

# 2. Extent and characteristics of bamboo resources

## EXTENT OF BAMBOO RESOURCES

Estimation of the area of bamboo was one of the main tasks of the present assessment. Country reports provided estimates based on an analysis of the latest inventory data. In many cases, additional data were obtained from remote sensing analyses. The information requested included bamboo resource composition, areas of monopodial and sympodial species and bamboo outside forest land. Although this study constitutes the most complete survey to date of bamboo resources at the global level, the data reflect both data availability and information gaps, the latter particularly in Africa and Latin America.

Figure 2 shows the share of world bamboo resources by continent. Asia remains the richest continent, with about 65 percent of total world bamboo resources.

FIGURE 2  
Contribution of world bamboo resources by continent

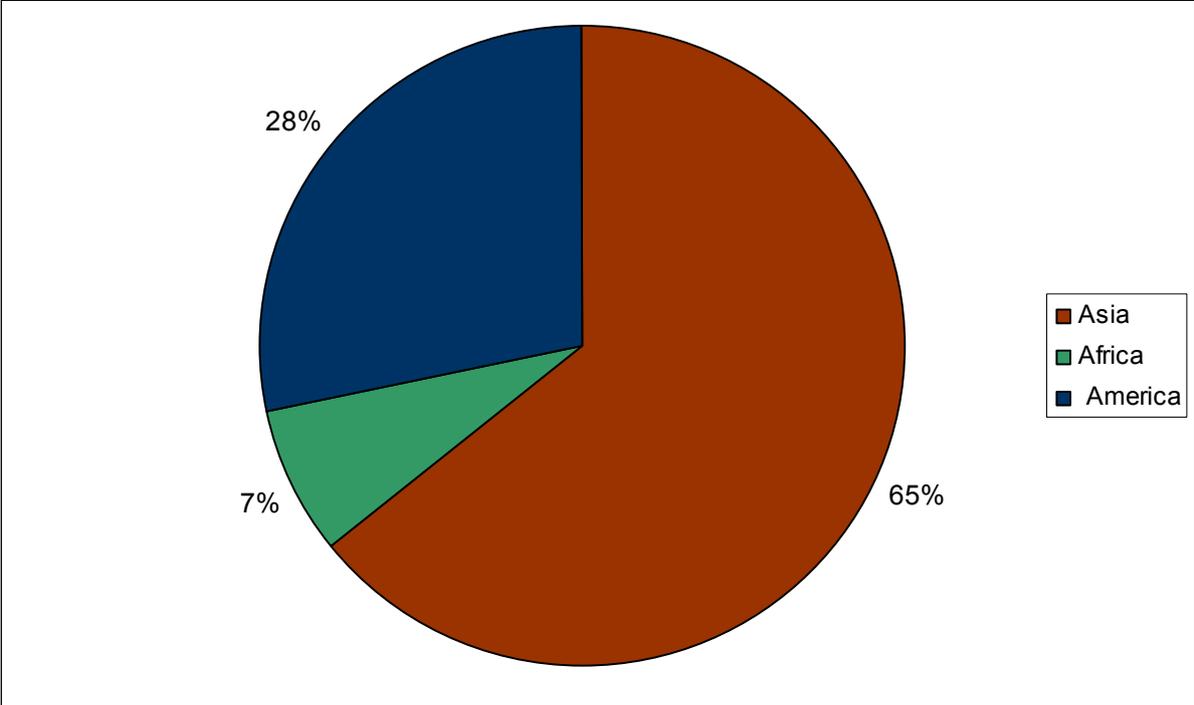


Table 4 presents the distribution of the bamboo resources by countries. The table shows that bamboo may total more than 36 million hectares worldwide or an average of 3.2 percent of the total forest area in the reporting countries if bamboo outside forest land is included. Sixteen countries in Asia together reported a total of close to 24 million hectares of bamboo forest, constituting some 4.4 percent of the total forest area in the countries surveyed. Although the information gathered from Africa is partial, a total of over 2.7 million hectares of bamboo forest was reported by six countries (Ethiopia, Kenya, Nigeria, Uganda, the United Republic of Tanzania and Zimbabwe). In Latin America, at least ten countries have significant bamboo resources. Although precise assessments are still to be done, a total of over 10 million hectares is considered a realistic estimate for the region. Brazil, Chile, Colombia, Ecuador and Mexico have the richest bamboo resources.

In some countries, a substantial part of the bamboo area is found as narrow belts along rivers and in small stands not classified as forest. In such cases, the percentage of forest area is somewhat misleading.

TABLE 4  
Extent of bamboo forest in Asia, Africa and Latin America

Country	Area of bamboo (1 000 ha)			Forest area (1 000 ha)	Bamboo to forest area, %
	1990	2000	2005		
Bangladesh	90	86	83	871	9.5
Cambodia <sup>a</sup>	32	34	29	10 447	0.3
China	3 856	4 869	5 444	197 290	2.8
India	10 711	10 863	11 361	67 701	16.8
Indonesia	2 151	2 104	2 081	88 495	2.4
Japan	149	153	154	24 868	0.6
Lao People's Democratic Republic <sup>a</sup>	1 612	1 612	1 612	16 142	10.0
Malaysia	422	592	677	20 890	3.2
Myanmar	963	895	859	32 222	2.7
Pakistan	9	14	20	1 902	1.1
Papua New Guinea	23	38	45	29 437	0.2
Philippines	127	156	172	7 162	2.4
Republic of Korea	8	6	6	6 265	0.1
Sri Lanka	3	3	3	1 933	0.2
Thailand <sup>a</sup>	261	261	261	14 520	1.8
Viet Nam <sup>a</sup>	813	813	813	12 931	6.3
<b>Total Asia</b>	<b>21 230</b>	<b>22 499</b>	<b>23 620</b>	<b>533 076</b>	<b>4.4</b>
Ethiopia	849	849	849	13 000	6.5
Kenya	124	124	124	3 522	3.5
Nigeria	1 590	1 590	1 590	11 089	14.3
Uganda <sup>a</sup>	67	67	67	3 627	1.8
United Republic of Tanzania <sup>a</sup>	128	128	128	35 257	0.4
<b>Total Africa</b>	<b>2 758</b>	<b>2 758</b>	<b>2 758</b>	<b>66 495</b>	<b>4.1</b>
Brazil	-	9 300	9 300	447 698	2.1
Chile	-	900	900	16 121	5.6
Ecuador	-	9	9	10 853	0.1
Peru <sup>a</sup>	-	190	190	68 742	0.3
<b>Total Latin America</b>	<b>-</b>	<b>10 399</b>	<b>10 399</b>	<b>543 414</b>	<b>1.9</b>
<b>Grand Total</b>	<b>23 988</b>	<b>35 656</b>	<b>36 777</b>	<b>1 142 985</b>	<b>3.2</b>

<sup>a</sup> Data on the extent of forest were obtained from other sources than national reports.

In Asia, the major bamboo producing countries are India (almost 11.4 million hectares) and China (over 5.4 million hectares), followed by Indonesia (2 million hectares) and the Lao People's Democratic Republic (1.6 million hectares). India accounts for roughly half the total area of bamboo reported for Asia and, together with China, approximately 70 percent. Over the last 15 years, the bamboo area in

Asia has increased by 10 percent, primarily due to large-scale planting of bamboo in China and, to a lesser extent, in India.

The total area of bamboo reported by the five African countries makes up over 2.7 million hectares. This equals 4.1 percent of their total forest area. Ethiopia reported 6.5 percent and Nigeria over 14 percent of bamboo in the forest cover. Nigeria may have overestimated the total area of bamboo due to a different methodological approach. It reported forest land with bamboo, but did not apply the reclassification method to calculate the pure bamboo area.

Latin America has no reliable data on the bamboo area at the regional level. Information exists in some countries, but it is insufficient, scattered and at times contradictory. Brazil, Chile, Ecuador were the only countries in Latin America that provided information on the extent of bamboo in their national reports. For Peru, extent of bamboo forest was calculated from a previous national study (INRENA, 1999). However, bamboo is known to exist in other countries in the region as well, including Argentina, Bolivia, Colombia, Costa Rica, Mexico and Paraguay. The most reliable expert estimate is of 11 million hectares of bamboo area in the region (Londoño, 2001), a little higher than the 10.4 million hectares reported in Table 4.

Lack of reliable data on bamboo resources in Latin America is partially explained by the current low economic value of bamboo on the continent. There, as well as in Africa, many people regard bamboo as a weed plant and do not yet appreciate its huge economic potential for development and poverty alleviation. Although the resources of native species are abundant, their exploitation is limited to mostly low-end, low-profit, traditional non-mechanized manufacturing.

In Brazil, Colombia and Ecuador, bamboo plays a more conspicuous economic role. In these countries, small-scale cultivation of commercial bamboo is limited to a few native (*Guadua angustifolia*, *G. amplexifolia*) and introduced species (*Bambusa vulgaris*, *B. tuldooides*, *Phyllostachys aurea*).

Despite the fact that time series are available for only a small proportion of the countries surveyed, the extent of bamboo forests shows an upward trend, mainly led by Asia. Of the six countries with the largest extent of bamboo, five are in Asia (Figure 3).

At the global level, sympodial bamboo dominates (Figure 4), although in Asia, the share of monopodial bamboo has increased from 28 to 30 percent in the last 15 years due to the extensive planting in China of *moso* bamboo (*Phyllostachys heterocycla* var. *pubescens*).

Extent of bamboo forest and types (sympodial/monopodial) by country are also found in Annex 4.

## ASIA

**Bangladesh.** Various forest units have been surveyed and inventoried in different years using different approaches. The diverse scopes and timing present challenges in systematizing and arranging the information and may have caused an overestimate of bamboo area. Although the extent of bamboo in forests has decreased due to overexploitation, it is reported that the extent of bamboo in and around villages has increased as a result of the community forestry activities promoted by the Government and non-governmental organizations over the last two decades. The data reported in this study were derived from the FRA 2005 country report. In addition to the inventoried areas, a substantial area of bamboo exists on homesteads and agricultural land – possibly as much as 270 000 ha (Government of Bangladesh, 1993).

**Cambodia.** National forest classification identifies bamboo as a separate forest type – "large areas of dense bamboo". Small plots of bamboo resulting from degradation of mixed deciduous or evergreen forests are not included in this class. Data for Cambodia were obtained from the FRA 2005 country report.

FIGURE 3  
Countries with the largest bamboo resources

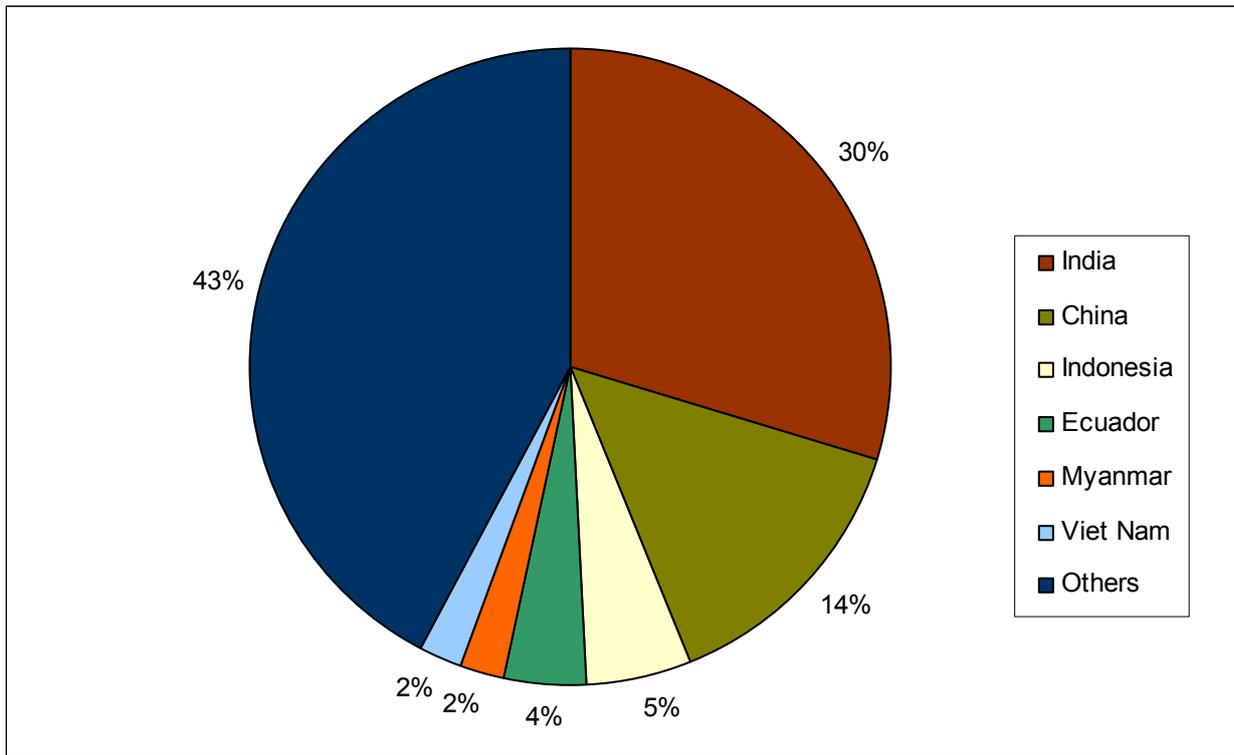
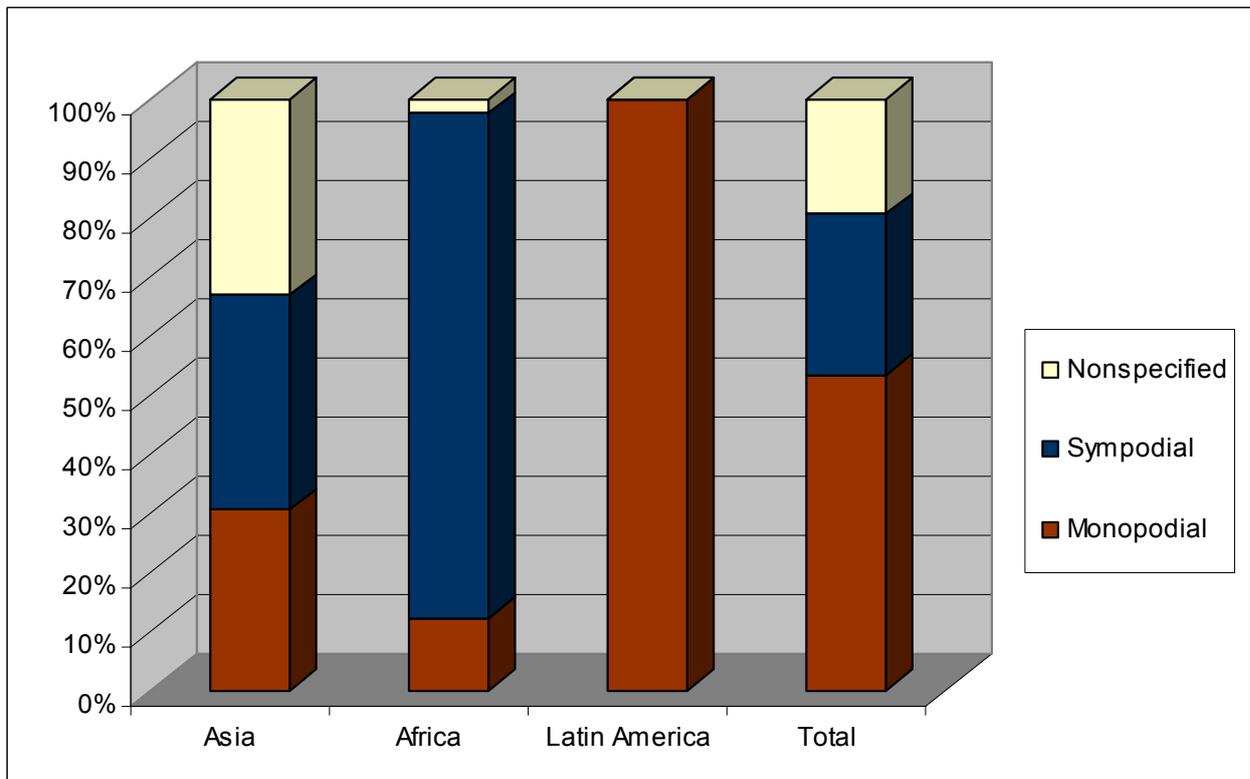


FIGURE 4  
Composition of bamboo types by continent 2005



**China.** In terms of bamboo area, potential and number of bamboo species, China is one of the richest countries in the world. The national forest inventories (NFIs) collect information on bamboo forest indicators such as bamboo type, area, number of culms, ownership, origin and canopy closure. Since the 1990s, the area of bamboo forest has been rapidly increasing at a rate of about 50 000 ha per year. According to the Government of China (2005), bamboo forests have reached an area of some 5 million hectares. This is a 1.5-fold increase compared with the 1950s. Quantity and quality of bamboo are improving due to optimized structure and better management. The average stock of *moso* forests has grown from less than 1 350 culms per hectare in the 1970s to about 2 000 culms per hectare at present.

China defines *moso* bamboo forest as forest land spanning more than 0.0667 ha (one *moo*) and having bamboo species with a diameter at breast height of over 2 cm. The canopy cover should include over 20 percent of *moso* bamboo (*Phyllostachys heterocycla* var. *pubescens*). The category 'other bamboo forest' includes all other bamboo species. *Moso* represents 70 percent of the bamboo in China. Bamboo is grouped into five geographical areas: 1. monopodial bamboo area in northern China; 2. mixed bamboo area south of the Yangtse River; 3. mountainous bamboo area in southeast China, with a predominance of mountainous monopodial bamboo; 4. sympodial bamboo area in southern China, including *Cephalostachyum* Munro, *Thyrsostachys* Gamble, *Dendrocalamus* Nees and *Gigantochloa* Nees species; and 5. Hainan and Yunnan provinces, with several climbing sympodial bamboo species.

**India.** In the framework of the national forest inventory, the Government of India regularly collects data on bamboo, employing both on-the-ground and remote sensing methods. Prior to the reorganization of the states, the survey work had been carried out in 25 states and union territories, covering the entire range of forest types. In some inventory areas where bamboo is predominant, sampling designs for bamboo stratum were slightly modified. It is now possible to identify pure bamboo patches through remote sensing. For mixed forest with bamboo, a field survey is still necessary.

**Indonesia.** The data originate from a variety of methodologies. Bamboo information is present in the national forest inventory database and includes the number of plots in which bamboo is present. The agricultural census, which is carried out by the Central Board of Statistics, also records the number of bamboo clumps outside of forest on other land. It is this bamboo that provides most removals. Calculations are based on the assumption that there are, on average, 31 clumps per hectare nationwide. This assumption is derived from national forest inventory data. The country report states that Indonesia has no monopodial bamboo and that the actual bamboo area on forest land may exceed the reported figure.

**Japan.** The national forest inventory includes a specific class for bamboo: forest that does not fall under "forest with standing trees" and that is dominated by bamboo, excluding bamboo grass. The data reported in the bamboo country report coincide with the data in the FRA 2005 country report.

**Lao People's Democratic Republic.** Bamboo forests are defined as the area in which bamboo species make up over 80 percent of the total vegetation. The data reported were derived from the FRA 2005 country report.

**Malaysia.** Information was collected through a study done in 1992. A questionnaire was sent to all district forest offices on the peninsula, requesting information on location and area of forest reserves containing naturally regenerated bamboo stands, major species and number of clumps per hectare.

**Myanmar.** The data reported were derived from a report by the Ministry of Forestry (Government of Myanmar, 2000). Bamboo is reported as a separate forest type within the total forest area. The original country report includes remote sensing data.

**Pakistan.** In the 1980s, Punjab Province introduced bamboo species from Bangladesh, China, Sri Lanka and Thailand, some of which did not adapt. The most successful species were *Dendrocalamus giganteus*, *D. strictus*, *D. hamiltonii*, *D. longispathus*, *Bambusa tulda*, *B. vulgaris* and an ornamental bamboo, *Phyllostachys aurea*. Planted bamboo was established on agricultural lands in Sargodha, Jhang, Khoshab and Mandibhaur districts of the Punjab. Most of these planted stands average half an

acre, although small farmers have successfully established 4–10-acre groves. The area of planted bamboo has fluctuated according to domestic and Middle Eastern markets. *Dendrocalamus strictus*, *Bambusa tulda* and *Dendrocalamus hamiltonii* are the major species cultivated on private farmland.

**Papua New Guinea.** Bamboo grows in most types of naturally regenerated forest, particularly in areas subjected to disturbances (logging activities, bushfires, shifting cultivation, etc.). National inventories do not include bamboo. There are no documented areas of naturally regenerated pure bamboo stands in the country. Verbal reports indicate that bamboo groves rarely exceed 50 ha. The reported data were based on the area of bamboo obtained from the 1998 Forest Inventory Mapping database (35 700 ha) and the assumption of a direct link between disturbed forests and the development of bamboo. Bamboo probably occupies 1 percent of the approximately 150 000 ha of annual logging of forest. The data in the present report are based on this assumption.

**The Philippines.** Data were obtained from the bamboo country report for 2000 and the FRA 2005 country report for 2005. Data for 1990 were extrapolated.

**Republic of Korea.** Bamboo forests are defined as the areas in which bamboo species constitute over 75 percent of the vegetation. Bamboo inventoried species include *Phyllostachys bambusoides*, *P. heterocyclus* var. *pubescens*, and *P. nigra* var. *henonis*.

**Sri Lanka.** Data were obtained from the literature (Swarnamali and Vivekanandan, 1991) and are likely an overestimate, combining pure bamboo with mixed forests. The definition of bamboo forest has to be clarified. The combination of pure bamboo plantations and mixed bamboo forests creates difficulties for data analysis, which is an issue for many reporting countries.

**Thailand.** Data were extracted from the country report for FRA 2000, which states that bamboo constitutes naturally regenerated undergrowth in deciduous forests. Large areas are now covered with bamboo as a result of earlier shifting cultivation. The main species are *Oxytenanthera albociliata* and *Oxytenanthera nigrociliata*, which thrive in open areas after disturbances. Other species include *mai sang* (*Dendrocalamus* spp.) and *mai bong* (*Bambusa tulda*). They are mainly found in the watersheds of the Mae Nam Kwan and Mae Nam Klong Rivers. Other bamboo species grow in the Salween area in the north, along the border with Myanmar. These species include *Thyrsostachys siamensis*, *Bambusa arundinacea*, *Dendrocalamus hamiltonii*, *D. giganteus*, *D. longispathus* and *Bambusa tulda*.

**Turkey.** The current reported bamboo area is very small, about 10 hectares only, and thus was not considered in the study.

**Viet Nam.** Data were derived from the FRA 2000 country report.

## AFRICA

**Ethiopia.** Information on bamboo resources is very limited. Bamboo forest is decreasing due to population growth, demand for land, migration and forest fires. Access to bamboo is becoming more difficult as authorities and users recognize the need to protect it from further decline. Management concepts and experience are lacking.

In the 1960s, the total area of bamboo was estimated at 1.5 million hectares, including 1 million hectares of lowland bamboo. However, a study by private consultants in 1997 significantly reduced this estimate. The currently estimated total area of bamboo is 849 000 ha. The area of sympodial bamboo is 700 000 ha. About 481 000 ha were mapped and partly surveyed for the 1997 study. The total area of mapped monopodial bamboo is 148 626 ha, including 129 626 ha of naturally regenerated and 19 000 ha of planted bamboo. It is likely that the Ethiopian bamboo area has been shrinking since 1997.

**Kenya.** Table 4 reports 124 000 ha of bamboo forest. Unlike many other country reports, the Kenya report includes reclassification calculations estimating the extent of bamboo forest where it is intermixed with other species. The report lists the following categories: pure bamboo area; bamboo with trees and shrubs where bamboo covers at least 50 percent of the total area; area with bamboo trees

and shrubs where bamboo covers over 30 percent of the total area; and alpine vegetation where bamboo covers over 20 percent of the area. Kenya has put a ban on forest logging, including bamboo, while experts recommend managing bamboo to prevent its deterioration. Some small farmers have been granted harvesting rights. There is as yet no formal bamboo management system in the country.

**Nigeria.** The country report probably overestimates actual bamboo forest, as the reported 14.3 percent bamboo forest cover is well above regional and global levels. No additional references are available to verify the data. Further investigation is needed in order to validate the methodology and figures.

**Uganda.** It is reported that most of the bamboo resources are located in the northwestern district of Arua and the western and southwestern districts of Hoima and Kabale (Esegu, Ssentenza and Sekatuba, 2000; FAO, 2003). Significant portions of the resource are also found in the eastern district of Mbale. Little exploration has been done of the use of bamboo resources in these areas. Most of the resources are located in protected areas under government control.

**United Republic of Tanzania.** Data presented in the study were derived from an INBAR working paper (Chihongo *et al.*, 2000). The researchers had difficulty assessing bamboo forest area because vegetation maps do not recognize bamboo as a separate class. A more detailed survey is needed. Bamboo is an important natural resource and is widely available here. It is mainly found in naturally regenerated forest or forest reserves in the southern and northern parts of the country. Tanzanian bamboo grows at low altitudes as well as in mountain forests. The main species are *Arundinaria alpina* (green mountainous bamboo found in the Kilimanjaro, Arusha and Iringa districts), *Bambusa vulgaris* (golden yellow-green, striped, low-altitude bamboo found in the area of Lake Victoria), and *Oxytenanthera braunii* (common in the southern highlands in the Iringa, Mbeya and Ruvuma districts). The main cultivated species is *Oxytenanthera braunii*, which is famous for its bamboo juice production. Bamboo juice provides a soft drink when freshly tapped and an alcoholic drink when fermented. *O. braunii* is cultivated by almost every family in the southern highlands. The farming pattern varies among families – some areas of planted bamboo, some along riverbanks and others scattered throughout the farmland.

**Zimbabwe.** Information on bamboo resources is available from an FAO report on a limited survey undertaken in three districts of Manicaland Province (FAO, 2001b). It is estimated that bamboo makes up about 2–5 percent of the surveyed 64 000 ha. As they do not represent the entire country, the results have not been included in the study.

Note: Reports from *Algeria* and *Togo* provided almost no quantitative information and thus were also not included in the study.

## LATIN AMERICA

**Brazil.** The country report from Brazil notes that there is no reliable information on the total extent of bamboo forest, but that an estimated 9 million hectares of forest in the southeastern Amazon region are dominated by bamboo. There is also a private area of planted bamboo with 30 000 ha of *Bambusa vulgaris*, which provides raw material for a paper mill in the northeastern region. Interest in bamboo, particularly its industrial utilization, is growing rapidly.

**Chile.** The country reports 899 935 ha of bamboo. The estimate is based on field and remote sensing studies undertaken over 1999–2000. *Chusquea culeou* and *C. quila* populate over 80 percent of the total area. Bamboo forest in Chile makes up about 5 percent of total forest area.

**Colombia.** Although no country report was provided, it is known that bamboo plays an important role in the local economy and traditional culture. Londoño (2001) estimated that Colombia's *Guadua* spp. are spread over 51 500 ha, of which approximately 46 250 ha are naturally regenerated forest and 5 250 ha are planted. Roughly half the bamboo is located in four central-western regions.

**Ecuador.** The information provided by the country report was complemented by additional sources. Ecuadorian bamboo is largely mountainous, and half the species are found at altitudes of 2500–3000 m (Clark, 1997). *Guadua angustifolia* is the most valuable industrial resource. The area of planted bamboo is about 5 000 ha.

**Mexico.** The country report did not provide any data on bamboo forest area. *Guadua* spp. have been cultivated in Chiapas and Tabasco. More than 4 000 ha of bamboo planted for commercial purposes are located in southern Mexico (Londoño, 2001).

**Peru.** Peru did not provide a country report. However, the national report on the state of the bamboo and rattan sector provides the latest and the most reliable information (INRENA, 1999). The study reports growing interest in bamboo as a substitute for wood. Efforts have been made to develop bamboo resources, particularly in the Amazon region. Naturally regenerated bamboo is mostly located in the southeast (Ucayali, Madre de Dios, Cusco and Junin). The Ucayali River basin (between Tambo and Urubamba) has an area of 400 000 ha of forest containing *Guadua* spp. (Londoño and Peterson, 1991). *Guadua weberbaueri* and *G. sarcocarpa* in the lowland Amazonian region (Amazonas, Cuzco, Huanuco, Junin, Loreto, Madre de Dios, Pasco and San Martin) cover over 500 000 ha. Total area of mixed bamboo forest (*pacales*) amounts to some 3.6 million hectares. Additional information is provided by remote sensing analysis. The major forest types associated with bamboo include: climax forest with less than 30 percent bamboo; mixed forest with 30–70 percent; and pure forest with 70–100 percent. Simple calculations indicate 190 000 ha of pure bamboo cover (INRENA, 1999). Peruvian data are more precise than those from many other states in Latin America because bamboo is recognized as a valuable economic resource.

## OWNERSHIP OF BAMBOO FOREST

### OVERVIEW

The ownership structure and tenure system are important in formulating effective bamboo resource policies. Forest ownership is in transition in many countries. FAO (2006) conducted a regional survey on ownership of forests and trees in over 20 countries in Asia. Preliminary results of the study indicated that over 80 percent of Asian forests are public. Most forest areas are under the formal jurisdiction of governments, and forest management is mostly a governmental issue. In the last 20 years, a gradual shift has been noticed towards decentralization. Ownership and control over natural resources is increasingly shifting from the state to local communities and the private sector – and to individual households in many countries (Scherr, White and Kaimowitz, 2003).

In FRA 2005, forest ownership structure included three classes: 1. *Private* – land owned by individuals, families, private cooperatives, corporations, industries, religious and educational institutions, pension or investment funds and other private institutions; 2. *Public* – land owned by the state (national, state and regional governments) or government-owned institutions or corporations or other public bodies including cities, municipalities, villages and communes; and 3. *Other* – land that is not classified as one of the two previous classes.

Twelve countries in Asia and three in Africa provided information on ownership of bamboo forests (Table 5). Trends by country are shown in Figure 5. Except for Ecuador, no data were received from Latin America. In Asia, from 1990 to 2000, public ownership of bamboo resources decreased from 81 to 73 percent. Indonesia, Japan and the Republic of Korea are exceptions, with a greater rate of private ownership. The same trend for the last two countries was noted by FAO studies on forest ownership. In China, no land was classified as private in 1990, while in 2000, roughly one-third of the bamboo forests were under long-term lease and classified as private.

TABLE 5  
Ownership of bamboo in Asia and Africa

Countries/years	1990			2000		
	Total bamboo area (1 000 ha)	Private (%)	Public (%)	Total bamboo area (1 000 ha)	Private (%)	Public (%)
Bangladesh	90	0	100	86	0	100
China	3 856	0	100	4 869	39	61
India	10 711	16	84	10 863	16	84
Indonesia	2 151	71	29	2 104	67	33
Japan	149	97	3	153	97	3
Republic of Korea	8	100	0	6	97	5
Malaysia	422	0	100	592	0	100
Myanmar	963	1	99	895	1	99
Pakistan	9	100	0	14	100	0
Papua New Guinea	23	100	0	38	100	0
Sri Lanka	3	0	100	3	0	100
Philippines	127	2	98	156	2	98
<b>Total Asia</b>	<b>18 511</b>	<b>19</b>	<b>81</b>	<b>19 780</b>	<b>27</b>	<b>73</b>
Ethiopia	849	2	98	849	2	98
Kenya	124	0	100	124	0	100
Nigeria	1 590	100	0	1 590	100	0
<b>Total Africa</b>	<b>2 563</b>	<b>63</b>	<b>37</b>	<b>2 563</b>	<b>63</b>	<b>37</b>

In the African countries surveyed, ownership structure did not change over time, with roughly one-third public and two-thirds private lands. These data should be interpreted with caution and do not represent the entire continent. The result was greatly affected by Nigeria's report, which attributed all bamboo forest to the private sector and did not provide any further clarifications regarding the country's tenure system. A clearer definition of the ownership classes is needed in the future.

## ASIA

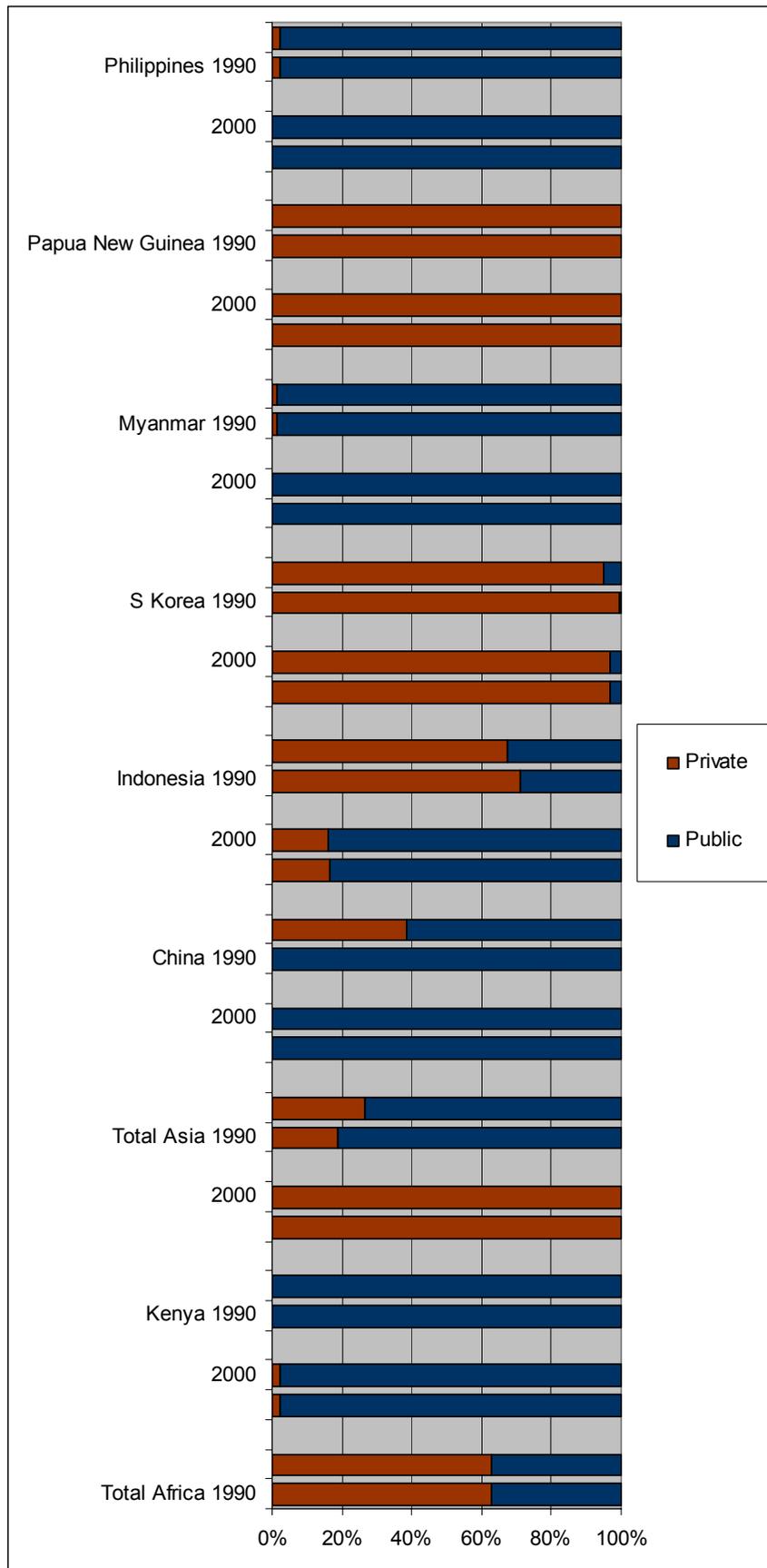
*China.* An important distinction was made between the ownership of land and the ownership of trees. The land is public, but cultivated bamboo may belong to farmers if the land is leased. Land can be leased to private entities for up to 50 years. Public ownership includes both land and trees owned by public entities such as state-owned institutions, enterprises, villages and communes. There was a significant shift in the ownership structure between 1990 and 2000. As mentioned, in 1990 all bamboo forest was owned by the state, while in 2000 about one-third of the bamboo was reported as belonging to the private sector. The new ownership structure has enhanced production opportunities and market access.

*Indonesia.* Bamboo areas reported by the agricultural census belong to farmers and thus are classified as private. Bamboo forest areas are owned by the government and are classified as public.

*Malaysia.* All bamboo area is publicly owned; no private bamboo forests were reported.

*Myanmar.* Most bamboo grows naturally in state forests, but some areas are privately owned by local communities. The data show that only about 1 percent of bamboo forest is privately owned. Some bamboo resources are not reported due to their inaccessibility. Privately owned forests include naturally regenerated areas as well as planted ones.

**FIGURE 5**  
**Trends in ownership of bamboo in Asia and Africa 1990–2000**



*Pakistan.* All bamboo area is reported as private. Planted agroforestry bamboo has been established on private agricultural lands in Punjab Province. Planted area increases or decreases according to market conditions, and market demand for bamboo is influenced primarily by timber prices.

*Papua New Guinea.* Ownership structure in the country is defined on the basis of clans and tribal groupings. Clans own the land and the resources on it. Almost 93 percent of the land is under this form of ownership.

*The Philippines.* In the past, 'bamboo production area' referred only to bamboo growing naturally in forests and in the 'naturally regenerated' stands on private lands. More recently, planted bamboo has become an important source of raw material for some segments of the bamboo industry (Rivera, not dated). There was no significant change in the ownership structure from 1990 to 2000.

*Republic of Korea.* Interestingly, the area of publicly owned bamboo has increased, while private bamboo ownership is declining. No explanation of the data was provided.

*Sri Lanka.* The country report specifies that all bamboo forest is publicly owned, while literature sources report small areas under private ownership.

## AFRICA

*Ethiopia.* Approximately 2 percent of bamboo area is classified as private forests, which normally lie on lower altitudes up to 1 800 m. Naturally regenerated bamboo stands are located above 2 000 m and belong to regional governments.

## CHARACTERISTICS OF BAMBOO RESOURCES

### OVERVIEW

Although most bamboo resources grow naturally, greater attention has been paid in recent years to the establishment of planted bamboo. In general, bamboo offers many opportunities because it serves both production and conservation purposes. Bamboos have long been cultivated in villages and, historically, the rural poor have been the prime users of naturally regenerating bamboo. However, farmers have knowledge of bamboo cultivation on a limited scale (Banik, 1996). Bamboo was rarely planted on forest land and there was little knowledge of bamboo afforestation and reforestation on a large scale.

In the last two or three decades, population growth and new bamboo processing opportunities have led to the overexploitation of bamboo resources, their stricter regulation and even harvesting bans in some countries. These factors have contributed to the development of bamboo plantations. Oprins *et al.* (2004) present an outline of traditional propagation techniques and the most recent micropropagation technology, which has emerged as a result of the growing interest in planted bamboo and its productivity. Several studies and pilot projects were developed, addressing seed and clump propagation and rhizome and culm cuttings. The traditional methods have relatively low cost and do not require skilled labour, but they are not always applicable to large-scale areas. While micropropagation is currently used primarily in ornamental horticulture, it can also be applied in large-scale initiatives. Studies are currently underway to transfer this technology to tropical bamboo countries.

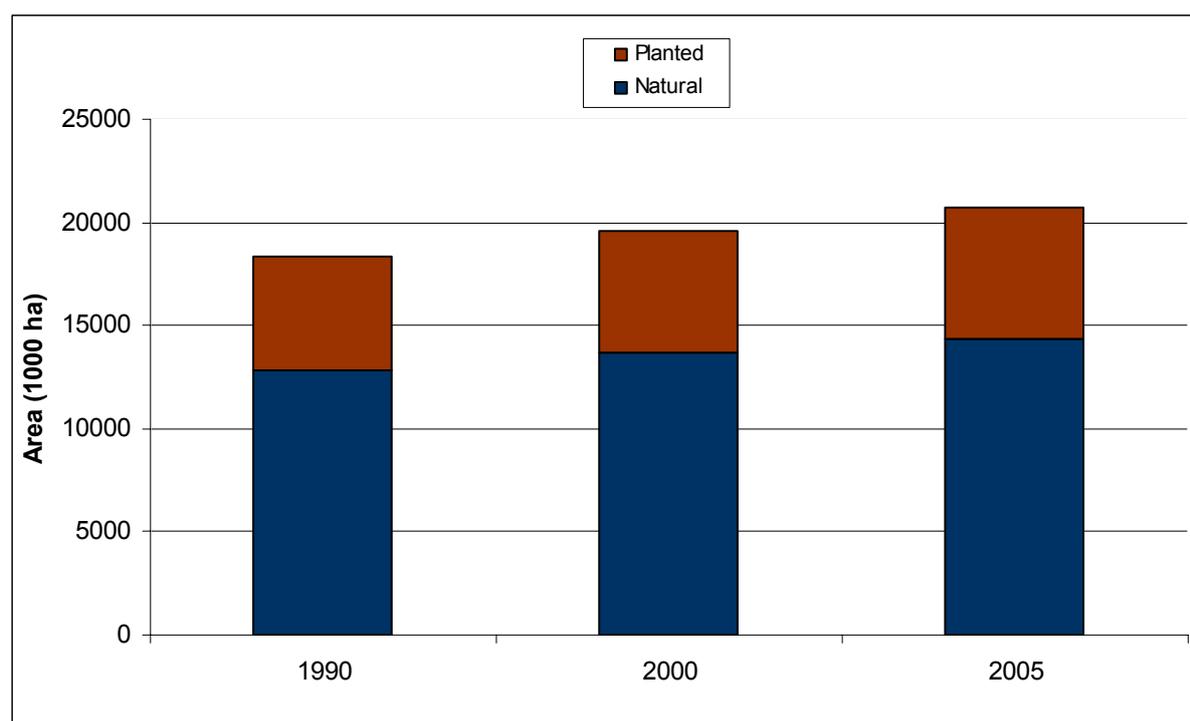
Approximately 30 percent of the total area of bamboo in Asia is planted (Table 6). This percentage has remained rather stable over the reporting period, although there has been a slight increase in recent years. Most of the reporting countries provided data for both naturally regenerated and planted bamboo resources (Figure 6). A few countries indicated a concentration of the resources in either planted or naturally regenerated forests. These cases would require clarification. A fine line separates planted bamboo from naturally regenerated stands, and this might be subject to different interpretations.

TABLE 6  
**Characteristics of bamboo resources in Asia (1 000 ha)**

Countries	1990			2000			2005		
	Naturally regenerated	Planted	Total	Naturally regenerated	Planted	Total	Naturally regenerated	Planted	Total
Bangladesh	80	10	90	76	10	86	73	10	83
China	2 789	1 067	3 856	3 235	1 634	4 869	3 354	2 090	5 444
India	7 844	2 867	10 711	7 996	2 867	10 863	8 434	2 927	11 361
Indonesia	624	1 527	2 151	690	1 414	2 104	723	1 358	2 081
Malaysia	422		422	592		592	677		677
Myanmar	951	12	963	883	12	895	847	12	859
Pakistan		9	9		14	14		20	20
Papua New Guinea	23		23	38		38	45		45
Philippines	124	3	127	153	3	156	168	4	172
Republic of Korea		8	8		6	6		6	6
<b>Total</b>	<b>12 857</b>	<b>5 503</b>	<b>18 360</b>	<b>13 663</b>	<b>5 960</b>	<b>19 623</b>	<b>14 321</b>	<b>6 427</b>	<b>20 748</b>
<b>% of total</b>	<b>70</b>	<b>30</b>	<b>100</b>	<b>70</b>	<b>30</b>	<b>100</b>	<b>69</b>	<b>31</b>	<b>100</b>

Note: Data on plantations in African and Latin American country reports are very limited and therefore not presented in the table.

FIGURE 6  
**Areas of natural and planted bamboo in Asia**



## ASIA

**Bangladesh.** The country report indicated 10 000 ha of planted agroforestry bamboo within tea estates (hill forest). Planted bamboo is also found on canal banks, roadsides, in villages and on other lands, but the actual area is not known. Although the forest department has been establishing stands of planted bamboo, it was not able to provide accurate data on the current extent because of lack of information on mortality or land-use change.

*China.* Planted bamboo receives a great deal of attention in this country, with very positive results. From 1990 to 2000, the share increased from 27 to 35 percent and is higher than in any other country. The improved quality of planted bamboo facilitates industrial development and promotes new planting.

*India.* The country reported nearly 3 million hectares of planted bamboo – approximately 25 percent of total bamboo resources. The share of planted bamboo remained stable, while the total area of bamboo gradually increased.

*Indonesia.* The country reported 65 percent planted bamboo, which contrasts with regional and global levels. The discrepancy may stem from differences in inventory and reporting methodologies.

*Malaysia.* The total area of bamboo was reported as naturally regenerated forest. Various authors have addressed the management issues related to naturally regenerated bamboo (for example Azmy, 1997). No data were provided on planted bamboo.

*Myanmar.* The country reported some 12 000 ha of planted bamboo, about 1 percent of the total bamboo forest area. A growth trend was clearly observed over the reporting period. Actual planted forest may exceed the presented figure due to lack of data from a few remote areas.

*Pakistan.* The country reported all bamboo area as planted forests. Farmers in the Punjab cultivate bamboo as pure stands or as an agroforestry crop.

*Papua New Guinea.* The total bamboo area was classified as naturally regenerated.

*The Philippines.* The report indicates some 3 400 ha of planted bamboo, constituting about 2.2 percent of total bamboo forest. The share has not changed over time.

*Republic of Korea.* The total area of bamboo was classified as planted; no statistical information is available on naturally regenerated bamboo stands.

*Sri Lanka.* Over 2 500 ha of planted bamboo were reported. However, other literature sources indicate roughly the same amount for the entire bamboo forest, with only small patches of planted bamboo around villages and on farmland.

In Africa, planted bamboo is generally established to provide raw material and to avoid depletion of naturally regenerated stands. Ethiopia, in its national report, indicates 19 000 ha of planted bamboo in the highlands, about 2.2 percent of total bamboo area. The same figure is presented in a socio-economic study of the bamboo sector (Kelbessa *et al.*, 2000). The study states that foresters and farmers have been slow in promoting cultivation of indigenous or introduced bamboo species. Nigeria reported less than 1 000 ha of planted bamboo in 2000. Kenya reported that the Kenya Forestry Research Institute (KEFRI) had been researching selection and growth of bamboo species in collaboration with Asian research and development institutions since 1986. Over 20 bamboo species from Asia were introduced into the country, including: *Bambusa brandisii*, *B. vulgaris* var. *striata*, *B. arundinacea*, *B. tulda*, *Dendrocalamus membranaceus*, *D. strictus*, *D. brandisii*, *D. aspera*, *Oxytenanthera abyssinica*, *Phyllostachys heterocycla* var. *pubescens* and *Thyrsostachys siamensis* (Ongugo *et al.*, 2000).

In Latin America, the report from Ecuador indicates 5 000 ha and Mexico indicates small areas of planted bamboo. Brazil reports approximately 30 000 ha of privately owned planted bamboo for pulp production. In Peru, small-scale planted bamboo stands exist in rural areas, mostly for family rather than commercial use (INRENA, 1999).

## **GROWING STOCK OF BAMBOO RESOURCES**

Growing stock is a major indicator of the extent of bamboo resources. Information on growing stock is also needed to estimate bamboo biomass and carbon content. Growing stock is normally measured in culms (for monopodial species), clumps (for sympodial species) and weight (for both types of species).

Coefficients exist for the different species to convert number of culms and clumps to fresh and dry weight.

Commercial growing stock is calculated from the number of commercial species, the quantity of each and their physical and economic accessibility. The definition of bamboo commercial growing stock varies from country to country. Only a few countries report volume of commercial stock and the estimates vary widely, owing mostly to diverse definitions and assumptions.

Table 7 includes information from the participating Asian and African countries. Available information on the bamboo growing stock in Latin America is partial, none of the country reports provided data and only limited information is available in the literature. About 332 million tonnes of bamboo growing stock was reported by the Asian countries surveyed.

China and India contributed over 80 percent of the total growing stock of the eight Asian countries that provided information on this variable. The table includes estimated average growing stock per hectare, which ranges from 4.9 tonnes per hectare in Indonesia to 35.2 tonnes per hectare in the Philippines. Interpretation of the data should take into consideration the various species composition and inventory methodologies in different countries.

The same note of caution applies to the results from Africa, where total growing stock for the five respondents is about 57 million tonnes. Ethiopia and Nigeria contributed roughly 80 percent of the total. Average growing stock by species per hectare in Ethiopia was applied to the neighbouring countries, considering similarity of species and other conditions.

## ASIA

*Bangladesh.* The country report indicates a number of regional estimates of bamboo growing stock. It also provides air-dry weight of the most common species. Total growing stock of the village bamboo groves is 0.80 million tonnes, while naturally regenerated bamboo growing stock amounts to 0.19 million tonnes.

TABLE 7  
Growing stock of bamboo resources

Country	1990			2000			2005		
	Stock (million tonnes)	Area (1 000 ha)	Average (tonnes/ha)	Stock (million tonnes)	Area (1 000 ha)	Average (tonnes/ha)	Stock (million tonnes)	Area (1 000 ha)	Average (tonnes/ha)
Bangladesh	1	90	11	1	86	12	1	83	12
China	96	3 856	25	144	4 869	30	164	5 444	30
India	115	10 711	11	117	10 863	11	122	11 361	11
Indonesia	13	2 151	6	11	2 104	5	10	2 081	5
Malaysia	7	422	17	10	592	17	11	677	17
Myanmar	18	963	19	18	895	21	18	859	21
Pakistan	0.09	9	10	0.14	14	10	0.21	20	11
Philippines	6	127	48	6	156	39	6	172	35
<b>Total Asia</b>	<b>257</b>	<b>18 329</b>	<b>14</b>	<b>307</b>	<b>19 579</b>	<b>15</b>	<b>332</b>	<b>20 697</b>	<b>16</b>
Ethiopia	21	849	25	21	849	25	21	849	25
Kenya	1	124	5	1	124	5	1	124	5
Nigeria	27	1 590	17	27	1 590	17	27	1 590	17
Uganda	3	67	37	3	67	37	3	67	37
United Republic of Tanzania	5	128	35	5	128	35	5	128	35
<b>Total Africa</b>	<b>57</b>	<b>2 758</b>	<b>21</b>	<b>57</b>	<b>2 758</b>	<b>21</b>	<b>57</b>	<b>2 758</b>	<b>21</b>
<b>Total</b>	<b>314</b>	<b>21 087</b>	<b>15</b>	<b>364</b>	<b>22 337</b>	<b>16</b>	<b>389</b>	<b>23 455</b>	<b>17</b>

**China.** China reports bamboo growing stock for *moso* bamboo separately from other bamboo species. *Moso* constitutes about 70 percent of the bamboo area and about 80 percent of total bamboo stock. Growing stock is calculated by the Chinese national forest inventory as the number of culms. A conversion coefficient (15 kg/culm) was used to convert culms to dry weight. Data show a significant increase, from 95.5 million tonnes in 1990 to 164.3 million tonnes in 2005. The average growing stock of Chinese bamboo reached over 30 tonnes per hectare in 2005.

**India.** The country report indicates growing stock of bamboo forest separately from bamboo on other land. A distinction was also made between total and commercial growing stock. Commercial stock is defined as the part of total stock available for harvesting each year. It constitutes about 13 percent of total stock. Although India has a larger area of bamboo than China, its total and unit growing stock per hectare are relatively lower – 75 and 30 percent respectively due to a different species composition.

**Indonesia.** The original data were expressed in terms of number of culms. The conversion factor (7.5 kg/culm or 133 culms per tonne) was adopted from the National Forest Research Institute study (Sindoesoewarno Darmono, 2001). The results indicate a decline from 13 million tonnes in 1990 to some 10 million tonnes in 2005. Unlike India, Indonesia defines commercial stock as the part of total stock suitable for commercial use, i.e. over three years old and with a diameter at breast height greater than 2.5 cm. This bamboo is regarded as mature. Roughly 60 percent of the stock is commercial.

**Malaysia.** Two productivity classes exist. The first is *Gigantochloa* spp., producing on average 20 culms of 6 m in height per clump, with 80 culms per tonne. The second class is *Schizostachyum zollingeri*, producing on average 10 culms of 6 m per clump. Total growing stock amounted to 11.3 million tonnes in 2005.

**Myanmar.** The national inventory recognizes bamboo culms of over 5 m in height and weighing 11 kg, i.e. 90 culms per tonne. The average growing stock was obtained from the country report and applied to the total area (as reported in Government of Myanmar, 2000) to estimate total growing stock.

**Pakistan.** Growing stock was 206 000 tonnes in 2005 and shows a slight upward trend. Commercial growing stock constitutes approximately 60 percent of the total. It is defined as all culms of more than 5 cm in diameter. Three main species make the greatest contribution to growing stock (over 80 percent): *Dendrocalamus strictus*, *D. hamiltonii* and *Bambusa tulda*. Average bamboo growing stock is similar to that of India and reaches some 10 tonnes per hectare.

**The Philippines.** Total growing stock was calculated based on the assumption that an average clump has 15 culms and an average culm weighs 25.8 kg. Commercial stock makes up 30 percent of the total. Total growing stock compared with bamboo area extent indicates an average value of 35.2 tonnes per hectare, the highest among the Asian countries surveyed.

## AFRICA

**Ethiopia.** Growing stock was calculated based on the reported average growing stock of the monopodial species (51 tonnes per hectare) and sympodial species (19 tonnes per hectare). Total stock is over 20 million tonnes, while average growing stock is 24.6 tonnes per hectare. The report also specifies that the average annual increment of unmanaged, naturally regenerated bamboo forests in Ethiopia is 8–10 tonnes per hectare of oven-dry weight.

**Kenya.** Total growing stock of 622 000 tonnes has been calculated based on the total area of bamboo (124 400 ha) and average stock in dry weight (5 tonnes per hectare). The average growing stock is substantially lower than in neighbouring countries.

**Nigeria.** The country reports 26.8 million tonnes growing stock on 1.59 million hectares, yielding an average of 16.9 tonnes per hectare. No methodology notes were attached to the report, thus the figures should be considered with caution.

*Uganda.* Growing stock was calculated using total area (Chihongo *et al.*, 2000) and an average growing stock by species derived from the Ethiopian report to produce a figure for total growing stock of 2.5 million tonnes.

*United Republic of Tanzania.* The same approach was used as in Uganda. Total bamboo area was multiplied by average growing stock by species estimates from the Ethiopian report.

Information from Latin America is incomplete. The figure on bamboo growing stock in Chile, 26 million tonnes, refers to *Chusquea culeon* in dominance Type I or II, distributed on 180 160 ha, with an average growing stock of 148 tonnes per hectare, the highest among all the reviewed countries. However, the country report does not explain how this figure relates to the total reported bamboo forest area (900 000 ha).

Additional information on annual productivity per hectare per year in Latin America was extracted from Londoño (2001). In Colombia, total *Guadua* spp. culm production for the four central western departments (about 25 000 ha), with an average of 31.5 tonnes per hectare per year, gives a total production of 0.79 million tonnes per year. The data may not represent the entire country. In Ecuador, the estimated average productivity is 30.3 tonnes of dry weight per hectare per year. The total amounts to 570 000 tonnes per year on 18 800 ha. In Venezuela, estimates indicate an average green weight of *Guadua angustifolia* of 59.6 kg/culm, with an average productivity of 44.5 tonnes per hectare per year, equivalent to an average dry weight of 30.7 tonnes per hectare per year.

## BAMBOO BIOMASS

### OVERVIEW

Adoption of the 1997 Kyoto protocol under the United Nations Framework Convention on Climate Change (UNFCCC) indicated increased recognition of forests as a carbon sink. Vigorous growth makes bamboo a particularly attractive plant for carbon sequestration. An INBAR study summarized the information available on bamboo biomass, including available methodologies and experiments (Hunter and Wu Junqi, 2002). Scarce information makes it difficult to draw any general conclusions on the comparative advantages of bamboo regarding the biomass and carbon issues.

The biomass data from the country reports (Table 8) mostly lack the needed precision. Specific studies on selected species and areas provide some guidance, but the scale remains too small to draw certain conclusions on regional or country levels. Only a few countries report bamboo forest biomass data. Lack of a general methodology makes it difficult to make a comparison between these countries and to draw conclusions beyond the country level. In some cases, biomass indices for tree species were used in the absence of clear estimates for bamboo. Some countries provided biomass calculations for selected species, but did not specify the methodology and conversion coefficients used. A general methodology is yet to be developed for bamboo reports.

The average bamboo biomass ranges from 6.5 tonnes per hectare in Pakistan to 167 tonnes per hectare in China.

*China.* No distinction between above- and below-ground biomass was specified in the country report. Per hectare biomass essentially varies with the site conditions and characteristics. Only the report from China includes an estimate of bamboo carbon stock. Carbon made up 50 percent of the total biomass.

*India.* The ratio of growing stock to biomass is 50 percent, and the ratio of below- to above-ground biomass is 26 percent. On average, the bamboo biomass equals 22 tonnes per hectare.

TABLE 8

**Bamboo biomass stock in some Asian countries (million tonnes)**

Country	1990	2000	2005
China	643	811	907
India	239	243	252
Pakistan	0.059	0.091	0.130
Republic of Korea	0.406	0.309	0.310

*Pakistan.* Growing stock/biomass ratio was about 55 percent. Below-ground biomass was calculated at 15.92 percent of above-ground biomass in dry weight. The biomass of bamboo averages 6.5 tonnes per hectare.

*Republic of Korea.* No data were presented for total growing stock. For bamboo biomass, reference was made to a study on *Phyllostachys* (Park and Ryu, 1996). The total biomass is about 50.75 tonnes per hectare.

**BOX 3****Animal species associated with bamboo**

The association of animal species with bamboo has been explored in a number of studies. Major findings were compiled in two reports (Haemig, 2005a and b). The best-known animals dependent on bamboo are the giant panda (*Ailuropoda melanoleuca*) and red panda (*Ailurus fulgens*). Their diet almost exclusively consists of bamboo shoots and leaves. Several other mammals and birds live in a symbiotic relation with bamboo forests. The southern bamboo rat (*Kannabateomys amblyonyx*) lives in groves of *Guadua* and some introduced bamboo species. Bamboo flowering and seeding lead periodically to an explosion of the rodent population, resulting in famine and social cataclysms in various parts of the world. Local populations in northeast India suffer particularly from the rat outbreaks triggered by bamboo flowering. The dynamics of the rat population fluctuations have still not been well explored.

Interestingly, the majority of bamboo-dependent birds and mammals are endemic to the Atlantic Forest of eastern Brazil. At least 27 species of birds are considered to be associated with bamboo in the Atlantic Forest. Some species live almost entirely in large bamboo stands. Others may migrate to other ecosystems, but may depend on bamboo for feeding and breeding. Most of the bird species feed on bamboo nodes, internodes and the insects on foliage. Some species feed extensively on bamboo seeds and do not reside in bamboo forests during non-seeding periods.

Studies of bird association in the Amazon Basin show that 25 of approximately 440 bird species (about 6 percent) live in *Guadua* bamboo thickets. The degree of dependence on bamboo varies among bamboo-dependent species. They may depend on it for feeding, breeding, shelter and protection from predators. Depletion of bamboo ecosystems threatens species biodiversity: it has been observed that birds and mammals are less abundant than before in the Atlantic Forest.

One initiative led by the American Bamboo Society (ABS) addresses the decline of bamboo habitat in Central and South America due to logging, land clearing and farming (BOTA, 2005). Over 20 bamboo species in this region were red-listed by the World Conservation Union (IUCN, 2004) as endangered or vulnerable. Collection of germplasm and establishment of national herbariums are the main approaches being used to ensure the sustainability of native bamboos.

Two joint studies, carried out by UNEP-WCMC and INBAR, adopted an innovative approach by quantifying the likely range of various bamboo species in certain forest types. The results show that over 400 bamboo species are potentially threatened by the destruction of naturally regenerated forest cover, thus conservation and sustainable management of wild bamboo populations should have high priority (Bystriakova *et al.*, 2003). Although these studies are based on potential distribution and did not include bamboo outside forests, the results strongly support a call for the conservation of bamboo as a key element of healthy forest ecosystems.

Based on Haemig, 2005a and b.

## DIVERSITY OF BAMBOO TREE SPECIES

There are over 90 genera of bamboo with about 1 200 species globally. Bamboo is able to adapt to a wide variety of ecosystems and climatic conditions. Diversity of bamboo has been addressed in many studies and in various countries and regions. Taxonomists have developed an excellent and comprehensive knowledge of the variety of bamboo species worldwide. Taxonomy of bamboo differs from the taxonomy of many other plants. Traditional plant classification relies on floral characteristics. Bamboo blossoms at irregular cycles and the dynamics are not yet clearly understood. Thus bamboo taxonomy must rely on other features.

The growing importance of bamboo requires the preservation of its genetic diversity. Bamboo provides a habitat for many other life forms. Box 3 summarizes some findings on the biodiversity of bamboo ecosystems, with particular reference to the Amazon Basin and the Atlantic Forest of eastern Brazil.

Table 9 presents information on bamboo diversity collected from the country reports and other sources (Ohrnberger, 1999; Londoño, 2001). Countries are listed by number of naturally occurring species. Data on bamboo species diversity were included in 21 country reports. Out of 22 reporting countries, only Nigeria did not provide data on diversity of its bamboo species.

Some discrepancies were noted in the data presented in the literature and the reports. Ohrnberger (1999) reported 626 species in China versus 500 in the country report, and 84 species in Japan versus 139 in the country report. The differences may be explained by gaps in taxonomical classification, but it is important that different sources provide the same or similar rankings of countries in terms of species biodiversity. The majority of the country reports also include a list of the main bamboo species in the country, with their description, distribution and specification of the main uses.

Ohrnberger (1999) listed an additional 25 countries with at least one bamboo species: Angola, Benin, Burundi, Central African Republic, Comoros, Côte d'Ivoire, Eritrea, the Gambia, Ghana, Guinea, Guinea Bissau, Mozambique, Nigeria, Réunion, Rwanda, Senegal, Sierra Leone, South Africa, Bahamas, Dominica, French Guiana, Guadeloupe, Jamaica, Martinique and the United States Virgin Islands.

Data on native bamboo species provide an indicator of bamboo diversity in the countries and the world. The number of introduced species reveals the efforts of many countries to promote bamboo-based economic development. Introduced species include specimens in botanical gardens, trial plots, ornamental, private and public areas.

The reporting table on bamboo diversity requested some additional information on endangered and vulnerable species. Bangladesh was the only country that presented these data, reporting three endangered species: *Dendrocalamus hamiltonii*, *Schizostachyum dulloa* and *Melocalamus compactiflorus*.

China has the highest bamboo biodiversity in Asia, with over 500 species, followed by Japan, India, Indonesia, Myanmar and Malaysia, each with more than a hundred species. Myanmar reports that the share of the bamboo species *Melocanna bambusoides* declined from 51.3 percent in 1990 to 36.2 percent in 2000 due to overexploitation. On the other hand, less-exploited species expanded their presence (*Dendrocalamus membranaceus*, *Bambusa polymorpha* and *Cephalostachyum pergracile*) due to intensive logging and degradation of the forest cover.

African countries have the lowest diversity of bamboo species. The United Republic of Tanzania reports four native species, followed by Uganda, Malawi and Zambia. The greatest potential for bamboo biodiversity is in eastern Africa, around Lake Victoria, and in southern Africa, including Zambia and Zimbabwe. West Africa has fewer bamboo species with the most widespread being *Oxytenanthera abyssinica* (INBAR, 2005). Madagascar is a special case. It has 33 bamboo species, including 32 native and one introduced pan-tropical species, *Bambusa vulgaris*. This species is found

mainly near villages and along rivers. Endemism of bamboo in Madagascar reflects its long isolation from continental Africa and its unique evolutionary path (INBAR, 2005).

Latin America has fewer species than Asia, but more than Africa. It accounts for 20 genera with over 429 species (Londoño, 2001). Bamboo is distributed from approximately 27° north (*Otate acuminata* in northwestern Mexico) to 47° south (*Chusquea culeou* in Chile). Brazil reports the highest species diversity, 232, while other sources present a more conservative view – 135 species in 17 genera (Judziewicz *et al.*, 1999). Venezuela and Colombia have over 50 species each, and Ecuador, Costa Rica, Peru and Mexico over 30 each.

The information on bamboo species diversity is still incomplete and contradictory. Deoxyribonucleic acid (DNA) sequencing provides a promising technique for species identification and classification, but further efforts are required to improve the knowledge of bamboo diversity and its role in different ecosystems.

## BAMBOO HEALTH AND VITALITY

Little information was provided on bamboo pests and pathogens. Ecuador indicated pathogens of *Guadua* spp., including *Podischnus agenor*, *Dinoderus minutes*, *Parisoschoenus* spp., *Atta cephalotes*, *Crematogaster* spp. and *Mielobia* spp. Bangladesh cited a report by Boa and Rahman (1987) containing a provisional list of fungal diseases of bamboo, including *Dilozythiella bambusina* (leaf-spot disease), *Puccinia* (rust disease in leaves and sheaths of some bamboo species), *Ustilago shiraian* (a fungus that attacks branches of *Bambusa*), *Sarocladium orysae* (serious die-back and blight disease of *Bambusa balcooa*, *B. tulda* and *B. vulgaris*). Additional information on bamboo insects and pests is available in Wang, Varma and Xu (1996).

TABLE 9  
Diversity of bamboo species

Countries and regions	Native species	Introduced species	Naturally occurring species according to Ohrnberger (1999)
<b>Asia</b>			
China	500	10	626
India	119	25	102
Japan	139		84
Myanmar	97		75
Viet Nam			69
Indonesia	118	17	56
Malaysia	92	1	50
Thailand			36
Philippines	21	32	26
Nepal			25
Papua New Guinea	25	12	22
Bhutan			21
Bangladesh	33	4	18
Lao People's Democratic Republic			13
Sri Lanka	10	20	11
Brunei Darussalam			6
Cambodia			4
Pakistan	3	13	3
Australia			3
Republic of Korea	5	46	2
Turkey		5	

Countries and regions	Native species	Introduced species	Naturally occurring species according to Ohrnberger (1999)
<b>Africa</b>			
United Republic of Tanzania	4	5	4
Uganda	2	4	3
Malawi			3
Zambia			3
Ethiopia	2		2
Zimbabwe	1	5	2
Cameroon			2
Sudan			2
Togo	3	11	1
Kenya	1	11	1
Algeria		7	
<b>South and Central America</b>			
Brazil	232	20	134
Venezuela (Bolivarian Rep. of)			68
Colombia			56
Ecuador	42	23	41
Costa Rica			36
Peru			35
Mexico			32
Bolivia			20
Panama			19
Chile	11	40	14
Cuba			13
Guatemala			12
Argentina			12
Honduras			8
El Salvador			7
Nicaragua			7
Haiti			7
Trinidad and Tobago			7
Dominican Republic			6
Paraguay			6
Uruguay			5
Guyana			5
Puerto Rico			5
Suriname			4
Belize			3