Chapter

# 6 Bamboo Resources of the Country

## 6.1 Introduction

Bamboo is an important non-wood forest resource found in forest as well as non-forest areas in the country. It is a fast growing, wide spread, renewable, versatile, low cost natural resource. Due to its multiple utility and accessibility to common man, it is also known as green gold, poor man's timber etc. With the growing demand of timber, bamboo is a viable alternative/substitute of timber in the country. Bamboo is capable of growing in extreme diverse ranges of soil conditions varying from organically poor to mineral rich soil and moisture level from drought to flooding which makes it effective for reclaiming degraded lands. Bamboos also play an important role in carbon sequestration and biodiversity conservation.

The bamboos are used from food and housing material to a wide range of value addition and industrial activities, both in rural and urban areas, engaging million of farmers, craft persons, industrial workers and others in the secondary and territory sector. It is an important source of employment in both organized and un-organized sector. Apart from its traditional uses, bamboo is extensively used for construction of houses in areas prone to the natural calamities such as earthquake and cyclones due to its being light weight, highly elastic and resistant to rupture etc.

Bamboo belongs to the grass family *Poaceae* (Gramineae). In India, there are 125 indigenous and 11 exotic species of bamboos belonging to 23 genera. As per the FAO report on world forest resources, India is the second richest country of the world after China in terms of bamboo genetic resources. Bamboo forests occupy an area of about 14 million hectares in India. They are found in almost all parts of the country from the tropical to the temperate regions and the alluvial plains to the high mountains, the only exception is the Kashmir region where bamboos do not occur naturally.

The principal bamboo genera occurring in India are *Arundinaria, Bambusa, Chimonobambusa, Dendrocalamus, Dinochola, Gigantochloa* etc. More than 50 % of the bamboo species occur in Eastern India, viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and West Bengal. Other areas rich in bamboos are the A&N Islands, Bastar region of Chhattisgarh and the Western Ghats.

*Bambusa* and *Dendrocalamus* are found under tropical conditions, whereas *Arundinaria* and its allies occur in the temperate region and are by far the most commonly found species on higher elevations

in the Western and Eastern Himalayas. *Dandrocalamus strictus* is predominantly found in dry deciduous forests, while Bambusa species flourishes best in moist deciduous forests. The most important bamboo species of the semi evergreen forests of Andamans is *Gigantochloa rostrata.* In the eastern region, i.e. West Bengal, Assam and North Eastern Himalayas, the commercially important bamboos are *Bambusa tulda, Dendrocalamus hamiltonii* and *Melocanna bacciferrum.* The distribution of bamboo species found in 178 inventoried districts have been shown in a map at the end of this Chapter.

The inventory of bamboos has been an integral part of National Forest Inventory undertaken by FSI. The data on bamboo resources are collected while carrying out the forest and Trees Outside Forest (TOF) inventory. With modification of sampling design in year 2002, aiming at the national level estimates on growing stock, the bamboo data has been collected from 178 districts along with other forest/TOF inventory data, between the period from 2002 to 2008. In the earlier State of Forest Reports, the growing stock data in respect of wood alone was given and it did not contain information on bamboos. However, considering the importance of bamboos as a major resource for rural economy as also its industrial uses, it has been decided to include information on bamboo resources at national and states level in the present ISFR.

## 6.2 Sampling Design

The sample design used for National Forest Inventory for assessment of Forest and TOF is two stage stratified sampling design. The first stage design is the same for both forest and TOF inventory which has already been described in Chapter 4. In the second stage, separate design is used for inventory of forests, TOF (Rural) and TOF (Urban). The information on bamboo resources from forests is recorded during forest inventory. The 60 districts selected in the first stage are taken for detailed inventory of forests. For inventory of forests, forest area is delineated based on green wash areas, double dotted lines and areas marked as thick jungle, forest on the Survey of India toposheets which generally depict notified and other forests. In addition, forest areas indicated by the local forest officials are also taken into account. For such forest areas, 36 grids of 2½'×2½' are further sub-divided into sub-grids of 1¼'×1¼' from the 15'×15' SOI toposheets on 1:50,000 scale. These 1¼'×1¼' grids form the basic sampling frame. Two of these sub-grids are then randomly selected to lay out the sample plots at the centre of the selected grid. Other forested sub-grids in the district are selected systematically taking first two sub-grids as random start. The intersection of diagonals of such sub-grids are marked as the centre of the plot at which a square sample plot of 0.1 ha area is laid out to record the measurements on field forms as per the manual.

For inventory of TOF, separate second stage sampling designs are followed for the rural and urban area, the details of which has been given in Chapter 5 dealing with Growing Stock. The information on bamboo resources is collected in the prescribed field forms.

## 6.3 Data Collection

### 6.3.1 Forest Inventory

The data on bamboos is collected from each main plot of 0.1 ha and the circular plot of 2.0

ha around the plot centre. The plot of 0.1 ha is actually laid out in the field for taking the measurements whereas the circular plot is not physically laid out but information from circular plot is observed occularly. The occurrence of bamboo in an area of 2.0 ha around the plot centre is recorded according to density and bamboo quality. The density of bamboo is categorized in nine classes depending upon the number of clumps per hectare for clump forming bamboo species and number of culms per hectare for non-clump forming bamboos. The bamboo quality is determined on the basis of average height of culms observed in the circular plot. In addition to bamboo density and quality, information on bamboo flowering and regeneration is also recorded from an area of 2.0 ha around the plot centre.

The information of total bamboo clumps and their respective diameters occurring in each 0.1 ha plot is recorded in the Plot Enumeration Form (PEF). For bamboo clump analysis, the data is recorded in a separate field form called as Bamboo Clump Analysis Form in which data of each individual culm occurring in certain selected clumps in the plot is recorded. For carrying out this analysis, at the outset, it is determined whether a culm is green sound, green damaged, dry sound or damaged and then further classified as current year's culms, one to two years old culms and over two years old culms. In case of dry and decayed culms (both sound as well as damaged), the age classification is not done. The culms other than the current year's and decayed culms (both green and dry) are further grouped under diameter at breast height classes 2 cm to under 5 cm, 5 cm to under 8 cm and 8 cm and above.

For non-clump forming bamboos, there is a separate field form called Bamboo Enumeration and Analysis Form (Non-Clump Forming). In this form, information is collected for non-clump forming bamboos occurring in the sample plot. For the purpose of counting the culms, only 1/8th area of the plot (touching North West semi-diagonal) is considered. The other analysis of culms is done in the same way as is done for clump forming bamboo described above.

For determining correlation between green and dry weights of utilizable bamboo culm length, data are recorded in Bamboo Weight Form. This form is, however, filled up for plots, in which bamboo has actually been found in 2 ha area. One mature bamboo culm from each culm diameter class as described above are selected for felling from the first clump enumerated in the plot. If, however, the required type of necessary number of culms in any diameter class is not available in the first clump, the shortfall is made good from the clump next in the serial order of enumeration. In case, the requisite number of suitable culms are not available from any other clump of the plot, the required number of culms will be obtained from the area in the immediate vicinity of the plot.

### 6.3.2 TOF Inventory

The information on bamboos from rural areas 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.

## 6.4 Data Processing:

### 6.4.1 Forest Inventory

The information on bamboos collected from 178 districts during the period from 2002-2008 in the prescribed formats, *viz*. Plot Description Form (PDF), Plot Enumeration Form (PEF), Bamboo Enumeration Form (Clump and Non clump forming separately) and Bamboo Weight form are entered in the data base using data entry module after checking of the data by the zonal offices. The entered data is sent to FSI Hqs. for further

processing. After receiving the entered data from the zonal offices, the data is again checked manually and also by using computer based software and data is cleaned wherever necessary. Once data is cleaned, it is processed at district level using a processing software developed by FSI.

For processing of the bamboo data, area factor (per plot area) is determined for a particular district on the basis of number of plots falling in the recorded forest area. Thereafter, the bamboo plots surveyed in the selected district are listed according to bamboo density and quality. The bamboo plots when multiplied with area factor gives the bamboo bearing area according to species and quality for that district. The number of clumps/ha is obtained from Plot Enumeration Form according to species, quality and size classes. The number of culms per clump is obtained from Bamboo Clump Analysis Form. Multiplying clump/ha with culms/clump, the culms/ha is obtained. The culms/ha multiplied with bamboo bearing area of the district will give the estimated number of culms in the district. The information on estimated culms is given in three categories namely green sound, dry sound and decayed. The estimated number of culms are converted into equivalent green weight using appropriate weight factors. The district-wise data is used for estimation of bamboo growing stock physiographic zone wise. The national level estimates are obtained by adding the estimates of all the physiographic zones.

### 6.4.2 TOF Inventory

The data processing is carried out separately for block, linear and scattered stratum. The area figures for block and linear strata are obtained by digital interpretation of remote sensing data, whereas the area of scattered stratum is obtained by subtracting the area of block and linear patches from rural culturable non-forest area. In case of urban stratum, the area is taken from office of the Registrar General of India (RGI). Species and size class-wise number of clumps/ha and culms/clump is obtained for each stratum. Multiplying the clumps/ha with culms/clump, the culms/ha are obtained. Thereafter, area factor of each stratum is used for estimation of number of culms at district level. The district-wise data is used for estimation of physiographic zone estimates. The national level estimates are obtained by adding the estimates of all the physiographic zones.

## 6.5 Results

Total no. of culms at the national level has been estimated to be 23297 million out of which the percentage of green sound, dry sound and decayed has been estimated as 79%, 16% and 5% respectively. Size class 2-5 cm has contributed maximum number of culms.

**Table 6.5.1: Number of Culms at Country level by Age and Soundness** (in million)

| Age Class | Culm Size Class | Green culms | Dry culms | Decayed | Total |
|---|---|---|---|---|---|
| Current | | 4304 | 0 | | 4304 |
| 1-2 Years | 2 - 5 cm | 5482 | 3207 | | 13922 |
| Over 2-Years | | 5233 | | | |
| 1-2 Years | 5 - 8 cm | 1537 | 448 | | 3402 |
| Over 2-Years | | 1417 | | | |
| 1-2 Years | 8 + cm | 217 | 58 | | 559 |
| Over 2-Years | | 284 | | | |
| | | | | 1110 | 1110 |
| **Total Culms** | | **18474** | **3713** | **1110** | **23297** |

**Table 6.5.2: Equivalent Green Weight at Country level (Age and Soundness)** (in 000 tonnes)

| Age Class | Culm Size Class | Green culms | Dry culms | Total |
|---|---|---|---|---|
| 1-2 Years | 2 - 5 cm | 22593 | 24780 | 71321 |
| Over 2 Years | | 23948 | | |
| 1-2 Years | 5 - 8 cm | 23293 | 14118 | 62597 |
| Over 2 Years | | 25186 | | |
| 1-2 Years | 8 + cm | 10111 | 6561 | 35394 |
| Over 2 Years | | 18722 | | |
| **Total Green weight** | | **123853** | **45459** | **169312** |

The total estimated green weight of bamboo culms at national level is estimated to be 169 million tonnes of which green sound bamboos contribute 73 % and dry sound bamboos contribute remaining 27%.

**Table 6.5.3: State-wise Distribution of Bamboo Area in Recorded Forests** ($km^2$)

| State/UT | Bamboo bearing area |
|---|---|
| Andhra Pradesh | 8,184 |
| Arunachal Pradesh | 16,083 |
| Assam | 7,238 |
| Bihar | 739 |
| Chhattisgarh | 11,368 |
| Dadra & Nagar Haveli | 55 |
| Goa | 308 |
| Gujarat | 4,091 |
| Haryana | 19 |
| Himachal Pradesh | 508 |
| Jharkhand | 3,603 |
| Karnataka | 8,186 |
| Kerala | 2,882 |
| Madhya Pradesh | 13,059 |
| Maharashtra | 11,465 |
| Manipur | 9,303 |
| Meghalaya | 4,793 |
| Mizoram | 9,245 |
| Nagaland | 4,902 |
| Orissa | 10,518 |
| Punjab | 75 |
| Rajasthan | 2,455 |
| Sikkim | 1,181 |
| Tamil Nadu | 3,265 |
| Tripura | 3,246 |
| Uttar Pradesh | 1,313 |
| Uttarakhand | 451 |
| West Bengal | 1,042 |
| **Total** | **139,577** |

***Note:*** *Information of bamboo bearing area for A & N Islands, Chandigarh, Delhi, Daman & Diu, Lakshadweep, J & K and Puducherry is not given due to inadequate data.*

The total bamboo bearing area of the country is estimated to be 13.96 million hectare. Arunachal Pradesh has maximum bamboo bearing area (1.6 m ha) followed by Madhya Pradesh (1.3 m ha), Maharashtra (1.15 m ha) and Orissa (1.03 m ha).

**Table 6.5.4: State-wise Bamboo bearing area by Density in Recorded Forests** ( $km^2$)

| State/UT | Pure bamboo | Dense bamboo | Scattered bamboo | Bamboo present but clumps completely hacked | Bamboo re-generation | No bamboo | RFA ($km^2$) |
|---|---|---|---|---|---|---|---|
| Andhra Pradesh | 26 | 1795 | 3963 | 309 | 2091 | 55630 | 63,814 |
| Arunachal Pradesh | 217 | 8681 | 6953 | 144 | 88 | 35457 | 51,540 |
| Assam | 105 | 4049 | 2878 | 166 | 40 | 19594 | 26,832 |
| Bihar | 1 | 239 | 393 | 75 | 31 | 5734 | 6,473 |
| Chhattisgarh | 54 | 3046 | 4577 | 1496 | 2195 | 48404 | 59,772 |
| Dadra & Nagar Haveli | 0 | 15 | 28 | 3 | 9 | 149 | 204 |
| Goa | 0 | 40 | 212 | 12 | 44 | 916 | 1,224 |
| Gujarat | 0 | 799 | 2408 | 367 | 517 | 14836 | 18,927 |
| Haryana | 0 | 3 | 9 | 7 | 0 | 1540 | 1,559 |
| Himachal Pradesh | 0 | 37 | 422 | 24 | 25 | 36525 | 37,033 |
| Jharkhand | 14 | 898 | 1571 | 509 | 611 | 20002 | 23,605 |
| Karnataka | 0 | 1925 | 4390 | 297 | 1574 | 30098 | 38,284 |
| Kerala | 0 | 461 | 2105 | 86 | 230 | 8383 | 11,265 |
| Madhya Pradesh | 76 | 2732 | 5264 | 2284 | 2703 | 81630 | 94,689 |
| Maharashtra | 56 | 2618 | 4604 | 1466 | 2719 | 50474 | 61,939 |
| Manipur | 192 | 5825 | 3101 | 124 | 61 | 8115 | 17,418 |
| Meghalaya | 63 | 2815 | 1830 | 68 | 17 | 4703 | 9,496 |
| Mizoram | 226 | 6116 | 2757 | 104 | 42 | 7472 | 16,717 |
| Nagaland | 101 | 3064 | 1644 | 65 | 28 | 4320 | 9,222 |
| Orissa | 35 | 2479 | 5230 | 1066 | 1708 | 47618 | 58,136 |
| Punjab | 0 | 5 | 39 | 31 | 0 | 3009 | 3,084 |
| Rajasthan | 0 | 516 | 1188 | 333 | 418 | 30185 | 32,639 |
| Sikkim | 0 | 481 | 684 | 8 | 8 | 4660 | 5,841 |
| Tamil Nadu | 5 | 650 | 1707 | 130 | 773 | 19612 | 22,877 |
| Tripura | 67 | 2039 | 1079 | 43 | 18 | 3048 | 6,294 |
| Uttar Pradesh | 2 | 311 | 647 | 189 | 164 | 15270 | 16,583 |
| Uttarakhand | 0 | 67 | 329 | 47 | 8 | 34200 | 34,651 |
| West Bengal | 0 | 362 | 582 | 58 | 40 | 10837 | 11,879 |
| **Total** | **1240** | **52068** | **60596** | **9511** | **16162** | **602420** | **741,997** |

***Note:*** *Information for A & N Islands, Chandigarh, Delhi, Daman & Diu, Lakshadweep, J & K and Puducherry is not given due to inadequate data.*

On analyzing 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% of the recorded forest area of the country. The dense bamboos are found in about 7% of the area and scattered in about 8% of the area. About 1% of bamboo area was found completely hacked. Regeneration of bamboo was observed in only about 0.02 % of the forest area.

Occurrence of pure bamboo was observed maximum in Mizoram ( 226 $km^2$) followed by Arunachal Pradesh (217 $km^2$), Manipur (192 $km^2$) and Nagaland (101 $km^2$). The dense bamboo was found maximum in Arunachal Pradesh (8681 $km^2$) followed by Mizoram (6116 $km^2$) and Manipur (5825 $km^2$). The area with hacked bamboo clumps was found maximum in Madhya Pradesh (2284 $km^2$) followed by Chhattisgarh (1496 $km^2$) and Maharashtra (1466 $km^2$). The bamboo regeneration was found maximum in Maharashtra followed by Madhya Pradesh, Chhattisgarh and Andhra Pradesh.

**Table 6.5.5: State-wise Number of Estimated Culms by Soundness in Recorded Forests**

(in million)

| State/UT | Green Culms | Dry Culms | Decayed | Total |
|---|---|---|---|---|
| Andhra Pradesh | 837 | 198 | 63 | 1098 |
| Arunachal Pradesh | 2666 | 234 | 80 | 2980 |
| Assam | 2046 | 201 | 94 | 2341 |
| Bihar | 270 | 38 | 19 | 327 |
| Chhattisgarh | 458 | 123 | 20 | 601 |
| Goa | 10 | 4 | 0 | 14 |
| Gujarat | 114 | 50 | 7 | 171 |
| Himachal Pradesh | 161 | 103 | 27 | 291 |
| Jharkhand | 181 | 49 | 8 | 238 |
| Karnataka | 310 | 97 | 10 | 417 |
| Kerala | 115 | 37 | 5 | 157 |
| Madhya Pradesh | 1229 | 819 | 222 | 2270 |
| Maharashtra | 536 | 191 | 21 | 748 |
| Manipur | 2035 | 192 | 70 | 2297 |
| Meghalaya | 1109 | 104 | 38 | 1251 |
| Mizoram | 1953 | 185 | 67 | 2205 |
| Nagaland | 1077 | 102 | 37 | 1216 |
| Orissa | 720 | 169 | 54 | 944 |
| Punjab | 3 | 2 | 0 | 5 |
| Rajasthan | 500 | 404 | 122 | 1026 |
| Sikkim | 206 | 17 | 5 | 228 |
| Tamil Nadu | 367 | 86 | 33 | 485 |
| Tripura | 735 | 70 | 25 | 830 |
| Uttar Pradesh | 122 | 87 | 26 | 235 |
| Uttarakhand | 143 | 92 | 24 | 259 |
| West Bengal | 568 | 59 | 33 | 660 |
| Dadra & Nagar Haveli | 3 | 0 | 0 | 3 |
| **Total** | **18474** | **3713** | **1110** | **23297** |
| **%** | **79** | **16** | **5** | **100** |

***Note:*** *Information for A & N Islands, Chandigarh, Delhi, Daman & Diu, Lakhsadweep, J & K, Haryana and Puducherry is not given due to inadequate data.*

The inventory results indicate that the maximum number of green sound culms are found in Arunachal Pradesh (2666 million) followed by Assam (2046 million), Manipur (2035 million) and Mizoram (1953 million). Dry sound culms were found maximum in Madhya Pradesh (819 million), Rajasthan (404 million) and Arunachal Pradesh (234 million).

**Table 6.5.6: State-wise Equivalent Green Weight by Soundness of Culms in Recorded Forests**

(000' tonnes)

| State/UT | Green Culms | Dry Culms | Total |
|---|---|---|---|
| Andhra Pradesh | 4732 | 2080 | 6812 |
| Arunachal Pradesh | 12359 | 2072 | 14431 |
| Assam | 9985 | 2301 | 12286 |
| Bihar | 1023 | 394 | 1417 |
| Chhattisgarh | 1863 | 904 | 2767 |
| Goa | 50 | 31 | 81 |
| Gujarat | 3433 | 1626 | 5059 |
| Himachal Pradesh | 773 | 567 | 1340 |
| Jharkhand | 736 | 357 | 1093 |
| Karnataka | 10436 | 4724 | 15160 |
| Kerala | 6399 | 2818 | 9217 |
| Madhya Pradesh | 4497 | 5671 | 10168 |
| Maharashtra | 13024 | 6087 | 19111 |
| Manipur | 11617 | 2121 | 13738 |
| Meghalaya | 6334 | 1157 | 7491 |
| Mizoram | 11150 | 2037 | 13187 |
| Nagaland | 6150 | 1124 | 7274 |
| Orissa | 3336 | 1404 | 4740 |
| Punjab | 13 | 10 | 23 |
| Rajasthan | 1692 | 2722 | 4414 |
| Sikkim | 772 | 115 | 887 |
| Tamil Nadu | 5797 | 2499 | 8296 |
| Tripura | 4198 | 767 | 4965 |
| Uttar Pradesh | 424 | 591 | 1015 |
| Uttarakhand | 690 | 506 | 1196 |
| West Bengal | 2158 | 681 | 2839 |
| Dadra & Nagar Haveli | 212 | 93 | 305 |
| **Total** | **123853** | **45459** | **169312** |
| **%** | **73** | **27** | **100** |

***Note:*** *Information for A & N Islands, Chandigarh, Delhi, Daman & Diu, Lakhsadweep, J & K, Haryana and Puducherry is not given due to inadequate data.*

The results show that green sound weight of culms is maximum in Arunachal Pradesh (12.4 m tonnes) followed by Manipur (11.6 m tonnes), Mizoram (11.2 m tonnes) and Karnataka (10.4 m tonnes). The dry sound weight of culms is maximum in Maharashtra (6.1 m tonnes) followed by Madhya Pradesh (5.7 m tonnes), Karnataka (4.7 m tonnes) and Rajasthan (2.7 m tonnes).

**Table 6.5.7: Physiographic Zone-wise* Bamboo Estimation in TOF (Rural)**

| Physiographic Zone | Geographical Area | Total Culms (million) | Equivalent Green Weight (million tonnes) |
|---|---|---|---|
| Western Himalayas | 329255 | 120 | 0.55 |
| Eastern Himalayas | 74618 | 83 | 0.32 |
| North East | 133990 | 289 | 1.72 |
| Northern Plains | 295780 | 57 | 0.24 |
| Eastern Plains | 223339 | 943 | 4.07 |
| Western Plains | 319098 | 8 | 0.03 |
| Central Highlands | 373675 | 124 | 0.53 |
| North Deccan | 355988 | 45 | 0.23 |
| East Deccan | 336289 | 212 | 0.97 |
| South Deccan | 292416 | 16 | 0.16 |
| Western Ghats | 72381 | 30 | 0.28 |
| Eastern Ghats | 191698 | 3 | 0.02 |
| West Coast | 121242 | 135 | 0.77 |
| East Coast | 167494 | 55 | 0.24 |
| **Total** | **3287263** | **2127** | **10.20** |

***Note:*** **The state wise estimates of number of culms and their weight is not given as the sample size was not adequate to give estimates with an acceptable precision.*

In TOF areas, the total number of culms estimated at national level is 2127 million with an equivalent weight of 10.20 million tonnes. Eastern Plains contribute maximum number of culms (943 million), followed by North East (289 million) and East Deccan (202 million). The equivalent weight has also been observed maximum in the Eastern Plains (4.07 m tonnes) followed by North East (1.72 m tonnes) and East Deccan (0.97 m tonnes).

# Distribution of Bamboo species in India

(As observed in 178 inventoried districts)

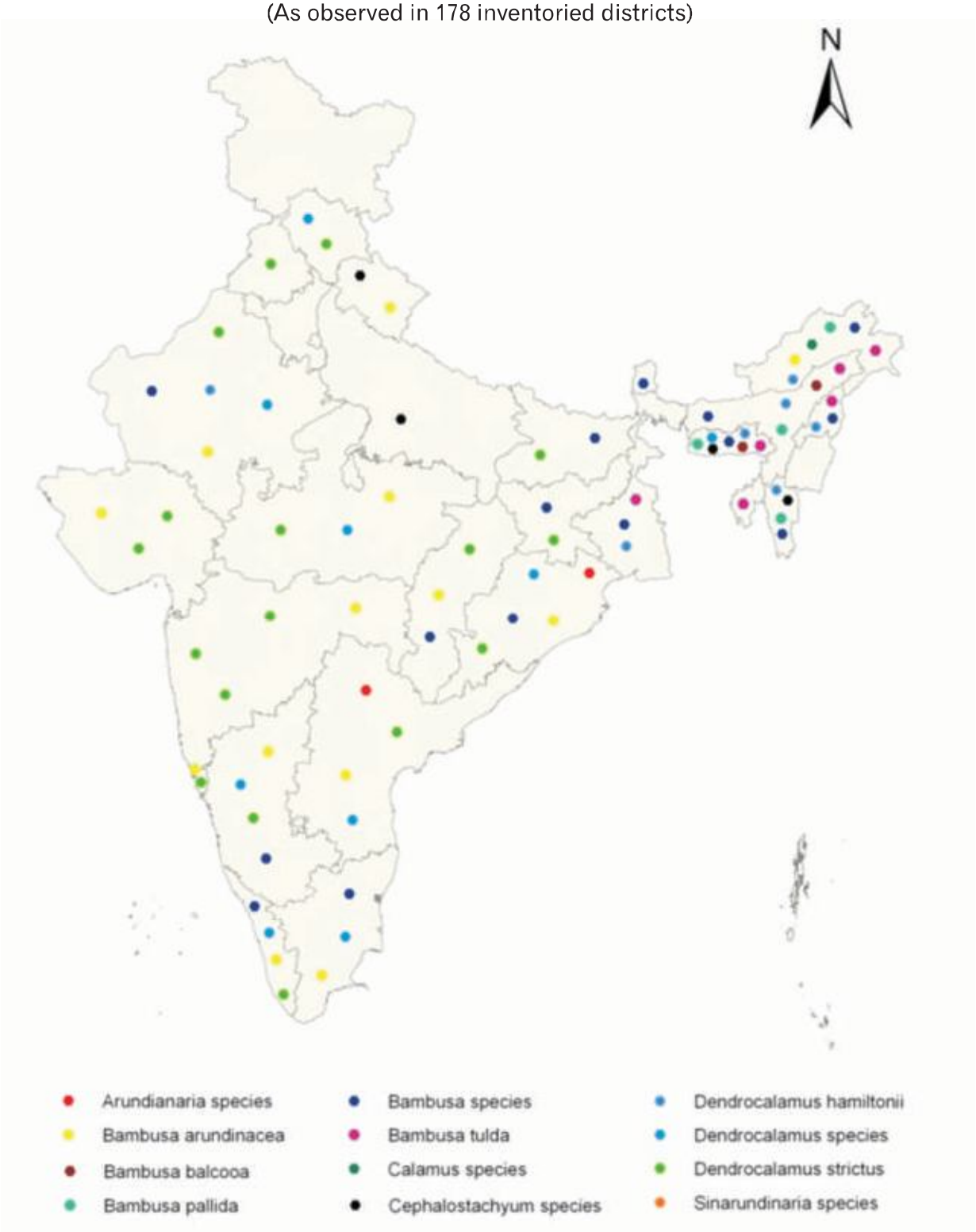


**Fig. 6.2: Distribution of Bamboo Species in India**