

Doi: [HTTPS://DOI.ORG/10.23910/IJEP/2019.6.1.0288](https://doi.org/10.23910/IJEP/2019.6.1.0288)

Status of Bamboo in India

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Article History

Article ID: IJEP0288
Received in 15th February, 2019
Received in revised form 21st February, 2019
Accepted in final form 24th February, 2019

Abstract

Bamboos are very important forest resources found in the forest as well as the non-forest area in the country. The total bamboo bearing area of India is estimated to be 15.69 million hectares. Endemism in Indian bamboos is of a very high order. The maximum concentration of species is found in the deciduous and semi-evergreen regions of North-east and the tropical moist deciduous forests of North and South India. The North-eastern hilly States of India harbor nearly 90 species of bamboos, 41 of which are endemic to that region. There are 3 large genera (*Bambusa*, *Dendrocalamus*, and *Ochlandra*) of bamboos in India with more than 10 species each. Together, these three genera represent about 45% of the total bamboo species found in India. On the other hand, there are some genera which are represented by only one species each e.g. *Ampelocalamus*, *Sarocalamus*, *Chimonobambusa*, *Pseudostachyum* and *Stapletonia*. Bamboos in India show a great diversity in both their habitat and habit of growth. They occur in different forest types, ranging from tropical to sub-alpine zones. Some species are found only in the cultivated state in few gardens. They are fast growing, widely present, renewable and versatile resource. With the growing demand for timber, bamboo can be used as a viable substitute for timber in the country. As per productivity and conservation are concerned, there is a need to assemble an adequate information base as a foundation for policy and management decisions. Also, the current market demand and supply gap accentuate the actions for the active promotion of the cultivation of bamboo outside the conventional or natural growth areas.

Keywords: Area, bamboo, cultivation, diversity, India, species

1. Introduction

Bamboos the most diverse group of plants in the grass family and the most primitive sub-family belonging to the sub family Bambusoideae of the family Poaceae (Gramineae). They are distinguished by woody culms, complex branching, robust rhizome system, and infrequent flowering (Soderstrom and Calderon, 1979). Bamboo is most important source of nature which is strong, versatile and highly renewable plant. It is found in every place mostly in moist deciduous, semi-evergreen, tropical, subtropical and temperate areas of forest. Other environmental factors such as latitude, altitude, soils are also related to growth of bamboo. The high temperatures promote bamboo growth and low temperatures inhibit the growth rate. Bamboos are distributed in the country differing from sea level to altitude of 3600 m. The most suitable conditions for the occurrence of bamboo however, are found in between 770 - 1,080 meter above sea level. Bamboos in India occur in different forest types, extending from tropical to sub-alpine zones. A few species are found only in cultivated state at few spots. In India, bamboos grow normally in all states with the exception of in Kashmir region of Jammu and

Kashmir. Bamboo prefers high rainfall of about 1200 mm to 6350 mm. However, the species like *Dendrocalamus strictus* is found even the drier area of Rajasthan.

Bamboo is used for the variety of purpose ranging from fodder, pulp, timber, construction works, charcoal, edible shoots, cottage industries etc. Bamboos have huge potential for substituting wood. It can be used for decorative and shuttering plywood, various board products such as block board, wafer board, strip board, laminated boards, roofing sheets; earthquake-resistant and long-lasting conventional housing and buildings, furniture, fuel-wood, charcoal and briquettes, active carbon, matchsticks, agarbattis, toothpicks, skewer sticks, etc. Bamboos have socio-economic and ecological value and their management can provide benefits on a local, national and global level through livelihood, economic and environmental security for many millions of rural people.

Bamboos are effective for the control of soil erosion, stream bank protection, reinforcement of embankments and drainage channels, etc. Due to high biomass accumulation and abundant litterfall, bamboos help in maintaining and



improving the soil physical, chemical and biological properties (Christanty et al., 1996; Shanmughavel et al., 2000). Due to rapid biomass accumulation and effective fixation of solar energy and carbon dioxide, the carbon sequestration ability of bamboo is very high. According to an estimate, one quarter of the biomass in tropical regions and one-fifth in subtropical regions comes from bamboo. Each acre of bamboo can isolate up to 40 tons of CO₂. It is estimated that a 1,000 sq. ft. green home built by bamboo living has over 15 tons of CO₂ locked up (sequestered) within its fibers. It's plethora of essential uses has led to the use of terms such as "Green Gold", "Poor Man's Timber", "Bamboo, Friend of The People" and "Cradle to Coffin Timber".

2. Taxonomy and Diversity Status of Bamboo in India

The earliest comprehensive taxonomic work on bamboos was that of 1839 by Ruprecht based on herbarium specimens which was followed by the studies of Munro (1868). Kurz (1876) recorded field observations, and described uses of Indian and Malayan bamboos. In his first comprehensive monograph on Indian bamboos, Gamble (1896) reported 15 genera and 115 species which was followed by the work of Camus (1913) from India and China. Brandis (1899, 1906), Camus (1935), also described the group. Parker (1929) and Blatter (1929) attempted a systematic analysis and arrangements of species. Some other important work on bamboo taxonomy includes that of McClure (1936, 1954, 1966), Dransfield (1980, 1982), Soderstrom (1985), Widjaja (1987), Soderstrom and Ellis (1988), Chao and Renvoize (1989), Bennet and Gaur (1990b), Tewari (1992) and Kumar (1990, 1995). Nomenclatural aspects have been studied by a number of researchers (Bahadur and Naithani, 1976, 1983; Majumdar, 1983; Naithani, 1986, 1990a, 1990b, 1993, 1994a, 1994b; Bennet, 1988, 1989; Bennet and Gaur, 1990a, 1990b; Naithani and Bennet, 1991 and Soderstrom and Ellis, 1988). Most of the taxonomic descriptions, including recent ones, are based on scanty herbarium specimens.

Worldwide there are more than 1,250 species of bamboo belonging to 75 genera which are unevenly distributed in various parts of the humid tropical, sub-tropical and temperate regions of the earth (Scurlock et al., 2000; Banik, 2000; Banik, 2014). India has abundant diversity of bamboo genetic resources after China. About 25% of bamboo species of the world are found in India distributed widely in almost all the states. In India, bamboos are distributed in five geographical zones- Western Himalaya, Eastern Himalaya, Northeast India, Peninsular India and Andaman and Nicobar Islands (Bedell 1997). They are found distributed as an understorey in southern hilltop tropical evergreen forests, west coast semi evergreen forests, southern moist deciduous forests and dry bamboo brakes (Champion and Seth 1968). Mehra and Sharma (1975) reported that bamboos grow from the coastal plains to elevations of 3700 meters in the Himalayas. Biswas (1988), Rai and Chauhan (1998) reported

that bamboos were particularly abundant in the Western Ghats and the Sister States of North-east India. Varmah and Bahadur (1980) reported about 19 principal genera of bamboos in India. Sharma (1987) reported about 130 species belonging to 24 genera of bamboos from India out of which 20 are indigenous and four are of exotic origin. Tewari (1992) described 23 genera and 128 species in India. Seethalakshmi and Kumar (1998) reported 123 species and 18 genera of bamboos in India which include 87 naturally occurring and 41 introduced or cultivated species. Naithani (2008) reported presence of 20 genera and 115 species of bamboos in India. Kumar (2011) reported 136 species of bamboos belonging to 29 genera in the country out of which 96 species are native bamboos and 40 species are cultivated ones. Sharma and Nirmala (2015) reported 148 species and 4 varieties belonging to 29 genera are found in India (both wild and cultivated).

The maximum concentration of species is found in the deciduous and semi-evergreen regions of the North-east and the tropical moist deciduous forests of North and South India. The Northeastern hilly States of India harbor nearly 90 species of bamboos, 41 of which are endemic to that region. As per diversity is concerned, the bamboo rich states in country are: Meghalaya, Arunachal Pradesh, Manipur, Assam, Mizoram, Sikkim, West Bengal, Nagaland, Kerala, Andaman, Tripura, Bihar, Odisha, Jharkhand, Karnataka, Chhattisgarh, Himachal Pradesh, Madhya Pradesh and Maharashtra while the States with least number of species are: Punjab, Jammu and Kashmir (only in Jammu area), Rajasthan, Gujarat, Haryana and Goa. As per Tripathi (2015), over half of the bamboo species occur in Eastern India, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and West Bengal.

There are 3 large genera (*Bambusa*, *Dendrocalamus*, and *Ochlandra*) of bamboos in India each having more than 10 species each. Two of these, *Bambusa* (37 species and 2 varieties) and *Dendrocalamus* (18 species) are growing in diverse regions and habitats while the third, *Ochlandra* (with 11 species and 1 variety), is restricted to South India. Together, these three genera represent about 45% of the total bamboo species reported from India.

Bamboo taxonomy poses certain difficulties for science due to its long flowering cycles. Thus, taxonomist still debate for the exact total number of species and genera. A list of various genera and species of bamboos found in India (both wild and cultivated) is as follows:

2.1. *Ampelocalamus* (1)

A. patellaris (Gamble) Stapleton

2.2. *Bambusa* (37sp +2var.)

Bambusa affinis Munro; *B. alemtenshii* Naithani; *B. assamica* Barooah and Borthakur; *B. atra* Lind.; *B. balcooa* Roxb.; *B. bambos* Voss; *B. bambos* var. *gigantea* Bennet and Gaur; *B. barpatharica* Borthakur and Barooah; *B. binghamii* Gamble; *B. burmanica* Gamble; *B. cacharensis* Majumdar; *B. comillensis*



Alam ; *B. dampaeana* Naithani; *B. garuchokua* Barooah and Borthakur; *B. glaucescens* (Willd.) Sieb.ex Munro; *B. griffithiana* Munro; *B. jaintiana* Majumdar; *B. khasiana* Munro; *B. kingiana* Gamble; *B. majumdarii* Kumari and Singh; *B. manipureana* Naithani and Bisht; *B. mizorameana* Naithani; *B. memberanacea* (Munro) Stapleton; *B. mohanramii* Kumari and Singh; *B. multiplex* (Lour.) Raeusch ex Schult. and Schult.f.; *B. nagalandeana* Naithani; *B. nairiana* Kumari and Singh; *B. nutans* Wall. ex Munro; *B. oliveriana* Gamble; *B. pallida* Munro; *B. polymorpha* Munro; *B. pseudopallida* R. Majumdar; *B. rangaensis* Barooah and Borthakur; *B. salarkhanii* Alam; *B. teres* Ham. ex Munro; *B. tulda* Roxb.; *B. vulgaris* Schrad. ex Wendl.; *B. vulgaris* var. *vittata* A. and C. Riviere; *B. wamin* Camus. (The natural occurrence of *Bambusa affinis* and *B. oliveriana* is controversial but both these bamboos are grown at the Indian Botanic Garden, Howrah).

2.3. *Cephalostachyum* (8)

C. capitatum Munro; *C. flavescens* Kurz.; *C. fuchsianum* Gamble; *C. latifolium* Munro; *C. longwanum* Naithani; *C. mannii* (Gamble) Stapleton and Li; *C. pallidum* Munro; *C. pergracile* Munro.

2.4. *Chimnobambusa* (1)

C. callosa (Munro) Nakai.

2.5. *Chimonocalamus* (4)

C. griffithianus (Munro) Hsueh and Yi; *C. longiusculus* Hsueh and Yi; *C. nagalandianus* (Naithani) M.L. Sharma *comb. nov.*; *C. lushaiensis* (Bor) M.L. Sharma *comb. nov.*

2.6. *Dendrocalamus* (18)

D. asper (Schult.) Backer; *D. brandisii* (Munro) Kurz.; *D. calostachyus* (Kurz) Kurz ; *Dendrocalamus collettianus* Gamble; *D. copelandii* (Gamble ex Brandis) Xia and Stapleton; *D. giganteus* Munro; *D. hamiltonii* Nees and Arn. ex Munro; *D. hookeri* Munro; *D. latiflorus* Munro; *D. longifimbriatus* Gamble; *D. longispathus* Kurz ; *D. manipureanus* Naithani and Bisht; *D. parishii* Munro; *D. sahnii* Naithani and Bahadur; *D. sericeus* Munro; *D. sikkimensis* Gamble; *D. somdevai* Naithani; *D. strictus* (Roxb.) Nees.

2.7. *Dinochloa* (2)

D. andamanica Kurz.; *D. nicobariana* Majumdar.

2.8. *Drepanostachyum* (including *Himalayacalamus*, which is recognized by several authors) (6)

D. falcatum (Nees) Keng f.; *D. falconeri* (Munro) D.C. McClint.; *D. hookerianum* (Munro) Keng f.; *D. intermedium* (Munro) Keng f.; *D. kurzii* (Gamble) Majumdar; *D. polystachyum* (Kurz. ex Gamble) Majumdar.

2.9. *Gigantochloa* (7)

G. albociliata (Munro) Kurz ; *G. andamanica* (Kurz.) Kurz; *G. apus* (Bl.ex Schult.f.) Kurz; *G. atroviolacea* Widjaja; *G. bastareana* Naithani and Pal; *D. macrostachya* Kurz; *G. pseudoarundinacea* (Steud.) Widjaja.

2.10. *Indocalamus* (2+1 var.)

I. walkerianus (Munro) Nakai; *I. wightianus* (Munro) Nakai; *I. wightianus* var. *hispidus* (Steud) Nakai. Though a new name *Karuna* has been given to *Indocalamus*, the old name *Indocalamus* is retained as more studies need to be conducted before the new name is used.

2.11. *Melocalamus* (5)

M. compactiflorus (Kurz) Benth.; *M. gracilis* Majumdar; *M. indicus* Majumdar; *M. maclellandii* (Munro) Naithani; *M. mastersii* (Munro) Majumdar.

2.12. *Melocanna* (3)

M. arundina Parkinson; *M. baccifera* (Roxb.) Kurz; *M. clarkei* (Gamble ex Brandis) Kumari and Singh.

2.13. *Neohouzeaua* (2)

N. dullooa (Camus) Gamble; *N. helferi* (Munro) Gamble.

2.14. *Neomicrocalamus* (2)

N. andropogonifolius (Griffith) Stapleton; *N. prainii* (Gamble) Keng f.

2.15. *Ochlandra* (11+1 var.)

O. beddomei Gamble; *O. ebracteata* Raizada and Chatterji; *O. keralensis* Muktesh, Ramesh and Stephen; *O. scriptoria* (Dennst.) Fischer; *O. setigera* Gamble; *O. sivagiriana* (Gamble) Camus; *O. soderstromiana* Muktesh and Stephen; *O. spirostylis* Muktesh, Seetha and Stephen; *O. talbotii* Brandis; *O. travancorica* var. *travancorica* Benth. and Hook. f.; *O. travancorica* var. *hirsuta* Gamble; *O. wightii* (Munro) Fischer

2.16. *Oxytenanthera* (5)

O. abyssinica (A. Rich.) Munro; *O. bourdillonii* Gamble; *O. monadelphica* (Thw.) Alst.; *O. ritcheyi* (Munro) Blatter and Mc Cann.; *O. stocksii* Munro.

2.17. *Phyllostachys* (5)

P. aurea Carr. ex A. and C. Riviere; *P. bambusoides* Sieb. and Zucc.; *P. edulis* (Carr.) Lehai; *P. mannii* Gamble; *P. nigra* (Lodd.) Munro.

2.18. *Pleiblastus* (1)

P. viridi-striatus (Regel) Makino.

2.19. *Pseudosasa* (1)

P. japonica (Sieb. and Zucc. ex Steud.) Makino ex Nakai.

2.20. *Pseudostachyum* (1)

P. polymorphum Munro.

2.21. *Sarocalamus* (1)

S. racemosa (Munro) Stapleton.

2.22. *Schizostachyum* (5)

S. andamanicum Kumar and Ramesh; *S. kalpongianum* Kumar and Ramesh; *S. kurzii* (Munro) Majumdar; *S. rogersii* Brandis; *S. seshagirianum* Majumdar.

2.23. *Shibataea* (1)



S. kumasasa (Zoll. ex Steud.) Makino ex Nakai.

2.24. *Stapletonia* (1)

S. arunachalensis (Naithani) Singh, Dash and Kumari.

2.25. *Teinostachyum* (2)

T. beddomei Fischer; *T. griffithii* Munro.

2.26. *Thamnocalamus* (4)

T. aristatus (Gamble) Camus; *T. longispiculatus* (Majumdar) M.L.Sharma *T. spathiflorus* (Trin.) Munro.; *T. occidentalis* Stapleton.

2.27. *Thyrsostachys* (2)

T. oliveri Gamble; *T. regia* (Munro) Bennet.

2.28. *Yushania* (9)

Y. densifolia (Munro) Majumdar; *Y. elegans* (Kurz.) Majumdar; *Y. hirsutea* (Munro) Majumdar; *Y. jaunsarensis* (Gamble) Yi; *Y. maling* (Gamble) Majumdar; *Y. microphylla* (Griffith) Majumdar; *Y. pantlingii* (Gamble) Majumdar; *Y. rolloana* (Gamble) Yi; *Y. yadongensis* Yi.

2.29. *Borinda* (1)

B. grossa (T.P.Yi) Stapleton.

Few species tentatively included here (e.g. *Bambusa binghami*, *B. griffithiana* and *B. kingiana*) whose presence in India requires confirmation.

3. Distribution Range of Bamboo in India

Among all of the commonly occurring genera of bamboos, the genus *Bambusa* is widely distributed in India. *B. bambos* occur either in natural forest (wild) or cultivated throughout the plains and low hilly areas of India from southern peninsular region to the lower Himalayas region. The next second widely distributed genus is *Dendrocalamus*. This bamboo occurs in the plains of South and Central India and dry hilly areas of North India. It occurs from East to west, Punjab to Assam and also occurs in other North Eastern states. *Bambusa*, *Oxytenanthera*, *Schizostachyum* and *Melocanna* are mainly available in the Western Ghats and in the North Eastern region. The genera *Schizostachyum*, *Phyllostachys* and *Gigantochloa* are widely distributed in North Eastern state of India. The different species recorded under different forests in the country is as under.

3.1. Bamboos in tropical forests

Different species of bamboo are found in moist and dry deciduous, evergreen and semi-evergreen forests and savannah type of vegetation. Principal species are *Bambusa bambos*, *B. balcooa*, *B. pallida*, *B. tulda*, *B. burmanica*, *B. cacharensis*, *B. khasiana*, *B. longispathus*, *Dendrocalamus patellaris*, *D. sikkimensis*, *D. strictus*, *Dinochloa compactiflora*, *Gigantochloa hasskarliana*, *Melocanna baccifera*, *Schizostachyum dullooa*, *S. latifolium*, *S. pergracile*, *S. polymorphum*, *Thamnocalamus aristatus* etc. The species of bamboo occurring on the edges of pine forests (*Pinus kesiya*) over Shillong Plateau

are *Chimonobambusa callosa*, *Drepanostachyum khasianum*, *D. polystachyum*, *Racemobambos prainii*, *Schizostachyum polymorphum*, *S. dullooa*, *Dendrocalamus sikkimensis* etc.

3.2. Bamboos in temperate forests

Temperate forests are composed of *Lauraceous* members, high level Oak-Hemlock, Coniferous and Birch-Rhododendron forests and confined to elevations ranging from 1500 m to 3000 m. The principal species are represented by *Chimonobambusa (Sinarundinaria) callosa*, *C. jaunsarensis*, *Drepanostachyum (Thamnocalamus) falcatum*, *D. hookerianum*, *D. intermedium*, *D. polystachyum*, *Himalayacalamus falconeri*, *Neomicrocalamus (Racemobambos) prainii*, *Arundinaria (Sinarundinaria) rolloana*, *Phyllostachys bambusoides*, *Semiarundinaria (Sinarundinaria) pantlingii*, *Sinobambusa elegans*, *Thamnocalamus aristatus* and *T. spathiflorus* etc.

3.3. Bamboos in sub Alpine and Alpine type of forests

The type of forest is represented by firs (*Abies* spp.), birches (*Betula* spp.), *Rhododendron* spp., *Juniperus* spp. etc. Very few bamboo species are present in this zone. Examples are *Pleioblastus simonii*, *Thamnocalamus aristatus*, *Arundinaria (Sinarundinaria) hirsuta*, *A. racemosa* etc. The upper altitudinal limit of alpine bamboos is around 3,500-4,000 m in the North-east however bring down in the west, where lower winter temperatures are encountered.

4. State Wise Distribution of Bamboo in India

Despite the fact that bamboo develops naturally in every state, its frequency changes in various regions mainly because of variations in climatic conditions. Bamboo species distributed on the basis of percentage in different states of India revealed that in Himachal Pradesh, Madhya Pradesh and Maharashtra, *Bambusa* spp. and *D. strictus* are found dominant. In Andhra Pradesh, Bihar, Jharkhand and Uttar Pradesh the main species are *B. arundinacea* and *D. strictus*. In sub-Himalayan and Siwalik tracts *Dendrocalamus strictus* and *Bambusa bambos* are naturally distributed. In the higher altitudes of Himachal Pradesh and Uttarakhand *Drepanostachyum falcatum* (local name: Ghal Ringal), *Himalayacalamus falconeri* (local name: Deo Ringal), *Thamnocalamus spathiflorus* (local name: Thaam Ringal), *Thamnocalamus jaunsarensis* (local name: Jamura Ringal) are found in on the hill slopes along with natural belt. In Jammu and Kashmir, *Dendrocalamus strictus* is the major species growing in mixed deciduous forests in the outer plains and low altitude sub-tropical area (Saleem and Sehgal 2008) *Melocanna bambusoides* is widely distributed in Assam (40%), Manipur (94%), Meghalaya (46%), Mizorum (93%) and Tripura (92%). *D. strictus* is the main species in Rajasthan, Gujarat (56%) and Karnataka (63%). *D. hemiltonii* is widely present in the states of Arunachal Pradesh (29%), Assam (60%) and Nagaland (54%); *B. tulda* in Arunachal Pradesh (32%) and Nagaland (25%) while *B. pallida* is 37% in Arunachal Pradesh and 13% in Nagaland. *B. arundinacea* is present in Gujarat (44%), Karnataka (34%) and Odhisa (24%) (Table 1). As per



Table 1: State wise bamboo density in recorded forest area

State/UT	Pure bamboo	Dense	Scattered	Bamboo present but clumps completely hacked	Re-genera-tion crop	No bamboo	RFA (sq km)
Andhra Pradesh	16	3,111	3,485	142	824	29,680	37,258
Arunachal Pradesh	137	5,358	9,558	34	38	36,282	51,407
Assam	41	1,543	7,244	102	25	17,877	26,832
Bihar	0	126	809	24	45	5,873	6,877
Chhattisgarh	11	2,005	6,010	933	2,101	48,712	59,772
Goa	0	66	279	12	25	843	1,225
Gujarat	1	1,103	1,840	176	424	18,103	21,647
Haryana	0	0	21	0	0	1,538	1,559
Himachal Pradesh	0	120	307	3	110	36,493	37,033
Jharkhand	5	684	2,769	259	753	19,135	23,605
Karnataka	3	2,821	4,393	282	2,943	27,842	38,284
Kerala	11	757	1,972	123	621	7,825	11,309
Madhya Pradesh	56	4,581	9,256	1,714	2,560	76,522	94,689
Maharashtra	51	3,911	7,951	1,389	2,625	45,652	61,579
Manipur	95	2,790	7,676	59	67	6,731	17,418
Meghalaya	47	2,035	3,816	21	24	3,553	9,496
Mizoram	35	922	2,287	16	7	2,374	5,641
Nagaland	57	1,669	4,196	30	73	2,598	8,623
Odisha	26	2,918	7,035	584	1,546	49,095	61,204
Punjab	0	6	28	0	10	3,040	3,084
Rajasthan	0	415	1,326	24	211	30,761	32,737
Sikkim	0	214	339	0	0	5,288	5,841
Tamil Nadu	23	718	2,265	163	985	18,723	22,877
Telangana	3	1,647	2,068	67	993	22,126	26,904
Tripura	19	545	3,018	4	31	2,677	6,294
Uttar Pradesh	1	145	620	43	127	15,646	16,582
Uttarakhand	0	190	470	17	401	36,922	38,000
West Bengal	0	92	349	261	240	10,937	11,879
Dadra & Nagar Haveli	0	11	24	3	20	146	204
Total	638	40,503	91,411	6,485	17,829	582,994	739,860

the studies conducted by Varmah and Bahadur (1980) and Shukla (1986), near about 60 species under 10 genera are distributed in the North-Eastern region alone.

According to FSI (2017), the total bamboo bearing area of the country is estimated to be 15.69 million hectare (Table 2). Madhya Pradesh has maximum bamboo bearing area of 1.8 m ha followed by Maharashtra (1.6 m ha), Arunachal Pradesh (1.5 m ha) and Odisha (1.2 m ha). On analyzing the forest area of different states according to bamboo density, it has been observed that the pure bamboo breaks are found in less than

1% of the recorded forest area of the country. Dense bamboos occur in about 5% of recorded forest area and scattered in about 12 % of the recorded forest area.

Maximum occurrence of pure bamboo was observed in Arunachal Pradesh (137sq km) followed by Manipur (95sq km) and Nagaland (57 sq km). Dense bamboo was found maximum in Arunachal Pradesh (5338 sq km) followed by Madhya Pradesh (4581 sq km) and Maharashtra (3911 sq km). The area with hacked bamboo clumps was reported maximum in Madhya Pradesh (1714 sq km) followed by

Table 2: State wise distribution of bamboo area in recorded forest area

State/UT	Bamboo bearing area (sq km)	State/UT	Bamboo bearing area (sq km)
Andhra Pradesh	7,578	Meghalaya	5,943
Arunachal Pradesh	15,125	Mizoram	3,267
Assam	8,955	Nagaland	6,025
Bihar	1,004	Odisha	12,109
Chhattisgarh	11,060	Punjab	44
Goa	382	Rajasthan	1,976
Gujarat	3,544	Sikkim	553
Haryana	21	Tamil Nadu	4,154
Himachal Pradesh	540	Telangana	4778
Jharkhand	4,470	Tripura	3,617
Karnataka	10,442	Uttar Pradesh	936
Kerala	3,484	Uttarakhand	1,078
Madhya Pradesh	18,167	West Bengal	942
Maharashtra	15,927	Dadra & Nagar Haveli	58
Manipur	10,687		
Total	111,386	Total	45,480

Maharashtra (1389sq km) and Chhattisgarh (933 sq km). Bamboo regeneration was found maximum in Karnataka (2943 sq km) followed by Maharashtra (2625 sq km) and Madhya Pradesh (2560 sq km).

5. Bamboo Resources of India

Bamboo falls into two main categories according to growth pattern, (i) sympodial or clump forming and (ii) monopodial or non-clump forming, runner bamboo. In India, clump forming bamboo constitute over 67% of the total growing stock, of which *Dendrocalamus strictus* is 45%, *Bambusa bamboos* 13%, *Dendrocalamus hamiltonii* 7%, *Bambusa tulda* 5% and *Bambusa pallida* 4%. All other species put together are 6%. *Melocanna baccifera*, a non-clump forming bamboo, accounts for 20% of the growing stock and is found in the north-eastern states (Naithani, 1993). Total number of culms at the national level has been estimated to be 28103 million out of which the percentage of green sound, dry sound and decayed has been estimated as 73.7, 19.1 and 7.1% respectively (Table 3). The total estimated green weight of bamboo culms at national level is estimated to be 188 million tonnes of which green sound bamboos contribute 70% and dry sound bamboos

Table 3: Number of culms at country level by age and soundness in recorded forest area (in millions)

Age Class	Culm Size Class	Green Sound	Dry Sound	Decayed	Total no of culms
Current		5034			5034
1-2 Years	2-5 cm	6529	3861		14199
Over 2-Years		3809			
1-2 Years	5-8 cm	2181	1113		5016
Over 2-Years		1722			
1-2 Years	8 + cm	820	400		1836
Over 2-Years		616			
				2018	2018
Total Culms		20711	5374	2018	28103

Source: FSI 2017

contribute remaining 30%. Maximum number of green sound culms are found in Arunachal Pradesh (3121 million) followed by Assam (1848 million) and Manipur (1772 million). Dry sound culms were found maximum in Arunachal Pradesh (637million) followed by Madhya Pradesh (527 million) and Maharashtra (429 million).

The national level, green sound weight of the culm in recorded forest was found to 131.3 m tonnes and dry weight was 57.4 m tones (Table 4). In TOF areas, the total number of culms estimated at national level was 2868 million with an equivalent weight of 17.412 million tonnes. Eastern Plains contribute maximum number of culms (1059 million), followed by North East (355 million) and East Deccan (259 million). The equivalent weight was also maximum in the Eastern Plains (7.085 m tonnes) followed by North East (3.579 m tonnes) and East Deccan (1.264 m tonnes). Of all the clump forming bamboos, *Dendrocalamus strictus* is 45%, *Melocanna bambusoides* is 20%, *Bambusa bambos* is 13%, *D. hamiltonii* 7%,

Table 4: Equivalent green weight of bamboo at country level by age and soundness in recorded forest area (in 000 tonnes)

Age class	Culm size class	Green sound culms	Dry sound culms	Total green weight
1-2 Years	2-5 cm	25873	20748	65947
Over 2-Years		19326		
1-2 Years	5-8 cm	25938	21861	69039
Over 2-Years		21240		
1-2 Years	8 + cm	20377	14812	53773
Over 2-Years		18584		
Total Culms		131338	57421	188759

Source: FSI 2017



B. tulda 5%, *B. pallida* 4% and all other species put together 6% of the total growing stock (Rawat et al. 2002).

6. Productivity Status

The present yield per hectare is very low compared to other countries such as Japan, China, Taiwan and Malaysia. As compared to China and Taiwan, India's productivity is one fourth to one fifth. In Odisha, productivity from homestead areas was an average of 5-6 MT per hectare per annum, much above the productivity level of bamboo in forest areas. In fact, the Odisha Bamboo Policy acknowledged that there was a need to enhance the productivity up to 20–25 MT per ha per annum through scientific cultivation, superior clones and species change. Correspondingly, in Maharashtra from homestead areas, the average productivity was 3-4 MT per hectare per annum, which also was much above the productivity level of bamboo in the forest areas. Similarly, the yield in Andhra Pradesh was 7 MT per hectare per annum from forest plantations, while in the managed plantations it was found to be 12 MT per hectare per annum (FRI 2014; Haque, 2007).

7. Demand and Supply

In country, 10 million people depend solely on bamboo for survival. The current demand of bamboo for various purposes estimated to 26.69 million tonnes as against supply of 13.47 million tonnes in the country as reported by Salam (2013). The share in global bamboo trade and commerce is only 4% though it possesses 45% of global bamboo growth. As per the policy statements, the Government of India would like to see its bamboo industry concentrated in the northeast of the country to hold 27% of the world market by 2015; when the international bamboo trade is expected to touch \$ 950 billion (Kumar et al., 2005). Therefore, there is an urgent need to reduce the gap between current market demand and supply of bamboo.

8. Issues in Bamboo Sector

Despite its well known characteristics and potential for multiple uses, bamboo sector suffers from technology constraints both in plantation technology and management and its various uses in terms of lack of application of known scientific methods in plantation and post harvest treatment and technology for product development (Haque 2014). Some of the key issues in bamboo sectors are as under:

8.1. Lack of awareness

Despite the high economic potential of bamboo and huge utility of bamboo for the rural areas, bamboo has not been able to find its desired place in the rural economy due to lack of awareness about the economic potential and utility of bamboos. There is a need for changing the 'forestry mindset' to the 'farming mind set' and creating awareness on the commercial viability and profitability of the species

(Mishra et al. 2014). Research results available in the public and private domain do not regularly reach the farmers due to lack of a dedicated extension system. In this regard, extensive awareness and capacity building programmes are required at all levels viz. farmers, extension workers, village level societies, tree growers' cooperative societies etc.

8.2. Limited choice of species and non-availability of quality planting stock

Choice of the species is one of the major constraints in the ravine region of India. So far, two species viz., *D. strictus* and *B. bambos* are dominating the plantations. These species though hardy have lower productivity as compared to commercial. New species of bamboos, having proven track record of higher yield which could grow successfully under different climatic and edaphic conditions thus need to be screened for higher yield. Research conducted under NMBA sponsored project have revealed that *D. hamiltonii*, *B. balcooa* and *B. vulgaris* have higher productivity in sub-tropical conditions of the country (Kaushal et al. 2014).

8.3. Lack of database

Lack of reliable data on growth, biomass, productivity, growing stock and area is adversely impacting the resource strengthening initiatives in the country. Majority of growth and biomass data available is only on one or two species i.e. *Dendrocalamus strictus* or *B. bambos* and *Melocana baccifera*. Further, the available data is largely based on the inferences drawn from the bamboo sale data maintained by the state forest departments. Thus, there is urgent need of data management based on actual removals of bamboo from forests both by right holders for domestic consumption and by the forest departments for commercial purposes. Efforts are also required to adopt uniform unit for recording bamboo harvest and sale data.

8.4. Lack of quality planting stock and genetic improvement

Quality planting material is not available for bamboos. Due to gregarious nature of flowering, seed is not easily available and has to be procured from suppliers whose quality is not known. Majority of plantation in India is being raised from seed obtained from unknown sources with no mechanisms to certify the productivity credentials of its source (FRI, 2014). Vegetatively propagated plants are also not easily available. There is immediate need to screen and develop genetically superior germplasm for commercial bamboo species and make them available on mass scale through developing protocols by macro and micro propagation methods. Genetic and breeding research to improve productivity through selection of superior clones is the need of the hour. Inter-varietal, inter-specific and inter-generic hybridization methods thus need to be taken up on urgent basis.

8.5. Harvesting and transport restrictions

The full potential of the bamboo sector in the past was not utilized due to the problems being faced by the cultivators like restrictive regulatory regime, requirement of permission for



felling, transit and processing, export restrictions, royalty and transit fee on the products etc. However, recently Government of India cleared an ordinance amending Indian Forest Act, which omits bamboo grown in non-forest areas from the definition of trees thereby exempting bamboo grown in non-forest areas from the requirement of felling/transit permit. This move will allow free movement of bamboo and would generate the demand for raw material leading to planting of bamboo trees on non-forest land, provide employment and encourage the growth of small and medium industries in the villages and smaller towns and reduce dependence on imports. Bamboo grown in forest areas however, shall continue to be governed by the Forest Conservation Act, 1980,

8.6. The need of value addition

Most of the handicraft sector in bamboo is traditional due to which the production level is low. For production of bamboo handicrafts, huge quantity of splits, sticks and semi-processed raw materials of various specifications are required which presently are obtained by manual processing of whole bamboos by artisans which results in more wastage and reduce the quality of the end product. Therefore, there is an immediate need to provide ready to use raw material including housing material, improved tools, machinery/skill development so that production can be enhanced without compromising with the quality.

8.7. Policy for leasing revenue degraded ravine lands and liberalization of ceiling limits/restrictions

A large portion of degraded lands, which could be profitably used for raising bamboo, are under the control of the Revenue Department/ Forest Department. Such lands are neither being developed by the Department nor leased away to the interested entrepreneurs for development. These lands can be economically utilized for promoting bamboos. Further, statutory ceiling limits on agricultural land holdings for wastelands should be liberalized. Plantation of bamboos should be treated on par with plantations of commercial crops like rubber, tea, coffee, etc. Long term finance, fiscal incentives and tax benefits should be provided to promote technology based reforestation and farm forestry projects. For encouraging the growth of bamboo sector in the country, Import Duties also need to be rationalized.

8.8. Capacity building

Bamboo is generally viewed as a group of plants having vast potential for improving the socio economic condition in rural areas in the country through its use in craft. There is, however, a need to create the capacity of the people to develop high-value bamboo articles. It was recommended that wide-ranging national programs to build the capacity of the rural artisans in bamboo craft be initiated towards developing bamboo based cottage industry in the country and enhancing cash incomes of the rural artisan.

9. Conclusion

Bamboos in India demonstrate great diversity in both their habitats and habit of growth. Bamboos are of conservation significance in their own privilege and may likewise serve as an indicator of high biodiversity in different groups. Keeping in view the value of bamboo, significant efforts are required to assemble an adequate information base for policy and management decisions for its conservation and cultivation. Current market demand and supply gap accentuates the actions for the active promotion of bamboo cultivation and expansion of area under cultivation by developing promising agroforestry models.

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