





08

**BAMBOO
RESOURCES OF
THE COUNTRY**



Introduction

8.1

Bamboos, the most diverse group of plants in the grass family belong to the sub-family *Bambusoideae* of the family *Poaceae (Gramineae)*. Bamboos are fast growing perennial plants and are found in the tropical, sub-tropical and mild temperate regions of the world.

Geographical distribution of Bamboo largely depends on climatic factors such as precipitation, temperature, altitude and soil conditions. Large tracts of natural bamboo forest are found in tropical Asian countries between 15° and 25° North latitudes. In India, bamboo is found naturally almost throughout the country except in Kashmir region.

As per an FAO report (2007)¹, there are about 1,200 species of Bamboo in 90 genera across the world. India has about 125 indigenous and 11 exotic species of bamboo from 23 genera. Bamboos are found in abundance in the deciduous and semi-evergreen forests of the North-eastern region of the country and the tropical moist deciduous forests of Northern and Southern India. The major bamboo genera found in India are *Arundinaria*, *Bambusa*, *Chimonobambusa*, *Dendrocalamus*, *Dinochola*, *Gigantochloa* etc. The North-eastern States and West Bengal account for more than 50% of the bamboo resources of the country. Other bamboo rich areas of the country are the Andaman & Nicobar Islands,

Chhattisgarh, Madhya Pradesh and the Western Ghats. Although, bamboo is found in almost every state of the country, its distribution and concentration varies primarily due to the climatic and edaphic conditions. *Bambusa* and *Dendrocalamus* are species of tropical conditions, whereas *Arundinaria* and its associates occur in the temperate region and are common at high altitudes in the Western and Eastern Himalayas. *Phyllostachys* is a genus of temperate to warm temperate regions. *Dendrocalamus strictus* is a predominant species of the dry deciduous forests, while *Bambusa bambos* thrives in the moist deciduous forests. *Gigantochloa rostrata* is the most important bamboo species in the semi evergreen forests of Andaman Islands. The commercially important bamboo species of the Eastern & the north-eastern India are *Bambusa tulda*, *Dendrocalamus hamiltonii* and *Melocanna baccifera*.

Bamboo culms grow from the dense root rhizome system. There are two types of rhizomes i.e. monopodial and sympodial. The monopodial rhizome grows horizontally and the buds develop either upward, generating a culm, or horizontally, with a new tract of the rhizomal net. Some bamboos are non-clump forming with culms distant from each other and can be invasive. They are generally found in temperate regions and include the genera *Phyllostachys* and *Pleioblastus*. In other species, the sympodial rhizomes are short and thick, and the culms, which are above the ground are close together in a compact clump, which expands evenly around its circumference. Their natural habitat is tropical regions and they are not invasive. The main genera are *Arundinaria*, *Bambusa* & *Dendrocalamus*.

¹ FAO (2007). *World bamboo resources: A thematic study prepared in the framework of the Global Forest Resources Assessment. Non-wood forest products-18*, Food and Agriculture Organization of the United Nations, Rome

Contribution of Bamboos in the socio-economic, cultural and ecological development of certain geographies is significant. Bamboo, contributes to subsistence needs of about 2.5 billion people around the world, a majority of whom are tribals, forest dwellers or communities dependant on forest resources. It is estimated that in India, there are about 2 million traditional artisans whose livelihoods depend on harvesting, processing, value addition and selling of bamboo products such as baskets, mats, handicrafts etc. Major advantage of bamboo is its versatility in making a variety of products by small entrepreneurs without any major initial investment.

Figure 8.1
Bamboo
Forest of
North-eastern
India
Phyllostachys
mannii



Bamboo thrives in a wide range of climatic and edaphic conditions. Owing to its worldwide distribution, bamboo plays a very important role in bio-diversity conservation, carbon sequestration and soil moisture conservation. The various properties of bamboos are availability in different sizes, light weight yet strong, hard, flexible, straight, fast growing, abundant, and hence having many uses such as in making normal and fine quality paper, fishing poles, furniture, flooring, handicrafts, walking sticks, etc. Young bamboo shoots are used as vegetables in some cuisines.

The Government of India promulgated the Indian Forest (Amendment) Ordinance, 2017 to exempt bamboo grown in non-forest areas from definition of tree, by amending the Section 2 (7) of the Indian Forest Act 1927 and thereby doing away with the requirement of felling/ transit permit for its transport and economic use. The major objective of the amendment is to promote cultivation of bamboo in non-forest areas to achieve the twin objectives of increasing the income of farmers and also increasing green cover of the country.

In this backdrop, the assessment of Bamboo has been an integral part of Forest Inventory and has been presented as a separate chapter in ISFRs. The data on bamboo resources are collected while carrying out the inventory of forest and TOF. Bamboo species are found in more than 18,000 inventoried grids during 2016-17 to 2019 - 20 and have been presented in a table at the end of this Chapter. Further, a comparison of bamboo bearing areas and its growing stock as compared to ISFR 2019² has also been given in this chapter.

² *India State of Forest Report (2019), Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India*

Sampling design

8.2

The two-stage stratified sampling design, which is used for inventory of forest and TOF, is also employed for the assessment of bamboo resources. The design of the first stage is same as that described in the chapter on Growing Stock of this report. The second stage comprises separate designs for the inventory of forests, TOF (Rural) and TOF (Urban), which are also described in the chapter dealing with Growing stock.

For forest inventory, a cluster of four-circular sub-plots is the sampling unit for enumeration of trees/bamboos. A circular plot of 60 m radius around the central sub-plot is used for recording data on plot description. In this form, data of trees and bamboo clumps is recorded from all sub-plots of 8 m radius. Plot Enumeration Form for each subplot of 8 m radius is maintained separately.

Data collection

8.3

Forest inventory

8.3.1

The data on bamboo is collected in every sample plot of the forest inventory. The information such as bamboo density, quality, flowering and regeneration is observed by the field crew, and recorded in the Plot Description Form (PDF). Bamboo density is classified into nine categories namely pure bamboo, very dense, dense, moderately dense, scattered, sparse, hacked, absent and regeneration for clump forming bamboo and for non-clump forming bamboo. For determining the bamboo production capacity of a site, bamboo areas are classified into bamboo-site quality classes on the basis of average height of culms of different bamboo species. For each enumerated bamboo clump, information is recorded on a number of parameters like species name, diameter of culm and crown width of the clump.

Bamboo Clump Analysis for Clump forming Bamboos

8.3.2

The data regarding total number of bamboo clumps and their respective diameters occurring in each sub-plot is recorded in the Plot Enumeration Form. The data is also collected in a separate field form called as Bamboo Clump Analysis Form in which data of each individual culm, occurring in certain selected clumps in each subplot is recorded. For analysis, it is first determined whether a culm is green-sound, green-damaged, dry or dry-damaged; these are then further classified as current years' culms, one to two-year-old culms and culms that are more than two year old. In case of dry and decayed culms, the age classification is not necessary. The culms, other than that of current year and decayed culms, both green and dry, are further grouped under different diameter classes i.e. 1 cm to under 2 cm, 2 cm to under 5 cm, 5 cm to under 8 cm and 8 cm and above.

All culms occurring in the clump selected for analysis are enumerated and each enumerated culm is recorded by 'dot-dash' method (dots represents counts from 1 to 4, lines 5 to 8, and diagonal lines 9 and 10) under its appropriate class. The total number of culms found under each class is recorded in two digits.

8.3.3 Bamboo Enumeration and Analysis for Non-Clump Forming Bamboo

The data is collected for non-clump forming bamboos occurring in the sample subplot 2 i.e. western half of the subplot 2. For the purpose of counting the culms, the subplot 2 is dissected by taking a bearing of 360° from the center of subplot. A rope is placed on this bearing upto the point where this bearing crosses the subplot circumference in North and South direction. All culms falling in western half of north subplot are counted and categorized in five classes viz. green-sound, green-damaged, dry-sound, dry-damaged & decayed.

These are further classified as current year's culms, one to two year old culms and culms more than two years old. In case of dry (both sound as well as damaged) and decayed culms, the age classification is not necessary. The culms, other than the current years and decayed culms, both green and dry are further grouped under diameter at breast height classes, 1 cm to under 2 cm, 2 cm to under 5 cm, 5 cm to under 8 and 8 cm and over.

8.3.4 Bamboo Weight

For determining correlation between green and dry weights for utilizable bamboo culm length, data is collected in 'Bamboo Weight Form'. This form is, however, to be filled up for plots, in which bamboo has actually been found in an area of 60 m radius from the center of subplot 1. One mature bamboo culm from each culm diameter class 1 cm to 2 cm, 2 cm to 5 cm, 5 cm to 8 cm, and 8 cm and over, is to be selected for felling from the first clump enumerated in the plot. If, however, the required number of culms of any diameter class is not available in the first clump, the shortfall is to be made good from the clump next in the serial order of enumeration. Further, if the necessary numbers of culms are not available from any other clump of the plot, the required number of culms is to be obtained from the area in the immediate vicinity of the plot.

8.3.5 Bamboo Assessment from TOF Inventory

As bamboo is not very common in urban areas, bamboo data is collected only from the rural areas of TOF. The information on bamboo is recorded in Plot Enumeration Form. The name of the bamboo species, the diameter of clumps and number of culms in each clump are recorded from each plot of rural inventory.

8.4 Data Processing for Assessment of Bamboo

Data processing is carried out separately for Forest and TOF inventory, which is described below.

Bamboo Assessment from Forest Inventory

8.4.1

The data collected from more than 18,000 points surveyed during four years from 2016-17 to 2019-20 has been used for processing. Data from five field forms namely Plot Description Form, Plot Enumeration Form, Bamboo Enumeration Form (Clump and Non-clump forming separately) and Bamboo weight form are entered in the database using data entry module developed in-house. The data is checked manually and also through computer-based software and cleaned wherever necessary. Once data is cleaned, it is processed at State level through the data processing software on the basis of an area factor (per plot area), which is determined for each State depending on the number of plots falling in the RFA. Thereafter, the bamboo plots surveyed in the States are listed according to bamboo density and quality. The bamboo plots, when multiplied with area factor, gives the species and quality-wise bamboo bearing area for that State. The information on estimated culms is classified into three categories namely green-sound, dry-sound and decayed. The estimated number of culms is converted into equivalent green weight using appropriate weight factors. The national level estimates are obtained by adding the estimates of all the States.

Results

8.5

Bamboo Resource assessment has been done for forest using NFI data. The bamboo resource assessment at the national level and for the State & UTs is presented in this section.

Culm Size Class	Green Sound	Dry Sound	Decayed	Total no of culms as per ISFR 2021	Total culms as per ISFR 2019	change with respect to ISFR 2019
Current year	5,109	0	0	5,109	4,917	192
1-2 cm	8,001	3,105	0	11,106	8,456	2,650
2-5 cm	16,694	4,618	0	21,312	15,258	6,054
5-8 cm	6,842	1,323	0	8,165	5,409	2,756
8 cm +	2,504	306	0	2,810	2,079	731
	0	0	4,834	4,834	3,335	1,499
Total	39,150	9,352	4,834	53,336	39,454	13,882

Table 8.1
Number of culms at country level by Age and Soundness in Recorded Forest Area

The total number of culms at the national level has been estimated to be 53,336 million out of which the percentage of green sound, dry sound and decayed culms has been observed as 73.40%, 17.54% and 9.06% respectively. Size class 2-5 cm has contributed to the maximum number of culms. The total number of culms has increased by 13,882 million as compared to estimates of ISFR 2019.

Table 8.1 shows that the estimated number of culms has increased in all the age classes and for all the soundness class. On an average, there is an increase of 35.19% in number of culms at country level between ISFR 2019 & ISFR 2021.

Table 8.2
Equivalent Green Weight of Bamboo at country level by Age and Soundness in Recorded Forest Area

Culm Size Class	Green sound	Dry Sound	Total Green weight as per ISFR 2021	Total Green weight as per ISFR 2019	Changes w.r.t. ISFR 2019
1-2 cm	36,847	28,519	65,366	61,347	4,019
2 - 5 cm	1,16,200	63,368	1,79,568	1,02,254	77,314
5 - 8 cm	77,783	35,826	1,13,609	80,112	33,497
8 + cm	32,726	10,731	43,457	33,874	9,583
Total	2,63,556	1,38,444	4,02,000	2,77,587	1,24,413

The total estimated green weight of bamboo culms at national level is 402 million tonnes of which green sound bamboos contribute 66 % and dry sound bamboos contribute remaining 34 %. As compared to the estimate of ISFR 2019, an increase of about 124 million tonnes equivalent green weight of bamboo has been observed in the present assessment.

Table 8.3
State/UT wise Distribution of Bamboo area in Recorded Forest Area

S. No.	State/UT's	Bamboo bearing area as per ISFR 2021	Bamboo bearing area as per ISFR 2019	Change in area with respect to ISFR 2019
1.	Andhra Pradesh	6,104	7,003	-899
2.	Arunachal Pradesh	15,739	14,981	758
3.	Assam	10,659	10,525	134
4.	Bihar	1,103	1,136	-33
5.	Chhattisgarh	10,467	11,255	-788
6.	Goa	288	418	-130
7.	Gujarat	3,547	3,393	154
8.	Haryana	39	72	-33
9.	Himachal Pradesh	1,027	650	377
10.	Jharkhand	3,717	4,123	-406
11.	Karnataka	8,624	10,181	-1,557
12.	Kerala	2,404	2,849	-445
13.	Madhya Pradesh	18,394	20,867	-2,473
14.	Maharashtra	13,526	15,408	-1,882
15.	Manipur	8,377	9,903	-1,526
16.	Meghalaya	5,007	5,410	-403
17.	Mizoram	4,561	3,476	1,085
18.	Nagaland	3,947	4,284	-337
19.	Odisha	11,199	11,827	-628
20.	Punjab	280	255	25
21.	Rajasthan	1,555	1,874	-319
22.	Sikkim	994	1,176	-182
23.	Tamil Nadu	4,001	4,357	-356
24.	Telangana	4,535	5,438	-903
25.	Tripura	4,201	3,783	418
26.	Uttar Pradesh	1,832	1,235	597
27.	Uttarakhand	1,201	1,489	-288
28.	West Bengal	702	855	-153
29.	Andaman & Nicobar Islands	1,413	1,814	-401
	Total	1,49,443	1,60,037	-10,594

Note: Information of bamboo bearing area for Chandigarh, Dadra & Nagar Haveli and Daman & Diu, Delhi, Lakshadweep, J & K, Ladakh and Puducherry is not given due to inadequate data

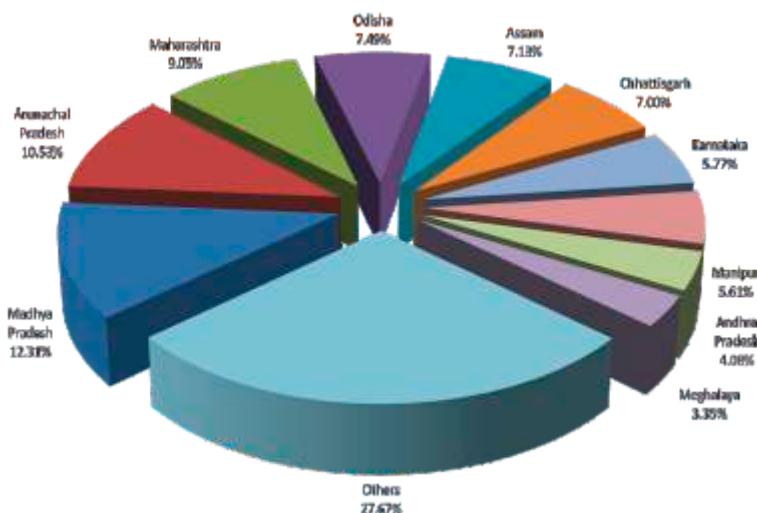


Figure 8.2
Top ten States in terms of bamboo bearing area (%)

The total bamboo bearing area of the country has been estimated to be 15.0 million ha. Madhya Pradesh has maximum bamboo bearing area of 1.84 m ha followed by Arunachal Pradesh (1.57 million ha), Maharashtra (1.35 million ha) and Odisha (1.12 million ha). As compared to the estimates of ISFR 2019, the total bamboo bearing area in the country has decreased by 1.06 million ha. Comparing state wise area of present assessment with ISFR 2021, it has been observed that bamboo bearing area in Mizoram has shown highest increase of 1,085 sq km followed by Arunachal Pradesh (758 sq km). Similarly, Madhya Pradesh has shown highest decrease of 2,473 sq km in the bamboo bearing area followed by Maharashtra (1,882 sq km).

S. No.	State/UT's	Pure Bamboo	Dense	Scattered	Bamboo present but clumps completely hacked	Regeneration crop	(in sq km)
1.	Andhra Pradesh	208	2,253	2,550	176	917	
2.	Arunanchal Pradesh	274	3,148	11,906	0	411	
3.	Assam	449	2,300	7,798	56	56	
4.	Bihar	23	70	511	162	337	
5.	Chhattisgarh	623	1,808	5,112	496	2,428	
6.	Goa	0	0	137	38	113	
7.	Gujarat	79	852	2,378	79	159	
8.	Haryana	0	13	26	0	0	
9.	Himachal Pradesh	100	276	576	25	50	
10.	Jharkhand	32	96	2,793	366	430	
11.	Karnataka	287	1,083	3,155	950	3,149	
12.	Kerala	92	504	1,167	46	595	
13.	Madhya Pradesh	847	4,046	8,327	1,928	3,246	
14.	Maharashtra	767	2,705	6,903	1,475	1,676	
15.	Manipur	161	1,450	6,766	0	0	
16.	Meghalaya	484	750	3,676	0	97	
17.	Mizoram	383	1,781	2,331	33	33	
18.	Nagaland	172	772	2,917	0	86	
19.	Odisha	117	1,723	8,302	117	940	

Table 8.4
State/UT wise bamboo bearing area under different classes in Recorded Forest Area

S. No.	State/UT's	Pure Bamboo	Dense	Scattered	Bamboo present but clumps completely hacked	Regeneration crop
20.	Punjab	0	112	149	19	0
21.	Rajasthan	19	226	602	414	294
22.	Sikkim	66	155	773	0	0
23.	Tamil Nadu	46	367	1,605	797	1,186
24.	Telangana	159	1,306	2,070	550	450
25.	Tripura	94	669	3,318	13	107
26.	Uttar Pradesh	0	351	1,255	25	201
27.	Uttarakhand	34	172	789	0	206
28.	West Bengal	0	43	638	0	21
29.	Andaman & Nicobar Islands*	0	177	1,118	0	118
Total		5,516	29,208	89,648	7,765	17,306
Total as per ISFR 2019		4,332	30,575	1,02,139	8,260	14,731
Changes w.r.t. ISFR 2019		1,184	-1,367	-12,491	-495	2,575

Note: Information of bamboo density for Chandigarh, Dadar & Nagar Haveli and Daman & Diu, Delhi, Lakshadweep, J & K, Ladakh and Puducherry is not given due to inadequate data

Table 8.4 reveals that pure bamboo area has increased and dense bamboo area has reduced from the estimates published in ISFR 2019. It implies that part of this area has changed from low to high density area.

On analysing the forest area of different States according to bamboo density, it has been observed that the pure bamboo brakes are found in less than 1%, dense bamboos in about 4% and scattered bamboos in about 12% of the RFA. In about 1% of the bamboo area, bamboo was present but clumps were found to be completely hacked. Regeneration crop of bamboo was observed in only 2% of forest area.

Maximum occurrence of pure bamboo was observed in Madhya Pradesh (847 sq km) followed by Maharashtra (767 sq km) and Chhattisgarh (623 sq km). The area under dense bamboo was found to be highest in Madhya Pradesh (4,046 sq km) followed by Arunachal Pradesh (3,148 sq km) and Maharashtra (2,705 sq km). The area with hacked bamboo clumps was found to be highest in Madhya Pradesh (1,928 sq km) followed by Maharashtra (1,475 sq km) and Karnataka (950 sq km). Bamboo regeneration was maximum in Madhya Pradesh (3,246 sq km) followed by Karnataka (3,149 sq km) and Chhattisgarh (2,428 sq km).

Table 8.5

State/UT wise number of estimated culms by Soundness of culms in Recorded Forest Area

S. No.	State/UT	Green Culms	Dry Culms	Decayed	Total as per ISFR 2021	Total as per ISFR 2019	Changes w.r.t. 2019
1.	Andhra Pradesh	1,362	676	206	2,244	1,820	424
2.	Arunachal Pradesh	7,455	812	557	8,824	5,769	3,055
3.	Assam	4,813	407	436	5,656	3,829	1,827
4.	Bihar	194	36	5	235	247	-12
5.	Chhattisgarh	1,542	860	398	2,800	2,114	686
6.	Goa	4	19	7	30	30	0
7.	Gujarat	625	149	104	878	677	201
8.	Haryana	13	1	1	15	0	15

(in million)

S. No.	State/UT	Green Culms	Dry Culms	Decayed	Total as per ISFR 2021	Total as per ISFR 2019	Changes w.r.t. 2019
9.	Himachal Pradesh	524	120	27	671	485	186
10.	Jharkhand	620	169	207	996	876	120
11.	Karnataka	1,884	549	220	2,653	1,910	743
12.	Kerala	800	229	58	1,087	1,030	57
13.	Madhya Pradesh	3,108	1,005	649	4,762	3,595	1,167
14.	Maharashtra	2,767	932	418	4,117	2,971	1,146
15.	Manipur	1,277	279	12	1,568	1,126	442
16.	Meghalaya	1,803	214	182	2,199	1,521	678
17.	Mizoram	1,219	173	98	1,490	1,074	416
18.	Nagaland	2,095	296	314	2,705	2,544	161
19.	Odisha	2,785	790	398	3,973	2,291	1,682
20.	Punjab	18	6	4	28	11	17
21.	Rajasthan	297	58	27	382	527	-145
22.	Sikkim	285	23	18	326	218	108
23.	Tamil Nadu	466	396	159	1,021	946	75
24.	Telangana	1,149	716	143	2,008	926	1,082
25.	Tripura	1,311	185	66	1,562	1,110	452
26.	Uttar Pradesh	200	80	30	310	236	74
27.	Uttarakhand	163	90	48	301	384	-83
28.	West Bengal	214	31	35	280	384	-104
29.	Andaman & Nicobar Islands	157	51	7	215	803	-588
	Total	39,150	9,352	4,834	53,336	39,454	13,882

Note:1. The difference in the total number of culms from ISFR 2019 is due to the fact that the culms of Dadar Nagar & Haveli is not included in ISFR 2021 due to inadequate area.

As per current assessment, maximum number of green culms are found in Arunachal Pradesh (7,455 million) followed by Assam (4,813 million) and Madhya Pradesh (3,108 million). Dry culms were found maximum in Madhya Pradesh (1,005 million) followed by Maharashtra (932 million) and Chhattisgarh (860 million). As compared to the estimates given in ISFR 2019, maximum increase in number of culms by soundness has been observed in Arunachal Pradesh (3,055 million) followed by Assam (1,827 million) and Odisha (1,682 million).

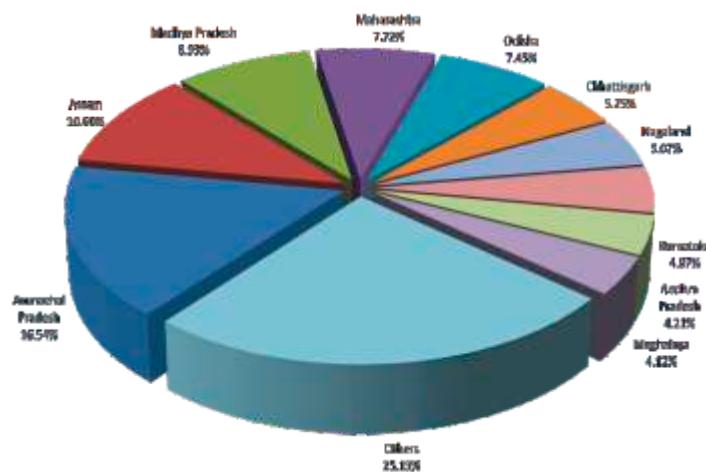


Figure 8.3
Top ten States in terms of bamboo culms (%)

Table 8.6
State/UT wise
Equivalent
Green Weight
by Soundness
of culms in
Recorded
Forest Area

S. No.	State	Green soundness	Dry Sound	Total 2021	Total as per ISFR2019	Change w.r.t. ISFR2019
1	Andhra Pradesh	12,262	14,957	27,219	16,157	11,062
2	Arunachal Pradesh	38,083	8,463	46,546	27,932	18,614
3	Assam	33,978	4,622	38,600	24,064	14,536
4	Bihar	1,249	423	1,672	1,822	-150
5	Chhattisgarh	7,940	8,840	16,780	11,743	5,037
6	Goa	15	242	257	202	55
7	Gujarat	6,663	3,897	10,560	8,877	1,683
8	Haryana	29	4	33		33
9	Himachal Pradesh	1,833	1,043	2,876	1,975	901
10	Jharkhand	3,846	2,301	6,147	4,573	1,574
11	Karnataka	20,579	14,429	35,008	26,456	8,552
12	Kerala	9,109	5,572	14,681	13,092	1,589
13	Madhya Pradesh	12,501	9,783	22,284	14,088	8,196
14	Maharashtra	15,856	13,256	29,112	26,515	2,597
15	Manipur	7,778	3,543	11,321	7,754	3,567
16	Meghalaya	19,096	5,649	24,745	12,323	12,422
17	Mizoram	9,606	2,979	12,585	8,812	3,773
18	Nagaland	24,039	8,363	32,402	20,547	11,855
19	Orissa	14,556	9,160	23,716	16,131	7,585
20	Punjab	61	52	113	47	66
21	Rajasthan	1,709	931	2,640	2,520	120
22	Sikkim	533	91	624	429	195
23	Tamilnadu	2,842	6,373	9,215	7,779	1,436
24	Telangana	6,055	6,461	12,516	6,781	5,735
25	Tripura	9,193	3,220	12,413	6,295	6,118
26	Uttar Pradesh	759	775	1,534	974	560
27	Uttarakhand	1,172	1,667	2,839	1,390	1,449
28	West Bengal	1,013	458	1,471	1,110	361
29	Andaman & Nicobar Islands	1,201	890	2,091	7,199	-5,108
	Total	263,556	138,444	402,000	277,587	124,413

The Table 8.6 shows that the weight of green sound culms is maximum in Arunachal Pradesh (38.08 million tonnes) followed by Assam (33.98 million tonnes) and Nagaland (24.04 million tonnes). The weight of dry sound culms is maximum in Andhra Pradesh (14.96 million tonnes) followed by Karnataka (14.43 million tonnes) and Maharashtra (13.26 million tonnes).

Arunanchal Pradesh has shown maximum increase of 18.61 million tonnes in equivalent green weight as compared to the assessment given in ISFR 2019 followed by Assam (14.54 million tonnes) and Meghalaya (12.42 million tonnes).



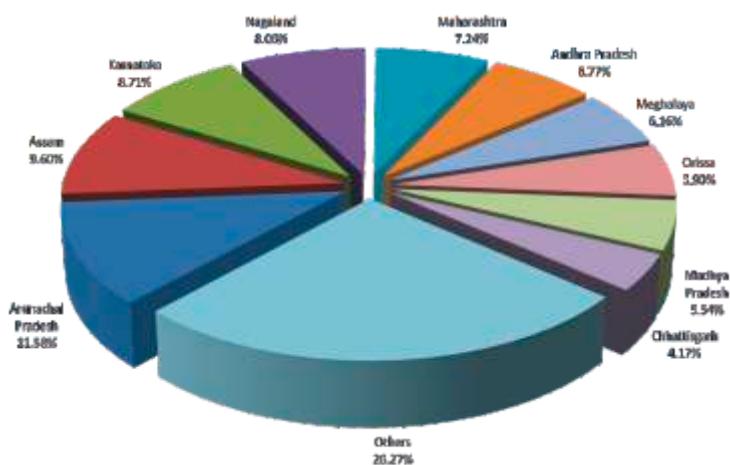


Figure 8.4
Top ten
States in
terms of
bamboo
bearing
weight (%)

