

Commercial edible bamboo species and their market potentiality in three Indian tribal states of the North Eastern Himalayan Region

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Abstract—A survey of the market places of Meghalaya, Mizoram and Sikkim states in India revealed four major commercial edible bamboo species. Considering the market potentiality of young shoot, *Melocanna baccifera* is identified to be the most commercial bamboo species in Mizoram; *Dendrocalamus hamiltonii*, *M. baccifera* and *Bambusa balcooa* in Meghalaya and *D. hamiltonii* and *Chimonobambusa hookeriana* in Sikkim. *C. hookeriana* is noticed to be restricted only to Sikkim and *B. balcooa* to few districts of Meghalaya. However, *D. hamiltonii* is observed to occur with different degrees of frequency in all the three states explored. In all the 19 districts of the three states, 76 rich pockets of these four edible bamboo species have been identified. Excluding the village/household level consumption, a total of around 980 tonnes of bamboo shoot per year has been recorded to be consumed through market places with a gross income of around US \$ 111 000 per annum in the three states. A maximum consumption of edible bamboo shoot is noticed in Mizoram (*ca.* 505 tonnes/year), followed by Meghalaya (*ca.* 448 tonnes/year) and Sikkim (*ca.* 27 tonnes/year). Whereas the net income is noticed to be highest in Meghalaya (*ca.* US \$ 23 880/year), followed by Sikkim (*ca.* US \$ 14 700/year) and Mizoram (*ca.* US \$ 14 200/year). The physical and financial investment made in merchandizing edible bamboo shoots are observed to be highest in Mizoram, followed by Meghalaya and Sikkim, which in turn have reduced the net annual income.

Key words: Edible bamboo; young shoot; *Melocanna baccifera*; commercial; *Dendrocalamus hamiltonii*; India.

INTRODUCTION

Bamboo, the giant grass of the subfamily Bambusoideae of Poaceae, represents one of the most important Non-Timber Forest Products (NTFPs) in the world. More than 1250 species, belonging to 75 genera, are being reported worldwide, to which

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Figure 1. A dense natural bamboo forest in Mizoram.

India has contributed more than 125 species belonging to 23 genera [1–3]. India is reported to be the largest bamboo producer in the world after China [3]. In spite of having very rich-diverse flora and fauna, the North Eastern Himalayan Region harbours more than 50% of the Indian bamboo genetic resources [4] having very dense bamboo forests (Fig. 1). In India, bamboo spreads over an area of 9.57 million ha, i.e. *ca.* 12.8% of the total forestland area of the country, one of the largest bamboo resources in the world [5–7]. The estimated annual output of bamboo (air dried) from the above area is 3.23 million tonnes, which represents one-fifth of the country's total wood production [5].

Bamboo and its plethora of essential uses and accessibility nature to all, having different economic, traditional and cultural status, is entitled with several names like 'poor man's timber, green-gold, friend of the people, cradle to coffin', etc. In India, more than half of the annual bamboo wood production (*ca.* 2 million tonnes) is consumed by paper and rayon industries. To illustrate this, four paper mills in the NEH (North Eastern Himalayan) Region alone consume more than 2000 tonnes of bamboo per day [8]. Bamboo, therefore, constitutes one of the most important renewable natural resources of India [4, 9], and hence, its judicious extraction is also necessary for the growth and development of clumps [10]. In addition to its thousands of applications so far reported world wide [11, 12], the edibility of tender shoots of few species has not only increased its commercial importance but also has achieved market potentiality compared to other NTFP. For centuries young succulent edible bamboo shoots remained one of the highly palatable dishes for its delicacy. It has become an inter-continental delicacy with export potential. China and Taiwan are among the leading countries to earn foreign currency through export

of edible bamboo shoots. In metropolitan Tokyo, more than 8000 tonnes of young shoot per annum are consumed [13].

In the Asian Pacific Region, it is reported that 26 bamboo species are used for edible purposes [1]. There are around 11 popular inter-continental dishes prepared from bamboo shoots in Indian restaurants [14]. Besides being delicious, edible bamboo shoots contain several nutritional components like proteins, amino acids, vitamins (thiamine and riboflavin), enzymes and co-enzymes, reducing and non-reducing sugars, carbohydrates, starch, fats, lactic acids and citric acids (in fermented products) and phenolic compounds, etc., with different concentrations (species specific) [15–20]. The medicinal values of young shoot are also being reported [21, 22]. In addition to the nutritive values of bamboo shoot, there are also reports on the presence of toxic substances like cyanogens [23] and quinic acid [24]. Studies on pickle and soft drinks of edible bamboo shoot also have been carried out [25].

Since bamboo is a potential resource of the North Eastern part of India, information is available on its taxonomy, distribution and various miscellaneous uses [4, 10, 26, 27]. However, information is lacking on commercially available potential edible bamboo species of the region and their ecological status. Keeping this fact in view, an attempt has been made to explore the potential edible bamboo species in three tribal states of the NEH region so that planning priorities may be fixed to use this resource for generating self-employment to resource poor farmers of the region. The information could also be utilized to include edible bamboo species in various agroforestry systems (which have a long tradition in the region) due to their short gestation period and recurring returns.

STUDY SITE

The seven North Eastern States, i.e. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura including Sikkim are localized in the North Eastern Himalayan Region of India (Fig. 2). The region is endowed with rich forest wealth comprising 25.70% of the area forest of the country [28]. The region has difficult terrain, topography and poor communication; although being rich in biodiversity, it is recognized as one of the 18 ‘hot spots’ of the world [29]. The total forest cover in the region is 12.21 million ha, representing about 65% of the geographical area against the national average of 19.39% [28]. The region is inhabited by many important tribes, which have their unique lifestyle and to a great extent are dependent on forests and, on average, 90% population of the region use biomass as an important source of energy, housemaking, etc.

Shifting cultivation is one of the characteristic features of Meghalaya and Mizoram in the region, whereas settled cultivation is practiced in the state of Sikkim. Shifting cultivation involves slashing the vegetation, burning the dried slash, raising a mixture of crops on temporarily nutrient enriched soil for a year or two, fallowing the plot for regeneration of natural vegetation and eventual return to the same

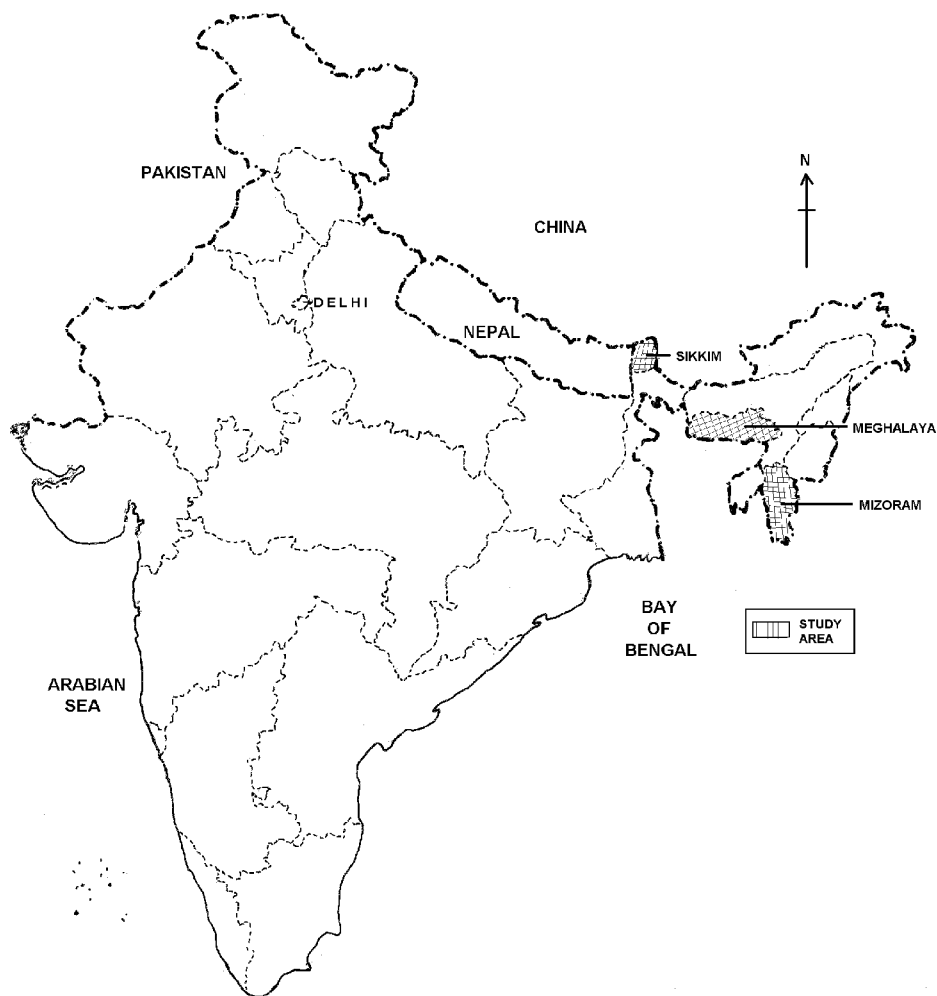


Figure 2. Location of the three states in India.

plot for another cropping phase after a few years. Till 3 decades ago, jhum cultivation was not alarming as its cycle was 20–30 years, but of late it has been reduced to 3–5 years, partly due to population explosion and loss of soil fertility due to over exploitation of the forest resources [30]. Even today, about 52 990 and 50 000 families, respectively, in Meghalaya and Mizoram are practicing shifting cultivation [31]. The cumulative areas of shifting cultivation in these two states have been recorded to be 0.18 and 0.38 million ha during the assessment years 1987–1997 [28]. Simultaneously, the loss of forest cover in Meghalaya and Mizoram during the assessment year 1997–1999, i.e. within a period of 2 years have been recorded to be 2400 and 43 700 ha, respectively. Large-scale deforestation has brought 36.64% of the total geographical area of NEH region under degraded lands, which is almost 2-fold higher than the national average of 20.17% [32]. Large forest

cover under bamboo in Mizoram and Meghalaya also represents the magnitude of shifting cultivation in these two states. Bamboo, being an early successional species, revegetates the jhum fallow or jhum-degraded lands very quickly, i.e. within 3–4 years of a fallow period (personal observation of authors) as compared to other tree species.

Pure tribal communities inhabit Meghalaya, Mizoram and Sikkim states of the region. Meghalaya has a geographical area of 2.24 million ha, of which 0.95 million ha is comprised of forest cover (42.34% of geographic area) [28]. It is located between 25°02' and 26°07' N latitude, and 89°49' and 92°50' E longitude. The elevation ranges from 150 m to 1950 m asl (above sea level), with an average annual rain fall of 4000 mm to 11 436 mm. Khasi, Garo and Jaintia are the major tribes of the state.

Mizoram is located in the extreme southern part of NEH, between 21°57' and 24°30' N latitude, and 92°15' and 93°29' E longitude. It has a geographical area of 2.11 million ha, of which 1.59 million is classified as forest cover (75.59% of the total geographical area). The terrain is hilly and mostly undulating with the elevation range of 500–2157 m asl. The average annual rainfall ranges from 2160 mm to 3500 mm. Mizo and Mara are the major tribal inhabitants of the state.

Sikkim has a geographical area of 0.71 million ha, of which forest land cover constitutes 37.34% of the total geographical area of the state. It is situated between 27°04' and 28°07' N latitude, and 88°00' and 88°55' E longitude. Its terrain is hilly with wide variation in altitude, ranging from 300 m to 8583 m asl. Average annual rainfall ranges between 210 mm and 2500 mm. Nepali and Tibetans are the major tribal inhabitants of the state.

A higher percentage of forests compared to other parts of the country has promoted the region a forest-based economy. People of this region have been using forest produces since time immemorial for self-sustenance and their utilization of bamboo is remarkable [26]. Over-exploitation for miscellaneous applications and supply of raw materials for paper mills, compelled in exhausting the bamboo genetic resources of the region. Shifting cultivation and land encroachment for human habitation are the other two most important factors accompanied for mass destruction of bamboo habitats (Fig. 3). Gregarious and mass flowering of few dominant commercial bamboo species are the natural threats for the drastic change in their population structure; productivity and young shoot production in the region [33]. An excessive and unscientific mode of harvesting young shoots for commercial purposes also has resulted in sudden and drastic reduction of bamboo forests in the region. Hence, an attempt has been made to understand the rate of harvesting/consumption of bamboo in the form of tender shoots from the natural habitats and home gardens. It has also been tried to screen out the edible–commercial bamboo species and their market potentiality with cost–benefit analysis in all three NEH states.



Figure 3. Destruction of bamboo forest for human habitation in Meghalaya.

METHODOLOGY

Meghalaya, Mizoram and Sikkim comprise 7, 8 and 4 districts, respectively. Overall 250 localities with 45 market places of all the 19 districts of the three states have been covered to undertake the study (Figs. 4–6). The methods employed in this study were designed with the purpose of producing baseline information for the use of bamboo shoots in the local systems. A preliminary survey was conducted to identify the important edible bamboo species at different places in each district of Meghalaya, Mizoram and Sikkim. As production of young shoots of all the bamboo species in NEH begins at the onset of the rainy season, i.e. May–June of the calendar, a continuous survey of randomly selected market places of all the districts of the entire three states was done to find out the commercial edible bamboo species. All primary, as well as secondary, vendors available in each market place explored were interviewed through pre-prepared questionnaires to find out the annual rate of consumption and its commercial value (Figs. 7–10). All the possible information on merchandizing edible bamboo shoot, like monetary input and output, physical efforts made for collection and selling, mode of utilization, efficiency and their ecological status (distribution, frequency and availability in the forest or home garden, etc.) are collected from all market places. On the basis of the information and primary data recorded, other secondary data sheets were prepared and represented in the present communication.

Several exploration trips of the entire three states were made to understand the ecological status of the commercial edible bamboo species available, and to explore

International boundary	— · — · — ·
State boundary	—————
District boundary	

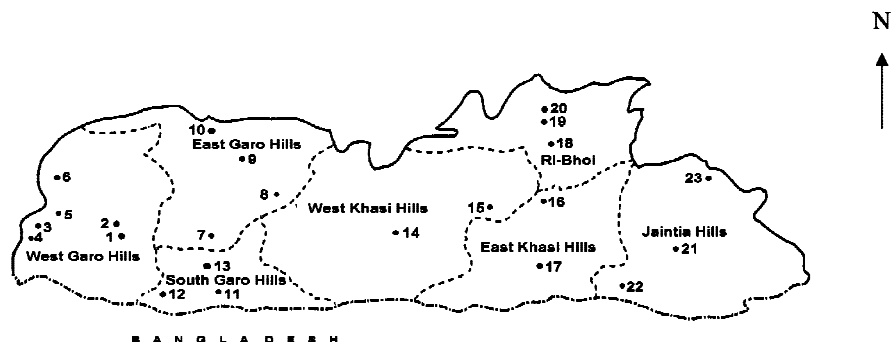


Figure 4. Market places explored for young edible bamboo shoots from Meghalaya, India: 1, Tura; 2, Modinigar; 3, Ampati; 4, Salampara; 5, Garobodha; 6, Manchor; 7, Williamnagar; 8, Rangung; 9, Songsah; 10, Bajingodha; 11, Baghmara; 12, Barangapara; 13, Siju; 14, Nongstoin; 15, Mairang; 16, Shillong; 17, Sohra; 18, Umsning; 19, Karbalu; 20, Nongpoh; 21, Jowai; 22, Dawki; 23, Sailsana.

rich pockets following the quadrature method [34]. All the data in this paper is represented as mean $\pm$ SD (standard deviation).

RESULTS

There are several bamboo species available in the region, which produce edible bamboo shoots but very few species are commercial in nature. After the survey of 45 market places out of 107 in the entire three states, only four bamboo species, i.e. *Melocanna baccifera*, *Dendrocalamus hamiltonii*, *Bambusa balcooa* and *Chimonobambusa hookeriana* are being identified to be edible commercial bamboo species (Table 1). All four bamboo species have a multipurpose nature and have different degrees of application in day-to-day life of tribal folk of the region (Table 2).

Amongst the four bamboo species, *M. baccifera* and *D. hamiltonii* are identified to be the common species occurring in all the three states, having the highest degree of sustainability and distribution in different agro-climatic conditions (150–1600 m asl and 160–1550 m asl, respectively). *C. hookeriana* is found only within a limited range of elevation in Sikkim (900–1500 m asl), whereas *B. balcooa* is found only in three tropical districts of Meghalaya (100–220 m asl). The distribution patterns of all four species in the three states along with the range of elevation are shown in Table 3. Out of the 250 localities explored in the entire 19 districts of the three states, 76 spots were identified as rich pockets for all four bamboo species (Table 4).

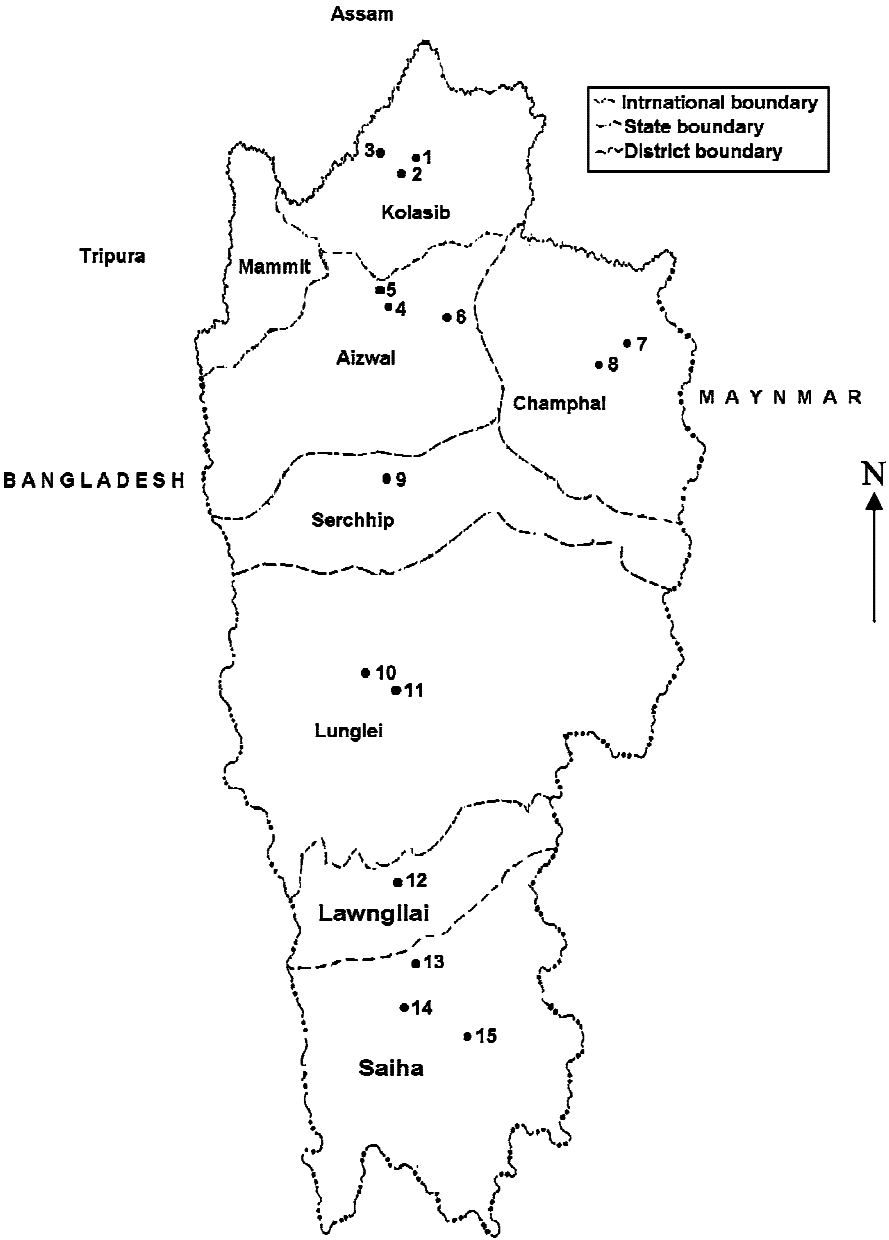


Figure 5. Market places explored for young edible bamboo shoots from Mizoram, India: 1, Kolasib; 2, Banglakawn; 3, Serkhan; 4, Aizwal; 5, Sairang; 6, Seling; 7, Champhai; 8, Kawlkuhl; 9, Serchhip; 10, Lunglei; 11, Zobawk; 12, Lawngllai; 13, Saiha; 14, Mawbawk; 15, Tuipang.

The total consumption of bamboo shoots per year of all four edible commercial bamboo species in the three states is around 980 tonnes. The highest consumption is that of *M. baccifera* (ca. 545 tonnes/year), followed by *D. hamiltonii* and

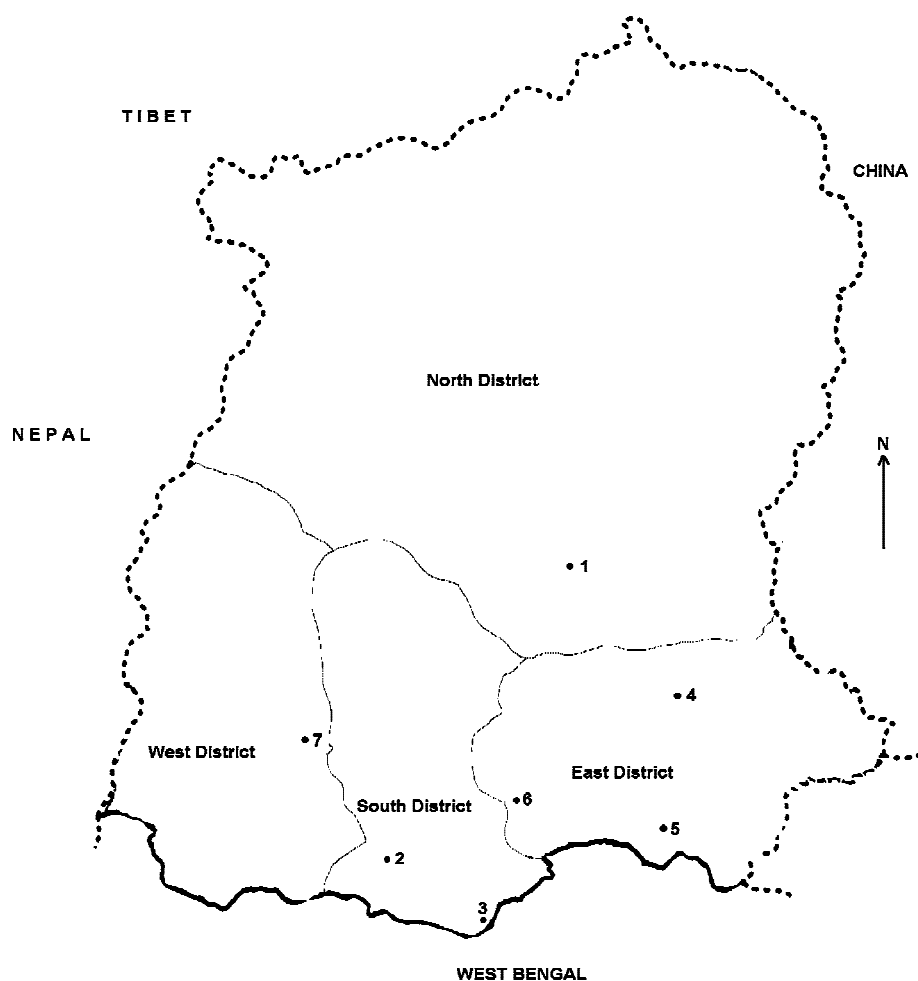


Figure 6. Market places explored for young edible bamboo shoots from Sikkim, India: 1, Mangan; 2, Namchi; 3, Melli Bazar; 4, Gangtok; 5, Pakyong; 6, Singtam; 7, Geyzing.

B. balcooa (ca. 390 and 41 tonnes/year, respectively) and the lowest consumption is that of *C. hookeriana* (ca. 3.7 tonnes/year) (Fig. 11). Figure 12 represents the state-wise rate of consumption of all species and it is highest in Mizoram, followed by Meghalaya and Sikkim (ca. 505, 448 and 26.7 tonnes/year, respectively).

The cost–benefit analysis in merchandizing bamboo shoots as vegetables in the three states shows a very high gross income of ca. US \$ 111 000 per annum with a net income of ca. 89 350 and US \$ 52 790, ignoring and considering the physical efforts, respectively. Figure 13 shows the total annual investment of financial and physical efforts as man-days with the net income in merchandizing bamboo shoot in the entire three states.

State wise cost–benefit analysis (Fig. 14) revealed that Meghalaya has the highest tendency to earn a gross income (ca. US \$ 47 465 per annum), followed by Mizoram



Figure 7. A primary vendor selling bamboo shoots in Meghalaya.

Table 1.
Commercially important edible bamboo species available in the three states

Sl. No.	State	Edible bamboo species	Bamboo species meant for commercial edible shoots
1	Meghalaya	<i>Bambusa balcooa</i> , <i>B. bambos</i> , <i>B. khasiana</i> , <i>B. tulda</i> , <i>Dendrocalamus hamiltonii</i> , <i>D. hookerii</i> , <i>Gigantochloa macrostachya</i> , <i>Melocanna baccifera</i> , <i>Phyllostachys manii</i> , <i>Schizostachyum dullooa</i>	<i>B. balcooa</i> , <i>D. hamiltonii</i>
2	Mizoram	<i>B. bambos</i> , <i>B. khasiana</i> , <i>B. tulda</i> , <i>D. hamiltonii</i> , <i>D. longispathus</i> , <i>D. hookerii</i> , <i>D. sikkimensis</i> , <i>M. baccifera</i> , <i>S. dullooa</i> , <i>S. polymorphum</i> .	<i>M. baccifera</i>
3	Sikkim	<i>B. tulda</i> , <i>C. hookeriana</i> , <i>D. giganteus</i> , <i>D. hamiltonii</i> , <i>D. hookerii</i> , <i>D. sikkimensis</i> , <i>D. strictus</i> , <i>P. manii</i>	<i>C. hookeriana</i> , <i>D. hamiltonii</i>

and Sikkim (ca. 45 530 and 18 000 US \$, respectively). The same earning trend has been observed in the case of net income by deducting the financial investments (but ignoring the physical efforts) for merchandizing young shoots with ca. 41 220, 32 100 and 17 190 US \$. Considering the physical efforts made for collection, cleaning, transportation and selling of young shoots, the figures of the net income are reduced to ca. 23 880, 14 200 and 14 710 US \$. Mizoram is located at higher



Figure 8. Bamboo shoots sold in a market place in Mizoram.

elevation compared to others with steep slopes; more physical efforts are required and the wages for man-days are also observed to be higher than the other two states.

Species-wise cost–benefit analysis of young shoots is shown in Fig. 15, where the gross income of all four species in the entire three states was calculated and observed to be highest with *M. baccifera* (ca. US \$ 50 700), followed by *D. hamiltonii* and *B. balcooa* (ca. 49 980 and 5 810) and least with *C. hookeriana* (ca. US \$ 4515). The net income ignoring physical efforts is the highest for *D. hamiltonii* (ca. US \$ 44 550) followed by *M. baccifera* (ca. US \$ 36 540), *B. balcooa* (ca. US \$ 5 190)

Table 2.
Importance and miscellaneous application of all the four bamboo species in the three states

Parts of the bamboo	<i>M. baccifera</i>	<i>D. hamiltonii</i>	<i>B. balcooa</i>	<i>C. hookeriana</i>
Young shoot	Boiled vegetable: Plain or with leafy vegetables	Boiled vegetable: Plain or with leafy vegetables	Boiled vegetable: Plain or with leafy vegetables	Boiled vegetable: Plain or with leafy vegetables
	Fried vegetable: Plain fry or with other vegetables and non vegetable components	Fried vegetable: Plain fry or with other vegetables and non vegetable components	Fried vegetable: Plain fry or with other vegetables and non vegetable components	Fried vegetable: Plain fry or with other vegetables and non vegetable components
	Pickle	Fermented product	Pickle	Fermented vegetable and other products
		Pickle		
Culm	Agricultural implements	Agricultural implements	Agricultural implements	Fishing rod
	House pole, water pipe, roofing material, ceiling, fencing	Supporting materials for building construction	Best for house pole, bridge pole, fencing	Handicrafts and implements for handloom
	Fishing implements	Raw material for paper and pulp industry	Fishing implements	Incense sticks, broom, toothbrush and tooth pick
	Supporting for building construction	Fire wood	Supporting materials for building construction	Musical instruments
	Handicrafts and implements for handloom	House pole, ceiling, fencing	Fire wood	Fire wood
	Incense sticks, broom, toothbrush and tooth pick	Container for long term preservation of fermented bamboo shoot		
	Raw material for paper and pulp industry			
	Fire wood			
Branch	Physical support for climber and twiner agricultural crops	Physical support for climber and twiner agricultural crops	Physical support for climber and twiner agricultural crops	Less important
	Map pointer	Fire wood	Fire wood	
	Fire wood			

Table 2.
(Continued)

Parts of the bamboo	<i>M. baccifera</i>	<i>D. hamiltonii</i>	<i>B. balcooa</i>	<i>C. hookeriana</i>
Leaf	Fodder for cattle and goat House roofing and partition wall making	Fodder for cattle and goat House roofing	Fodder for cattle and goat	Fodder for cattle and goat House roofing
Seed/fruit	Used for macro propagation	Does not produce seed/fruit	No information	Cooked and used as substitute of rice Brewing & other fermentation products



Figure 9. Boiled-processed young shoots sold in the Gangtok market in Sikkim.

and *C. hookeriana* (ca. US \$ 4 230), respectively. When the physical efforts are considered, there is a drastic change in the net income, being the highest value for *D. hamiltonii* (ca. US \$ 28 010), followed by *M. baccifera* (ca. US \$ 17 230), *C. hookeriana* (ca. US \$ 3 815) and *B. balcooa* (ca. US \$ 3 730). The state-wise and species-wise financial investment and physical efforts made for commercialising bamboo shoots are represented in Figs 16 and 17, respectively.

The cost–benefit analysis of bamboo shoot-based pickle in a single market place in Meghalaya state shows a very high potentiality with a gross income of ca.



Figure 10. Young shoot and bottled pickles sold in a market place in Meghalaya.

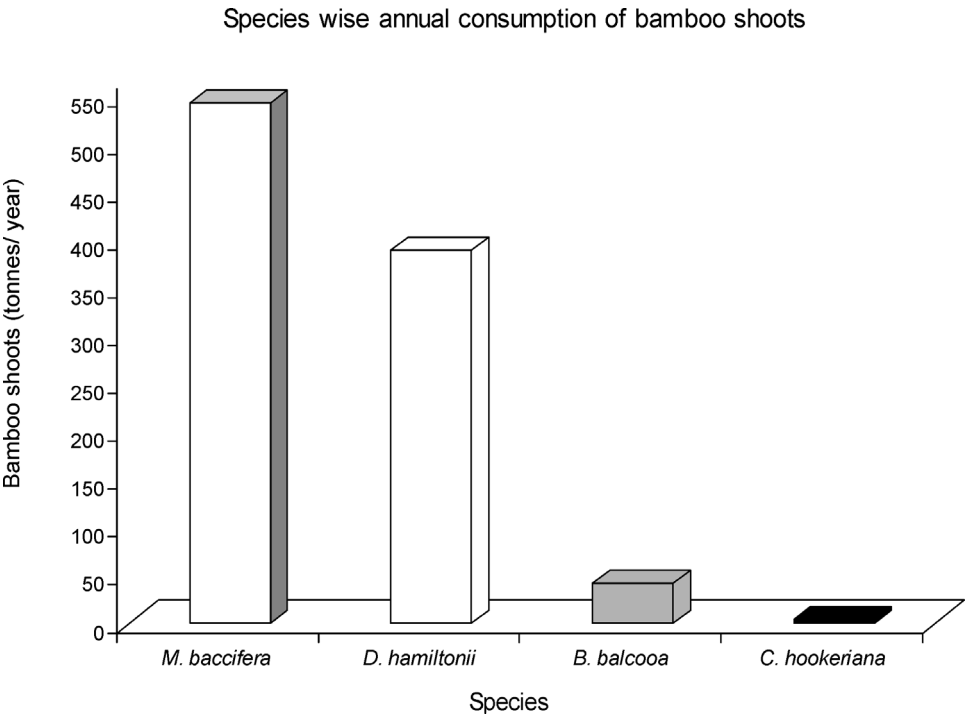


Figure 11. Species-wise consumption of bamboo shoots in the three states.

Table 3.

Distribution of all four edible commercial bamboo species in Meghalaya, Mizoram and Sikkim (up to district level)

State and elevation (m asl)	District	Distribution of the bamboo species with elevation			
		<i>M. baccifera</i> (m asl)	<i>D. hamiltonii</i> (m asl)	<i>B. balcooa</i> (m asl)	<i>C. hookeriana</i> (m asl)
Meghalaya (150–1950)	Ri-bhoi	+	+	—	—
		(250–400)	(250–900)		
	East Garo Hills	++	+	+	—
		(150–200)	(160–250)	(100–150)	
	West Garo Hills	++	++	++	—
		(150–250)	(200–250)	(175–200)	
	South Garo Hills	+	+	++	—
Mizoram (200–2157)		(160–200)	(170–200)	(180–220)	
	East Khasi Hills	—	+	—	—
			(200–500)		
	West Khasi Hills	+	+	—	—
		(500–900)	(200–500)		
	Jaintia Hills	—	+	—	—
			(400–700)		
Sikkim (300–8583)	Kolasib	++	++	—	—
		(250–650)	(300–540)		
	Aizawl	++	+	—	—
		(800–1015)	(800–900)		
	Lunglei	+	+	—	—
		(900–1200)	(800–1000)		
	Champhai	++	+	—	—
		(700–1350)	(750–900)		
Sikkim (300–8583)	Serchhip	+	—	—	—
		(550–700)			
	Lawngtlai	++	+	—	—
		(750–1100)	(700–850)		
	Saiha	++	++	—	—
		(800–1600)	(650–1100)		
	Mammit	++	+	—	—
		(500–850)	(450–740)		
Sikkim (300–8583)	East Sikkim	+	++	—	++
		(1000–1200)	(300–1300)		(900–1350)
	West Sikkim	—	++	—	++
			(800–1550)		(900–1400)
Sikkim (300–8583)	North Sikkim	—	++	—	++
			(750–1200)		(1000–1500)
Sikkim (300–8583)	South Sikkim	—	+	—	+
			(350–1450)		(950–1450)

+, availability of the bamboo species with less abundance; ++, availability with higher abundance; —, complete absence of the species.

Table 4.
Rich pockets identified for all four edible commercial bamboo species in the three states (up to locality)

State	District	Rich pockets			
		<i>M. baccifera</i>	<i>D. hamiltonii</i>	<i>B. balcooa</i>	<i>C. hookeriana</i>
Meghalaya	Ri-Bhoi	—	Umbang, Umsning, Nongpoh	—	—
	East Garo Hills	Bajengdoba, Mendal, Jeng-jal	—	Jengjal	—
	West Garo Hills	Modinagar, Garobada, Tura	Salmanpara Manchor	Modinagar, Garobada Rongram, Ampati	—
	South Garo Hills	Dalu, Gasua-para	Baghmara	Barangapara	—
	East Khasi Hills	—	Williamnagar, Rangung, Songsak, Bajengdoba	—	—
	West Khasi Hills	Nongstoin	Nongkhlaw, Nongstoin, Mairang	—	—
	Jaintia Hills	—	Jowai, Sonapur, Ladrymbai	—	—
Mizoram	Kolasib	Vairengte, Belk Hawthlir, Kolasib, Serkhan	Kolasib, Serkhan	—	—
	Aizawl	Sairang, Lung-dai, 10 km beyond Zambawak	Sairang	—	—
	Lunglei	Thualthu, Tawipui, Zowawk	Thualthu	—	—
	Champhai	Kawlkuh, Hlaikhan	—	—	—
	Serchhi	Buakpui, Chekawn	—	—	—
	Lawngtlai	Thingphal, Chawngte	—	—	—
	Saiha	Mawbawak, Tui-pang	Mawbawak	—	—
	Mamit	Mamit	—	—	—
Sikkim	East Sikkim	—	Tadong, Rangpo, Dicliling (Pakyong), Singtam	—	Dicling, (Pakyong), Gangtok (Near STC Bus stand)

Table 4.
(Continued)

State	District	Rich pockets			
		<i>M. baccifera</i>	<i>D. hamiltonii</i>	<i>B. balcooa</i>	<i>C. hookeriana</i>
	West Sikkim	—	Geyzing, Naya Bazar	—	Geyzing, Upper Pelling and Lower Pelling
	North Sikkim	—	Beethu, Kabi, Mangan	—	Kabi, Mangan
	South Sikkim	—	Namthang, As-santhang	—	Namchi, Melli, Jorethang

State-wise annual consumption of bamboo shoots

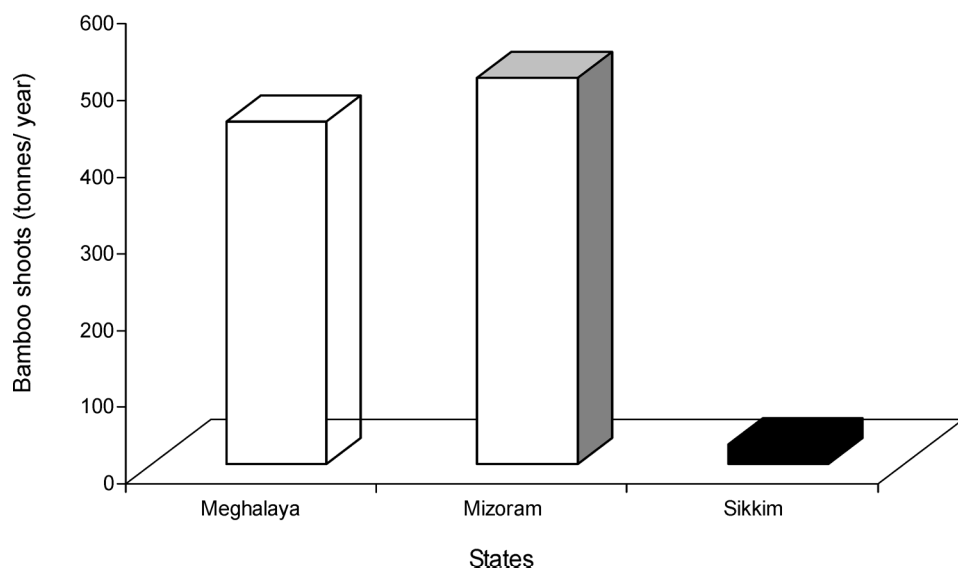


Figure 12. Annual consumption of bamboo shoots in the three states.

US \$ 8 465 with a net income of *ca.* US \$ 4 180 per annum (Table 5). Market days and availability of bamboo shoots of all four commercial species in all three states are shown in Table 6.

DISCUSSION

In addition to commercially available edible young shoots, *M. baccifera* and *D. hamiltonii* were found to be very useful multipurpose species in Mizoram and Meghalaya. *B. balcooa* is a very commercial and highly-preferred bamboo species

Cost–benefit analysis of bamboo shoots

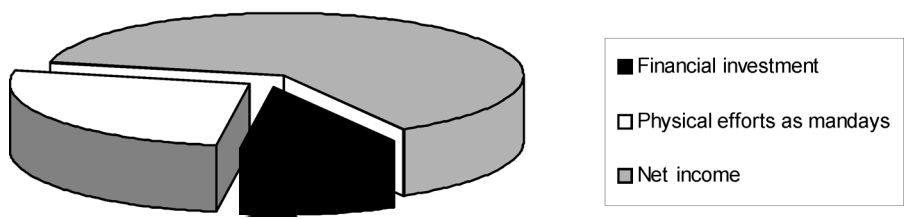


Figure 13. Cost–benefit analysis of young shoots in the three states.

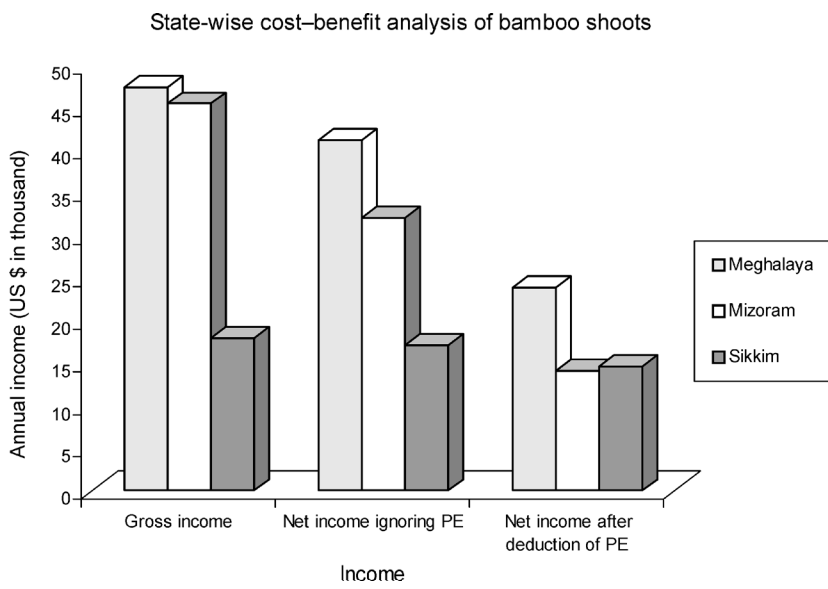


Figure 14. Cost–benefit analysis of young shoots of the four bamboo species in the three states. Net income ignoring PE represents values after deduction of financial investment from gross income, whereas Net income after deduction of PE represents values after deduction of financial investment and physical efforts made as man-days from the Gross income.

in Meghalaya due to its delicacy and strong culm. In Sikkim *C. hookeriana* is the most preferred bamboo species for its young shoots, as well as for handicraft, musical instruments and implements for handloom.

The gross and net income of bamboo shoots from natural resources show their potential, which in fact can improve the financial condition of the entire region. Fresh shoots remain available in the market places only for 2–4 months every year. After harvesting, if they are not consumed in time, there are chances for mass waste and loss. Bamboo shoot-based pickle, other boiled and fermented products have added to its market potential, which in turn, could make the introduction of society-based food processing units in different corners of the region feasible. This can not only reduce the chances of waste of harvested young shoots but also generate means

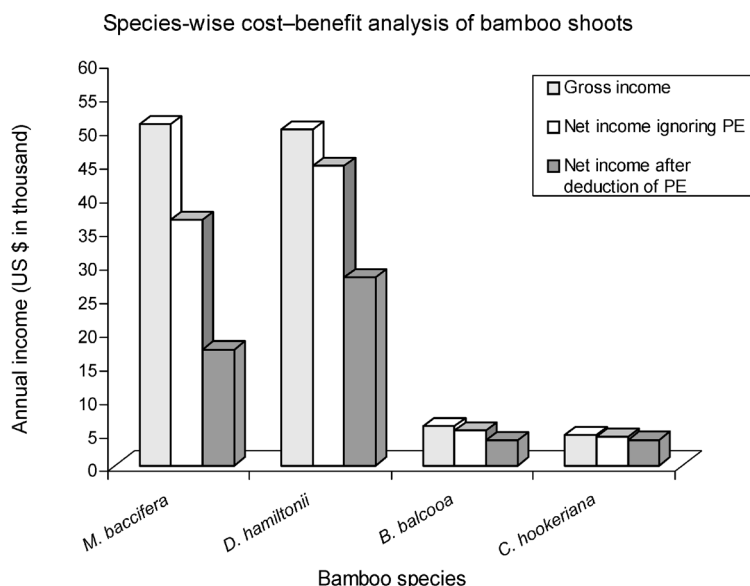


Figure 15. Species-wise cost–benefit analysis of young shoots in the three states. Net income ignoring PE represents values after deduction of financial investment from gross income, whereas Net income after deduction of PE represents values after deduction of financial investment and physical efforts made as man-days from the Gross income.

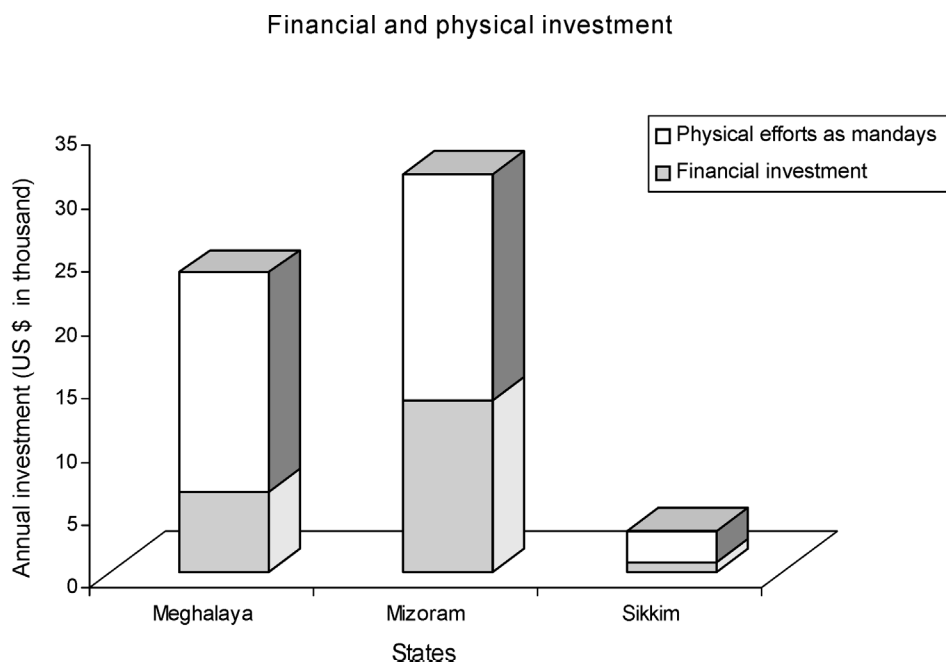


Figure 16. Species-wise financial investment and physical efforts (in terms of man-days) made in merchandizing edible bamboo shoots.

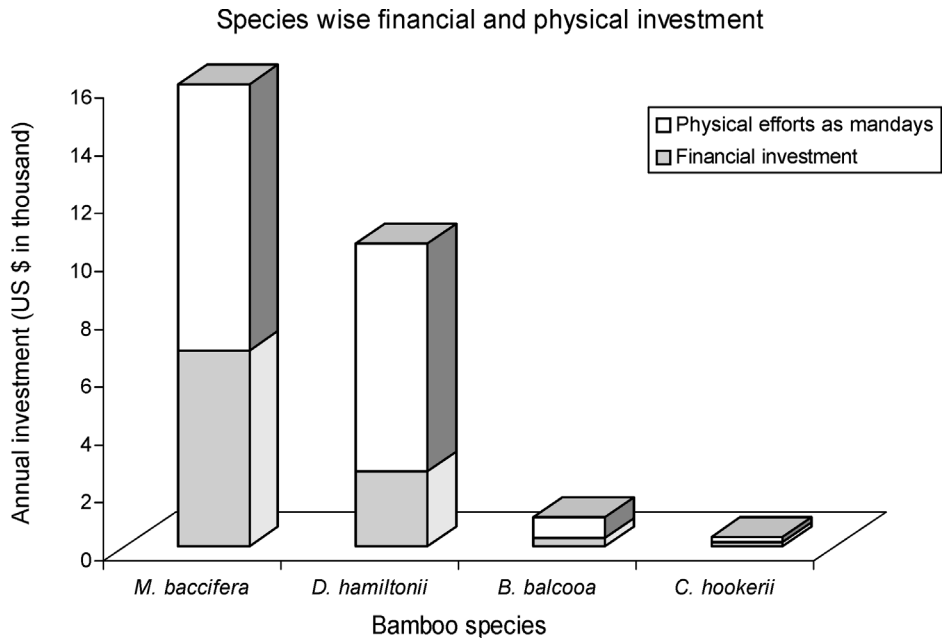


Figure 17. Species-wise financial investment and physical efforts (in terms of man-days) made in merchandizing edible bamboo shoots.

for self-employment and ultimately reduce the unemployment problem. There is a strong need for capacity of locals to build a market-oriented bamboo cottage industry to meet the demand of the outside world. China has crossed US \$ 2.1 billion business from bamboo, while India is lacking behind in spite of having the enough resource.

From the conservational point of view, shifting cultivation and other anthropogenic effects resulted by population explosion herald fast depletion of bamboo gene pools in the entire region. Mass flowering of few important bamboo species of the region is also one of the natural threats for frequent disaster and natural mode of genetic erosion. Mass flowering of *M. baccifera* and *D. hamiltonii* in the region occurred in the years 1815, 1863, 1911 and 1959, and 1921, 1991 and 2000, respectively [33]. A scientific mode of exploitation and proper utilization of the bamboo resources will not only lead to improvement of the socio-economic situation of the region, but will also maintain the ecological balance. Development of a bamboo gene sanctuary for *in situ* conservation and their maintenance by the relevant authority and development of ‘Bambusetum’ in suitable places for different species as meant for *ex situ* conservation are immense needs. This will not only assure the availability of this important natural resource in the near future, but also will help in understanding its ecology and lead to higher productivity.

Based on the above-mentioned facts, it has been calculated that harvesting of young shoots only for domestic consumption may provide employment opportunities to 109 persons in Meghalaya, 85 persons in Mizoram and 45 persons in Sikkim

Table 5.

Annual consumption and cost–benefit analysis of pickles made from bamboo shoot in a market in the Ri-Bhoi district of Meghalaya

Quantity of pickle per container (kg)	No of containers sold/day	Total quantity of shoot sold (tonnes/year)	Gross income (US \$/year)	Gross input (US \$/year)	Net income (US \$/year)
0.250	8.0 ± 3.0	0.63 ± 0.22	1575 ± 589	1000 ± 29	575 ± 560
0.350	7.0 ± 2.0	0.75 ± 0.22	2295 ± 655	1780 ± 63	520 ± 593
0.750	5.0 ± 2.0	1.16 ± 0.44	2625 ± 1050	1050 ± 105	1580 ± 945
1.000	3.0 ± 1.0	0.94 ± 0.31	1970 ± 655	457 ± 126	1510 ± 530
Total	23.0 ± 8.0	3.47 ± 0.19	8465 ± 2950	2040 ± 0.15	4180 ± 2630

Gross income represents the total income generated from the bamboo pickles at US \$ 0.62, 1.04, 1.67 and 2.09, respectively, per 0.25 kg, 0.35 kg, 0.75 kg and 1.00 kg of pickle. Gross input = Price of bamboo shoot, wages of man days required for pickle processing and cost of ingredients (mustard oil, pickle powder, salt, chilli and spices) and cost of container. Wages of man-days at US \$ 0.32 for processing of 1 kg pickle. Data are means ± SD. 1 US \$ = 47.69 rupees in Indian currency.

Table 6.

Market days and availability of young shoot of all the four commercial edible bamboo species in the market places of the three states

State	Market days/ week (mean ± SD)	Availability of young shoot in the market places (species-wise)			
		<i>M. baccifera</i>	<i>D. hamiltonii</i>	<i>B. balcooa</i>	<i>C. hookeriana</i>
Meghalaya	3 ± 2	June 1st week to September 1st week	May last week to September 2nd week	May 1st week to August 1st week	—
Mizoram	4 ± 2	June 1st week to September 2nd week	—	—	—
Sikkim	2 ± 1	—	June 1st week to September last week	—	June last week to September 2nd week
Cost of bamboo shoot (US \$/ kg)	0.11 ± 0.004	0.24 ± 0.18	0.10 ± 0.01	0.56 ± 0.12	0.56 ± 0.12

Market days vary from place to place in all three states. Data are means ± SD.

on sustainable basis (with prevailing wages of US \$ 1.05/day per person) round the year. If the export possibilities were explored, the revenue may increase manifold. It will be worth to mention here that most of the tribal folk earn their subsistence through selling bamboo shoots from May to September every year. Processing of pickles from young bamboo shoots may take a shape of a small-scale industry in these tribal states. Hence, state or central Government may assist the rural educated

youths, school dropouts and females in establishing bamboo shoot-based pickle and other allied processing units in these states.

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