	-	-	+
57	*Neomicrocalamus clarkei* (Gamble ex Brandis) Pandey	-	-	+	-	-	-	-
58	*N. manii* (Gamble) Pandey	-	-	-	+	-	-	-
59	*N. prainii* (Gmble) Keng	-	-	-	+	-	+	-
60	*Oxytenanthera parvifolia* Brandis ex Gamble	-	+	-	-	+	-	-
61	*Phyllostachys assamica* Gamble ex Brandis	+	+	-	-	-	-	-
62	*P. mannii* Gamble	+	-	-	+	-	-	-
63	*Pleioblastus simonii* (Carr.) Nakai	+	-	-	-	-	-	-
64	*Schizostachyum arunachalensis* Naithani	+	-	-	-	-	-	-
65	*S. capitatum* (Munro) Majumdar	+	-	-	+	+	+	-
66	*S. capitatum* (Munro) Majumdar var. *decompositum* (Gamble) Majumdar	-	-	-	+	-	-	-
67	*S. dullooa* (Gamble) Majumdar	-	+	-	+	+	-	-
68	*S. fuchsianum* (Gamble) Majumdar	+	-	+	-	-	+	-
69	*S. griffithii* (Munro) Majumdar	-	+	-	+	-	-	-
70	*S. helferi* (Munro) Majumdar	-	-	-	+	-	-	-
71	*S. mannii* Majumdar	+	+	+	+	+	+	+
72	*S. pergracile* (Munro) Majumdar	-	+	+	-	-	+	-
73	*S. pallidum* (Munro) Majumdar	+	-	+	+	-	-	-
74	*S. polymorphum* (Munro) Majumdar	+	+	+	+	+	+	-
75	*S. seshagirianum* Majumdar	+	-	-	-	-	-	-
76	*Sinarundinaria longispiculata* Chao and Renvoize	-	-	-	-	+	-	-
77	*Sinobambusa elegans* (Kurz) Nakai	+	-	-	-	-	+	-
78	*Thamnocalamus aristatus* (Gamble) Ca.	+	-	-	-	-	-	-
79	*Yushania maling* (Gamble) R. Majum.	+	-	-	-	-	-	-
	Total	**39**	**29**	**21**	**36**	**20**	**20**	**12**

Nevertheless, no efficient storing techniques have so far been standardized.

For sustainability, harvesting is prescribed every year for culms older than three years under farm sector, and alternate year in the wilderness. Harvesting is not encouraged during active growth period (April-October) and clear felling should be barred in order to prevent degeneration of clumps. Intensive cultural practices to mitigate congestion of clumps in order to facilitate growth of new clumps should be done. Trees providing light sheds should not be removed in the habitat, as the bamboo grow better under shady environment.

In all, bamboo being a multipurpose eco-friendly crop is abundantly available, yet an underutilized natural resource, needs to be managed and exploited for sustainable use. Bamboo is conceived as a thrust area in Industrial Development of NEH Region for the economic and ecological security of the people. This precious resource needs to be fully tapped as an industrial raw material, as substitute for wood in rural/urban housing, engineering works, handicrafts, furniture and value addition through export. Potentially, bamboo can revolutionize the economy of the States ensuring employment opportunities to a large number of people.

Research and policy framework on bamboo

Having the socio-biological principles of the local livelyhoods, the research and development approach should follow the following framework in order to have backward and forward linkages integrated into bamboo resources management and marketing *per se.*

1. Inventory of bamboo and short-listing the edible bamboo through extensive survey.
2. Market survey to understand the bamboo consumption and preparation of detailed inventory of bamboo species.
3. Development of agro-techniques for identified bamboo species for higher yields.
4. Establishment of planting stock for edible bamboos to farmers/growers.
5. Nutritive value analysis of young edible bamboo shoots.
6. Restoration of degraded lands and watershed through potential bamboo germplasm.
7. Evaluation and conservation of economically important bamboo germplasm.

Strategically, the strengths and weaknesses, opportunities and threats of edible bamboo scenario in the NEH region are given in Table 3. Overall, planning and management of bamboo resources could be effective by strengthening inventories, of creation of holistic database on important products and allied information, and economic analysis related to domestic market and export. In NEH region, a critical issue of land/resource tenure has to be resolved by appropriate legislation and policy framework for sustainable management of bamboo resources, as reportedly most land is under private ownership in the region.

Perhaps, we may need to strategically regulate bamboo-exploitation in jhum regrowth and jhum areas by involving Village Councils/Village Forest Development Committees (VFDCs) and eventually facilitating a gradual change to systematic agroforestry management and practices. Sustainable management and use of dedicated bamboo forests and or regrowth areas for providing essential bamboo materials for traditional use and commercial use in bamboo-based industries, enterprises, handicraft sector and also for bamboo trade and commerce (Kharlyngdoh and Barik, 2008) is encounraged. In spite of this fact, shortage of raw material for industry is anticipated in the near future. Therefore, appropriate policy instruments to encourage community and/or private bamboo plantations need to consider subsidy and incentives, apart from the mundane forward and backward linkages.

Simultaneously, expanding market for bamboo in various sector like biochemical, edible shoot, fodder, ornamental, hedge, geotechnical structures for earth reinforcement, low-cost housing and water supply systems for rural masses and handicraft and many other industrial application will be a boost to this sector in the country as a whole, and NEH region in particular. Improving access to appropriate market informations and reducing restriction for domestic market and export as well as reducing fiscal disincentives could help accelerate growth of bamboo sector in India (Nimachow et al., 2010). Capacity building to stakeholders in management of micro-enterprise or a cooperative, availability of mirco-credit for people operating at very subsistence level, value added bamboo processing and design technologies will be beneficial, if adopted under a logical framework in a phased and systematic manner.

Institutional arrangements

Funding support to implement the various policy initiatives enunciated shall be provided from the programme funds of the various development departments (Figure 1). While bamboo resource development within the notified forest area shall be supported by bamboo development projects under centrally sponsored schemes, development of bamboo plantation in agroforestry sector shall be supported from respective programme funds of Agriculture/Horticulture-/Rural Development departments. Special programmes to finance bamboo plantation in farmer sector shall also be supported by Developmental Banks. Establishment of cottage and small and medium sector industries can be supported by government subsidies with due institutional finance from industrial financing agencies and industrial investors/exporters.

Table 3. SWOT analysis of edible bamboo scenario in the NEH region.

Strengths	Weaknesses
- High diversity of edible bamboo in NEH region - Amicable climatic conditions and diverge harvesting seasons - Easy to grow - Low production costs - Processing possibilities: drying, semi fresh packaging - Strong indigenous knowledge systems associated with growing bamboo	- Limited supply - Low productivity due to poor socio-economic condition of the farmers and faulty land tenure system - Non-conventional taste and odour - Lack of storage and processing facilities - Lack of policy frame work for channelization of production, processing and marketing.
Opportunities	**Threats**
- Diverse range of products and markets - Growing demand of (semi) fresh shoots in the neighboring countries such as Myanmar and Thailand. - High export potential - Development of agro-ecological zone specific farming and production systems using bamboo - Industrial approach to bamboo sector.	- Illegal to trade bamboo shoots - Poor market linkage - Low cost-benefit ratio at times - Loss of traditional knowledge systems - Diversification into high value case crops

States such as Tripura and Mizoram have adopted bamboo policy in the NEH region. In the Valley, the Assam State has bamboo and cane policy, realizing its potential both ecologically and also in economics terms. Nevertheless, a biodiversity rich state like that of Arunachal Pradesh is yet to develop inclusive bamboo policy. Thus, sensitization and thorough awareness of the potential edible bamboo species would only set in remarkable returns that could manifest sustainably in bamboo-based livelihood system in the northeastern hill region in particular.

Conclusion

Despite food self-sufficiency at the national level, the country has not attained food security at a household level particularly in the tribal states of the NEH region. Eventually, a considerable proportion of rural population is still under-nourished and they meet their nutritional requirement through non-conventional means, that is, by consuming various wild plants and animal resources and bamboo shoots. Being at par with various edible fruits leaves, twigs roots and tubers in nutritive value, bamboo resource plays a significant role in the food and nutritional security of the tribal population of the NEH region. Recent break-through in induction of bamboo flowering through appreciation of tissue culture technology (Nadgauda et al., 1990) provides greater opportunities for genetic improvement of bamboo. Further research is needed to study the microelements in various edible species besides studies on homogentisic acid (HGA), which is reported to be responsible for the disagreeable pungent taste of bamboo shoots (Etsuko and Susumu, 1989).

Since there is no systematic documentation on edible bamboo and its utilization pattern tin NEH region, planning priorities should be fixed for exploration, validation, mass multiplication and production of edible bamboo species. Natural death of some of the potential edible bamboo species due to flowering is a serious threat in the region. Hence planning priorities are needed to conserve the germplasm of major edible species of the region. Meanwhile, a few potential species have already been identified along with production potential and cost-benefit analysis (Bhatt and Bujarbaruah, 2003), and hence an inclusive policy framework (Figure 1) shall yield better market prospects that could help improve the quality of bamboo products and also the socio-economic development of indigenous communities that practice bamboo-based livelihoods, considering its potential in the region.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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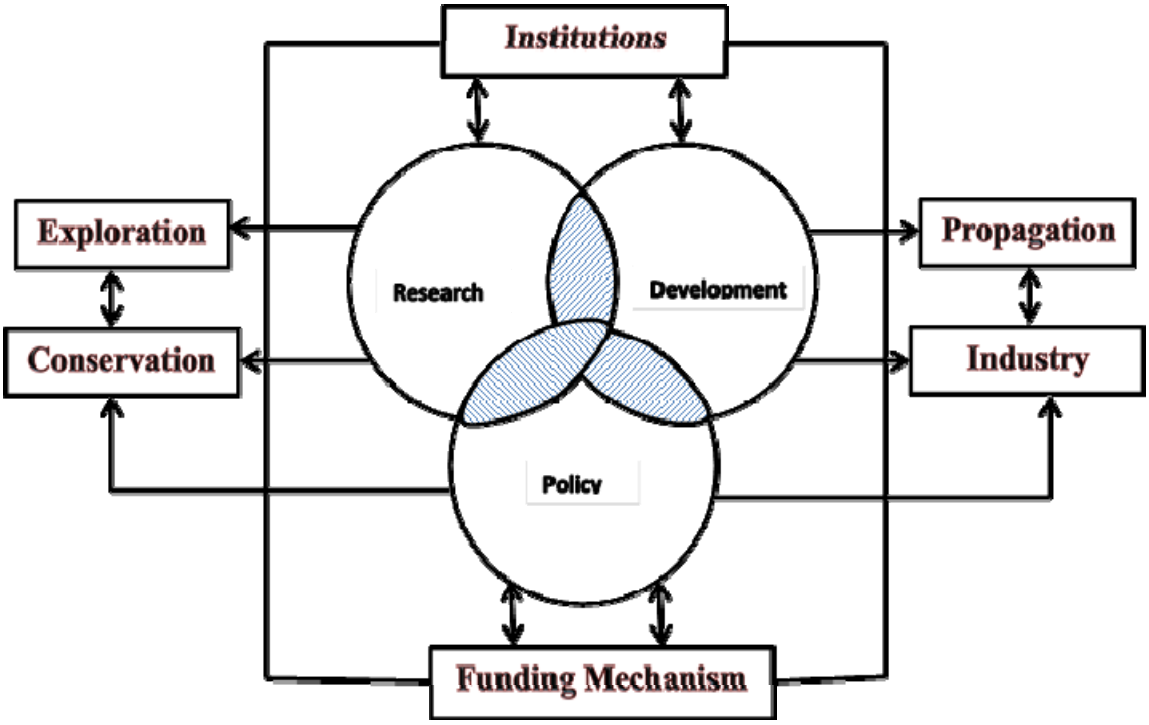

Figure 1. Framework for bamboo utilization and conservation.

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