ISSN 1020-3370

NON-WOOD FOREST PRODUCTS

18

World bamboo resources

A thematic study prepared in the framework of the Global Forest Resources Assessment 2005

INBAR

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A thematic study prepared in the framework of the Global Forest Resources Assessment 2005

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2007

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Acknowledgements

This study is a product of an FAO/INBAR initiative involving member countries of both organizations, donors, agencies, institutions, organizations and individuals. More than 100 individuals, representing 30 national and international organizations and agencies, contributed directly to the report.

The authors are particularly grateful to the United Nations Environment Programme and the United States Geological Survey for their support, assistance, training and help to team members during the study and the drafting of the report. National forest inventory departments in China, India and Indonesia provided crucial contributions to the design of the study and the testing and finalization of the reporting format and guidelines. Participants of four joint FAO/INBAR workshops and meetings in 2004–2005 discussed, supported and further developed the study. Twenty-five FAO and INBAR member states submitted country reports. National correspondents to FAO's Global Forest Resources Assessment 2005 and their teams, together with experts from participating countries, collected and validated data and provided the best available knowledge on the subject.

Editing and production of the report were carried out by Lynn Ball, María Guardia and Laura Russo. FAO and INBAR are grateful to all the countries, organizations and individuals that provided their excellent contributions to this study.

Foreword

Bamboo is a major non-wood forest product and wood substitute. It is found in all regions of the world and plays an important economic and cultural role. Used for housing, crafts, pulp, paper, panels, boards, veneer, flooring, roofing, fabrics, oil, gas and charcoal (for fuel and as an excellent natural absorbent), it is also a healthy vegetable (the bamboo shoot). Bamboo industries are now thriving in Asia and are quickly spreading across the continents to Africa and America.

In spite of bamboo's importance worldwide, global statistics on its resources, production and trade remain rather scarce and inconsistent. Lack of reliable, comprehensive data on bamboo resources and utilization hampers their sustainable development and limits their potential to contribute to poverty reduction. In the past, both FAO and INBAR, under their respective mandates, have addressed the issue of bamboo resources assessment through various activities and studies. The present thematic study on bamboo was developed by FAO and INBAR jointly in the framework of FAO's *Global Forest Resources Assessment 2005* (FRA 2005), with the aim of filling the gap in global information and providing a first, comprehensive assessment of the world's bamboo resources. The study was officially launched during a joint FAO/INBAR workshop in Thailand in November 2004, preceded by much preparatory work, regional consultations and pilot testing. The study is thus the result of a three-year process of data collection and validation, involving many partners from participating countries and international organizations, in line with the FRA 2005 philosophy of global partnership.

It is hoped that the information and knowledge generated by this study will be used by national policy processes and that, conversely, feedback from users will serve to improve future global resources assessments.

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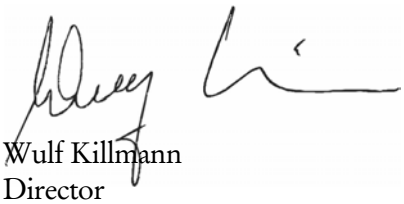

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Acronyms and abbreviations

ABS	American Bamboo Society
DNA	Deoxyribonucleic acid
FRA	Global Forest Resources Assessment
HS	Harmonized System (WCO)
INBAR	International Network for Bamboo and Rattan
ITTO	International Tropical Timber Organization
IUCN	World Conservation Union
KEFRI	Kenya Forestry Research Institute
NFI	National Forest Inventory
NWFP	non-wood forest products
SFA	State Forestry Administration (China)
UNEP	United Nations Environment Programme
UNEP-WCMC	World Conservation Monitoring Centre (UNEP)
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
WCO	World Customs Organization
WWF	World Wide Fund for Nature

Executive summary

Bamboo is an ancient woody grass widely distributed in tropical, subtropical and mild temperate zones. It is a major non-wood forest product. There are about 1 200 species of bamboo in some 90 genera. Bamboo taxonomy poses certain difficulties for science, owing to the plant's often long flowering cycles, thus taxonomists still debate the total number of bamboo species and genera.

Bamboo is an integral part of forestry, but it is also widely spread outside forests, including farmlands, riverbanks, roadsides and urban areas. It is quickly changing its image from the "poor man's tree" to a high-tech, industrial raw material and substitute for wood. Bamboo is an increasingly important economic asset in poverty eradication and economic and environmental development. It has always played an important economic and cultural role across Asia. Now the use of bamboo is growing rapidly in Latin America and Africa as well. In some countries, the processing of bamboo is shifting from low-end crafts and utensils to high-end, value-added commodities such as laminated panels, boards, pulp, paper, mats, prefabricated houses, cloth and bamboo shoots.

The rapid growth in the use of bamboo is bringing concern about the sustainability of global bamboo resources. Despite the successful bamboo trade, very little is known about the actual status and dynamics of the bamboo resource base. One of the first attempts to assess bamboo resources on a global scale was carried out by FAO and the United Nations Environment Programme as part of the Global Forest Resources Assessment 1980 (FRA 1980) – it covered 13 countries known to possess substantial bamboo resources.

There are a number of national, regional and international studies on different aspects of bamboo resource development. Most provide rough, broad expert estimates instead of baseline statistics based on field observation. In the absence of reliable data, INBAR developed an innovative approach to quantify a possible range of bamboo resources in known forest types. An INBAR study matched bamboo species to site characteristics and mapped potential global distribution of species. INBAR's regional production-to-consumption studies attempted to link bamboo resources to supply-chain development. However, hypothetical maps and expert estimates cannot substitute for a proper resource assessment. Comprehensive data on bamboo resources are still missing, which threatens their sustainable development.

The present study is the result of a joint effort by FAO and INBAR to launch a systematic assessment of bamboo resources and their dynamics. It was undertaken as one of seven thematic studies within the FRA 2005 process.

The reporting format generally follows the structure of the main FRA 2005 assessment and includes tables, maps and lists of native and introduced bamboo species. Four joint FAO/INBAR workshops were organized in the course of the study to encourage and assist countries in providing bamboo statistics.

A total of 22 countries responded to the FAO/INBAR call for information and submitted national reports. The country reports confirmed data availability, although data quantity and quality varied significantly. Asian countries presented the most advanced resource statistics, while Latin America and Africa used primarily remote sensing and expert estimates.

Sixteen countries in Asia reported a total of 24 million hectares of bamboo resources for this study. Five African countries reported 2.8 million hectares. It is estimated that ten Latin American countries may have over 10 million hectares of bamboo resources, taking the world total to some 37 million hectares or roughly 1 percent of the global forest area. However, the figures represent only rough estimates and include pure bamboo forests, bamboo mixed with other species (in which bamboo is not necessarily predominant) and bamboo on other land (also pure or mixed with other trees or crops). Monopodial species normally prevail in the subtropics, while sympodial bamboo is much more common in the

tropics. The present study also addresses issues of bamboo resource ownership, naturally regenerated and planted areas, growing stock, biomass, species biodiversity, removals, products and trade.

One of the main conclusions of the report is that bamboo statistics are often poor, inconsistent, fragmented and based on different definitions, methodologies and assumptions in different countries. A common methodological approach is missing. The study results are, therefore, essentially preliminary and should be treated with caution. However, this does not diminish the importance of the initiative, whose main value is that it has established a systematic methodology and has launched the most comprehensive assessment of global bamboo resources to date.

1. Introduction

BAMBOO AS A PLANT

Bamboo belongs to the *Gramineae* family and has about 90 genera with over 1 200 species. Bamboo flowers rarely and in irregular cycles, which are not yet clearly understood. Thus taxonomists do not always agree on the identification of bamboo species and genera, but modern genetic analysis may shed new light on bamboo taxonomy.

Bamboo is naturally distributed in the tropical and subtropical belt between approximately 46° north and 47° south latitude, and is commonly found in Africa, Asia and Central and South America. Some species may also grow successfully in mild temperate zones in Europe and North America. Bamboo is an extremely diverse plant, which easily adapts to different climatic and soil conditions. Dwarf bamboo species grow to only a few centimeters (cm), while medium-sized bamboo species may reach a few metres (m) and giant bamboo species grow to about 30 m, with a diameter of up to 30 cm. Bamboo stems are generally hard and vigorous, and the plant can survive and recover after severe calamities, catastrophes and damage. Young bamboo shoots were the first sign of new plant life after the nuclear bombing of Hiroshima and Nagasaki.

Bamboo shoots and culms grow from the dense root rhizome system. There are two main categories of rhizomes: monopodial and sympodial. Monopodial rhizomes grow horizontally, often at a surprising rate, and thus their nickname of 'runners'. The rhizome buds develop either upward, generating a culm, or horizontally, with a new tract of the rhizomal net. Monopodial bamboos generate an open clump with culms distant from each other and can be invasive. They are usually found in temperate regions and include the genera *Phyllostachys* and *Pleioblastus*. Sympodial rhizomes are short and thick, and the culms above 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 genus is *Bambusa*.

BAMBOO AS A RESOURCE

Bamboo has received increasing attention over the last two decades for its economic and environmental values (Box 1). In Africa, Asia and Latin America, it is closely associated with indigenous culture and knowledge and is widely used for housing, forestry, agroforestry, agricultural activities and utensils. In countries undergoing economic development, traditional bamboo culture gradually disappears. However, industrial development of bamboo is offering a new opportunity to younger generations to retain and continue developing cultural traditions related to the cultivation, harvesting and use of bamboo.

The physical and environmental properties of bamboo make it an exceptional economic resource for a wide range of uses and for poverty reduction. It grows quickly and can be harvested annually without depletion and deterioration of the soil. Bamboo can grow on marginal land, not suitable for agriculture or forestry, or as an agroforestry crop. It has a relatively light weight, because the culms are hollow, and unlike wood can be easily harvested and transported without specialized equipment or vehicles. It splits easily for weaving and is thus easy to handle also for women. Bamboo is often cultivated outside the forest on farms, where it is more easily managed. Processing normally does not require highly skilled labour or special qualifications and can be started by rural poor communities at a minimal cost. For the same reason, it could offer income-earning opportunities to handicapped people.

Bamboo use and trade have been growing rapidly in recent years. Bamboo is becoming popular as an excellent substitute for wood in producing pulp, paper, board and charcoal. It is widely used in construction, either in its natural form or as a reconstituted material (laminated boards and panels). In addition, bamboo shoots have become a popular vegetable, with Asian cuisine spreading quickly around the globe.

BOX 1

INBAR and FAO activities related to bamboo

Recognition of the socio-economic benefits of bamboo and rattan led to the establishment in 1997 of the International Network for Bamboo and Rattan (INBAR), with the mission of improving the well-being of producers and users within the context of sustainable bamboo and rattan development. INBAR is an international organization, registered with the United Nations, and has its headquarters in Beijing, China. It currently has over 30 member countries, five regional offices and over 400 affiliates around the globe. The network connects governments, the private sector, non-profit organizations and individuals in over 50 countries. The recent work in bamboo concentrates on the Millennium Development Goals and includes the establishing of an International Bamboo and Rattan Trade Database, new standards and codes, production-to-consumption and policy studies and field projects in Africa, Asia and Latin America.

Bamboo is an integral part of forestry and a major non-wood forest product (NWFP). FAO recognizes the increasing role of bamboo in forestry and sustainable economic development, and regularly reports new information on bamboo and rattan in *NWFP-Digest-L*, its NWFP electronic digest, and in its biannual newsletter, *non-wood-news*. Over the years, articles and news items have presented bamboo from a country perspective or as a product, emphasizing its great versatility. Past issues of both *non-wood news* and the digest can be found on FAO's NWFP home page at www.fao.org/forestry/site/nwfp/en, together with more information on NWFPs in general.

In the 1990s, two large FAO/UNDP regional projects supported bamboo-related work in Asia: the Forestry Research Support Programme for Asia and the Pacific (FORSPA) and the Improved Productivity of Man-Made Forests through Application of Technological Advances in Tree Breeding and Propagation (FORTIP) project.

In Latin America, in 2004, FAO supported a Technical Cooperation Project in Colombia on industrial processing of bamboo (*Guadua angustifolia)*. The objectives of the project were to support intensive harvesting of *Guadua* and to improve the production chain through feasibility studies and establishment of an industrial processing plant for bamboo, with the participation of small-scale farmers.

FAO and INBAR have organized joint project activities and events on bamboo, such as a workshop on bamboo trade (2003), joint side events during International Union of Forest Research Organizations congresses (2000, 2005) and the World Forest Congress in Quebec (2003), in addition to the present study and a study on the role of bamboo in climate change, carbon sequestration and poverty alleviation under the Clean Development Mechanism of the Kyoto Protocol (to be published in 2007).

PREVIOUS STUDIES ON BAMBOO RESOURCES

A review of bamboo resource statistics shows that the information available is scarce, fragmented and contradictory and cannot be compared within or between regions. Previous studies have focused on three main areas: bamboo forest extent, utilization and trade, and species taxonomy. Taxonomic studies have received the most attention, whereas the first two areas, particularly bamboo extent, were rarely approached systematically and the results are mostly based on rough expert estimates. This can be attributed to the nature of bamboo, which often grows intermixed with other species as forest understorey or outside forests on farmland. Only a few countries, which are the most advanced in bamboo processing, include bamboo in their periodic national forest inventories. The remaining countries may rely on remote sensing (and the mentioned expert estimates). Bamboo products are also difficult to track and introduce into national statistics because they are often intermixed with other, usually wooden, commodities when traded, or they are traded locally without entering official statistics.

Table 1 presents findings from some previous studies. A few regional reports have attempted to summarize available bamboo resources data. They were used in the current study mainly for verification and validation. FAO's Global Forest Resources Assessments in 1980 and 1985 (FAO, 1981a, b, c and 1988) included some data on the extent of bamboo forests in Asia and Africa. Unfortunately, no information was available on the methodology used in the data collection and processing. The reports reflect a time in which bamboo industries were just emerging and interest in bamboo as a resource was still quite low. These reports essentially underestimated bamboo resources, as the present study will show.

TABLE 1
Extent of bamboo forest area as reported by previous inventories *(1 000 ha)*

Country	FRA 1980	FRA 1985	Kigomo 1988	FRA 2000
Bangladesh			213	23
Cambodia	380	380		34
China			3 300	4 211
India	1 440	1 420	9 570	
Japan			125	
Lao People's Democratic Republic	600	600		1 532
Malaysia			20	
Myanmar	632	617		3 251
Nepal	1	1		
Philippines			8	
Republic of Korea				8
Thailand	900	865	1 020	261
Viet Nam	1 200	1 200	1 300	813
Subtotal Asia	**5 153**	**5 083**	**15 556**	**10 132**
Congo	100	100	102	
Ethiopia	800	800		167
Gambia				
Kenya	165	150	156	
Rwanda	19	17		
Uganda	15	15		
Other African countries			1 500	
Subtotal Africa	**1 099**	**1 082**	**1 758**	**167**
Brazil (state of Acre)			94	
Belize				12
Jamaica				3
Subtotal Central and South America			**94**	**15**
Total	**6 252**	**6 165**	**17 408**	**10 313**

In the late 1980s, the Kenya Forest Research Institute attempted to sum up some regional data on bamboo forest cover and species distribution (Kigomo, 1988). The author reported that "about 80 percent of bamboo area is distributed within the southern tropical region of Asia. Africa and South America are poorly populated with bamboo". Madagascar was recognized as the richest country in Africa in terms of biodiversity of bamboo species.

In the *Global Forest Resources Assessment 2000* – FRA 2000 (FAO, 2001a), although bamboo data were not requested or specified, eleven countries – eight from Asia, one from Africa and two from Central and South America – provided data on the extent of their bamboo forests. However, inconsistency in the countries' methodologies for assessment and reporting affected data quality. Interestingly, India, which has the largest area of bamboo resources in the world, did not present data on their extent. On the other hand, Myanmar seems to have overestimated its bamboo area.

Bamboo resources were addressed in several FAO publications on NWFPs (FAO 1995, 2001c, 2002). The publications include some statistics on bamboo removal and utilization, but regard the data as 'tip of the iceberg' (FAO, 2002).

Pabuayon and Espanto (1997) support the statements made by FAO. Their report reviewed China, India, Indonesia, Nepal and the Philippines and focused primarily on markets and trade rather than resources. Despite information gaps and inconsistencies, the most reliable information comes still from Asia, where bamboo is treated as an important economic asset.

Londoño (2001) provides the most comprehensive collection of data on bamboo resources in Latin America. She presents valuable information and references from several countries, and her report was used in the current study for data validation.

Two joint studies, carried out by the United Nations Environment Programme (UNEP), its World Conservation Monitoring Centre (UNEP-WCMC) and INBAR, shed some additional light on the issue (Bystriakova *et al.*, 2003, 2004). The studies quantified the likely range of various bamboo species. Analysing the loss of species and their productive area, the authors argued that the survival of about half of all bamboo species may be threatened.

INBAR has also developed a number of studies of production-to-consumption systems to identify constraints and opportunities for the development of bamboo supply chains. Although the studies vary in size and quality, they offer a valuable data verification tool, which takes into account social, economic, environmental and policy aspects.

The available literature on bamboo lacks reliable quantitative data, especially at the broad regional and global scale. Reports from local projects are not comparable, owing to the use of different approaches and methodologies. The present study is the first attempt to estimate global bamboo resources and to launch their regular and systematic assessment and monitoring. It also attempts to develop a common methodology for data collection, reporting, processing and analysis.

APPLICATION OF REMOTE SENSING TO BAMBOO RESOURCES ASSESSMENT

Remote sensing has recently become popular in natural resources assessment, planning, management and monitoring. The system acquires images from remote sensors (such as satellites, planes and balloons) and sends them to ground stations. The ground stations process and analyse the images and provide the necessary information and assessment.

Remote sensing enables spatial and temporal assessment of land and vegetation. It has been successfully used not only for global assessment and classification of major forest resources, but also for monitoring of non-wood forest vegetation, including bamboo. Higher spatial and spectral images (such as LANDSAT, IKONOS and SPOT) can be used in assessing secondary and minor vegetation. The temporal images offer an opportunity to observe ecosystem dynamics and development. Some remote sensing data may be acquired at low or even no cost. For example, MODIS provides useful information for large-scale resource mapping.

Remote sensing is a quick, reliable, rather accurate and comparatively cheap method for the assessment, classification and mapping of natural resources. It is very important in the planning, management and sustainable utilization of these resources. A geographical information system (GIS) is generally integrated with remote sensing for storing and analysing data and producing maps and statistics. GIS can be used to monitor the vast resources of bamboo regularly, as well as for smaller project activities.

Inventory of bamboo resources is still in an initial phase of development. Ground inventory is rather accurate, but may be costly in time and resources. Remote sensing alone cannot compete with ground methods in accuracy and scope, but can provide an excellent framework for field inventories and can save on cost. In combination with limited field samples, remote sensing can produce excellent results at a reasonable and competitive price. It can be especially useful in the monitoring and analysis of bamboo cover changes.

It is not easy to apply remote sensing techniques to bamboo compared with other forest species. The electromagnetic reflection of bamboo may be confused with that of other forest species and crops, such as pine, sugarcane and maize. Given that bamboo is often scattered throughout the forest and on other lands, it might be difficult to separate it from other species and would require field validation. Sympodial bamboo is particularly difficult to spot because it grows in smaller clusters. Medium resolution images (such as Landsat with 30 m resolution) may not be sufficient for bamboo identification of clusters of less than one hectare. Due to the scattered nature of bamboo, its assessment

requires sufficient ground-truth information, with the exact GPS coordinates. A possible solution is to use high-resolution images, but they are generally quite expensive. Some bamboo represents undergrowth, which is difficult to map without accurate field data. On the other hand, remote sensing can easily locate forest types typically associated with bamboo understorey and thus provide a rather accurate guess, which can then be used to develop an effective sampling design.

There are already several promising studies and pilot projects on assessing the area of bamboo using remote sensing (Box 2). Pure monopodial and sympodial bamboo forest can be easily detected with very limited on-the-ground information. Bamboo is evergreen. If it is intermixed with deciduous trees, a temporal seasonal analysis may detect bamboo resources by measuring its reflection patterns. Bamboo is easier to locate during winter or the dry season, when other trees are losing their green crowns.

Some algorithms (such as neural networks and decision trees) can help map potential bamboo areas using a series of additional parameters, including climate, soil and elevation. High-resolution images such as IKONOS and Quick Bird can be used for data training. The available experience indicates that using remote sensing in combination with ground samples, GIS and other appropriate technologies may provide a valuable tool for global bamboo resources assessment.

BOX 2

Pilot studies

Several successful pilot studies on remote sensing of bamboo are discussed below:

Bamboo undergrowth mapping at Woolong Nature Reserve. This pilot study mapped the spatial distribution of understorey bamboo in Woolond Nature Reserve in southwestern China. Using artificial neural network methods, Landsat thematic mapper (TM) data and training on limited ground data, the study achieved 80 percent accuracy despite the occurrence of other understorey vegetation. The results prove that remote sensing can successfully map forest undergrowth. This success in bamboo mapping has important implications for the conservation of the giant panda (Linderman *et al.*, 2004).

Forest-cover mapping in India. The Centre for Indian Bamboo Resource and Technology (CIBART) has carried out bamboo development planning using remote sensing and GIS in northeast India, including the Tamenglong district in Mapur state and two districts in Tripura state (Bharadwaj *et al.*, 2003). IRS 1D LISS III images were analysed and classified using the supervised classification technique. The training set included images from different forest types. The knowledge-based system used the digital evaluation model and considered such parameters as bamboo resource types, slopes and drainage level. The information collected during the field survey was used to correlate distribution of the various species with the land characteristics. The correlation provided guidance for the classification of sites. The accuracy of this study was over 85 percent.

Guadua bamboo presence in the Amazon area. The study used remote sensing techniques for the spatial and temporal analysis of the *Guadua* bamboo forest in the southwestern Amazon area of Brazil (Nelson, 2004). Key findings of the study included the following:

- *Guadua* genets reproduce and die synchronously.
- The life cycle of a genet is about 30 years.
- Dying bamboo creates a wave of mortality.
- Edges of bamboo areas are well defined, but some of these edges may only be visible at exactly the same intervals, approximately every 30 years.
- For about one year after mortality, the dead plant material remains visible to satellites.
- For about 10–15 years after mortality, a new cohort of seedlings remains in the understorey. At this stage, the spectral pattern of a bamboo-dominated forest resembles forest without bamboo. Bamboo cannot be detected by satellites during about 30–50 percent of its life cycle.
- The lifecycle pattern of bamboo makes it difficult to accurately map the extent of bamboo forest unless two images are available for the entire area, ideally with a time interval of approximately 15 years.

Forest mapping in China. The Chinese State Forestry Administration (SFA) is mapping forests using remote sensing techniques (Han, 2005). SFA used Landsat TM and enhanced TM (ETM)+ for the mapping. According to experience, bamboo shows a special pattern in the band combination of 453. Supervised classification was done with sufficient ground information. A map of the country was prepared and was complemented by provincial maps.

THE PRESENT STUDY

Because bamboo can also grow outside forests on other lands, the assessment has tried to include these resources. This approach does not contradict the framework and methodology of FAO's Global Forest Resources Assessment, in which forest resources are defined as encompassing forests, other wooded land and trees outside forests.

The reporting framework was developed in the course of the current study and consisted of a reporting outline and guidelines. The outline contained a set of tables to be completed by national correspondents for the bamboo study. The guidelines provided the appropriate methodology, techniques and instructions for completion of the outline. The outline and guidelines in general reflected the reporting tables for FRA 2005, addressing specific bamboo-related issues when necessary. The following tables were included (see Annex 1):

1. Extent of bamboo
2. Ownership of bamboo
3. Characteristics of bamboo
4. Bamboo growing stock
5. Bamboo biomass and carbon stock
6. Diversity of bamboo species
7. Bamboo removals (poles and fuelwood)
8. Value of bamboo removals
9. Other bamboo products
10. Value of other bamboo products

In addition, the map of country bamboo resources distribution and the list of bamboo species in the country were included.

Although formally bamboo is a grass, it is included in the definition of forests used by FAO when the minimum height, crown cover and area criteria are met, and the surveying of bamboo resources is not much different from the surveying of the other tree species. It can easily be incorporated into national forest resource assessments and has been in many countries. Where there are differences between bamboo and tree species, they were specified and addressed in the outline and guidelines of the present study. The State Forest Administration of China (SFA) tested the new reporting format in the spring of 2004 and managed to complete almost all required fields in the reporting tables successfully and to provide the necessary explanatory notes. For ownership, data were requested for 1990 and 2000, and for diversity of bamboo species for 2000 only.

THE PROCESS

The study was initiated early in 2004 by FAO, INBAR and SFA. INBAR and SFA jointly developed the reporting outline and guidelines. In May 2004, a joint FAO/International Tropical Timber Organization (ITTO)/INBAR workshop was held at ITTO headquarters in Yokohama, Japan. The Chinese delegation presented its first national report on bamboo, and the workshop resolution encouraged the national correspondents for FRA 2005 from India and Indonesia to complete their reports on a trial basis. Both countries successfully completed the reporting format, which indicates that most of the data for the report were available and could be compiled from existing sources. Where data were not available, expert evaluations were employed to bridge the information gap.

Pilot results from the three countries were presented at a joint FAO/INBAR workshop in Bangkok in November 2004, attended by over 30 national correspondents from across Asia. The workshop participants recommended inclusion of bamboo as a seventh thematic study in the framework of FRA 2005, along with the six already selected.

In May 2005, some 30 national correspondents and country representatives gathered at INBAR in Beijing for the FAO/INBAR International Workshop on Bamboo Resources Assessment, at which

they submitted their country reports. Although the reports differed in the quality and reliability of the data presented, they did signify the first attempt of a comprehensive assessment of the world's bamboo resources.

The information provided in the reports was reviewed, analysed, verified and, where needed, complemented by additional information from literature sources and from consultations with the FRA 2005 national correspondents and bamboo experts (see Annex 2 for the list of contributors to the study). FAO and INBAR bibliographic databases were reviewed in order to incorporate relevant information currently available on bamboo resource assessment and utilization.

The information was processed according to the recommended methodology for FRA 2005. Linear interpolation was used in cases where figures for two inventory periods were provided, while data for 2005 were obtained through forecasting and extrapolation of values into the future. Reclassification was performed where necessary and possible, with the objective of fitting national data into the reporting format. Reclassification matrices were particularly useful for bamboo, which, as mentioned earlier, is often mixed with other species and can grow outside forests. The FAO methodology ensured more reliable, realistic and comparable results.

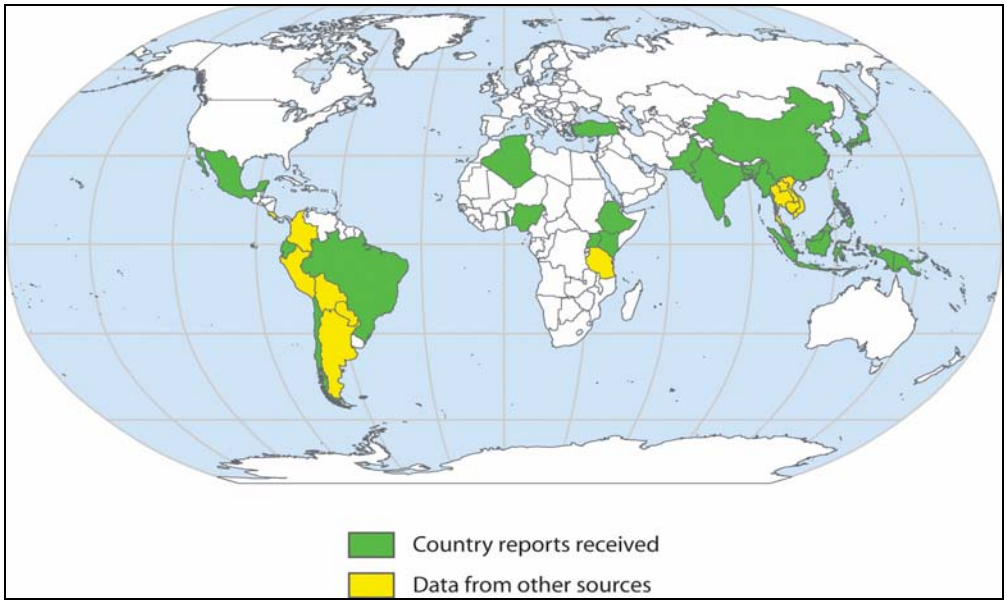
During the summer of 2005, two INBAR teams worked on the study, one in Rome with FAO and the other in the United States with UNEP and USGS. The United States team worked on remote assessment aspects, with the goal of establishing an INBAR bamboo inventory laboratory to train national correspondents and country representatives in bamboo resources assessment.

A joint Bamboo Inventory Training Workshop in support of the study was held in China by FAO, INBAR and the International Centre for Bamboo and Rattan in October–November 2005. Two international task forces were formed during the workshop to design bamboo inventory manuals for the on-the-ground and remote sensing assessments. Both manuals will assist countries in including data on bamboo in their national forest inventory programmes.

INFORMATION AVAILABILITY

The data presented in this report were mostly provided in the form of reports submitted by participating countries. A total of 22 countries submitted national bamboo reports – five countries in Africa, 13 in Asia and the Pacific and four in Latin America (Figure 1).

FIGURE 1
Countries participating in the FAO/INBAR bamboo thematic study



The reports were compiled by the FRA 2005 national correspondents and their teams, together with experts, and in most cases represent the best available knowledge on the subject. Where possible, the presented information was verified using other available sources, including expert estimates.

The quality and quantity of the information provided in the country reports varied significantly depending on the significance of the bamboo sectors in the countries surveyed. Asia has the longest tradition of bamboo utilization, and bamboo plays a fundamental role for a significant part of the population. Hence, Asian countries as a rule submitted more comprehensive and accurate data than Latin America and Africa. Several countries highlighted the need for a more systematic assessment of bamboo resources to further their sustainable development.

Generally speaking, current bamboo resource statistics are inconsistent, fragmented and scattered. There are several reasons for this:

- Systematic inventories of global bamboo resources have never been done.
- Consistent methodology and techniques have not yet been developed.
- Bamboo is often intermixed with other forest species or grows outside forests, making assessment more difficult.
- Most bamboo is harvested and traded locally without entering official statistical records.
- The term 'bamboo forest' often has different and incompatible definitions in different countries.

Table 2 lists the sources of the data used for the present study, including additional verification and validation sources.

TABLE 2
Sources of information and validation for the study

Sources of information	No. of sources
National reports from INBAR member states	14
National reports from other countries	8
National forest research institutions	9
FRA 2005 country reports	7
Expert estimates	6
National forestry inventories	5
Other sources	13

Annex 3 lists the classifications and definitions of bamboo in different countries and indicates that less than 30 percent of the countries surveyed have a clear definition of 'bamboo forest' in their national forest classification systems. Several countries include subclasses for selected forest tree species, such as rubber tree and mangroves, in recognition of their economic and social value. It is hoped that recognition of the development value of bamboo will promote its better assessment and further development.

Table 3 summarizes the information contained in the reports received, classified according to the reporting tables.

The table on bamboo species diversity is the most complete. Almost all the countries managed to fill in this table reasonably well. About 80 percent completed the tables on bamboo resources extent, ownership and characteristics. Some complementary information was extracted from national forest inventories. Some 50 percent of the respondents completed the tables on bamboo growing stock and biomass. Lack of an appropriate methodology for obtaining biomass data was reported as a primary reason for the data gaps. Information on the amount and value of bamboo

removals was also rather scarce. This relates particularly to the bamboo products that are traded locally, without entering national statistical records.

TABLE 3
Summary of information provided in country reports

Country Reports	Extent	Ownership	Charac-teristics	Growing stock	Biomass stock	Diversity of bamboo species	Removals *(poles & fuelwood)*	Value of poles & fuelwood removed	Removals of other bamboo products	Value of other bamboo products
Bangladesh	1	1	1	1	1	1	1	-	-	-
China	3	2	3	3	3	1	3	3	3	3
India	3	2	3	3	3	1	1	1	1	1
Indonesia	2	2	2	2	-	1	2	2	1	1
Japan	3	2	-	-	-	1	3	3	-	-
Republic of Korea	3	2	3	-	3	1	-	-	2	2
Malaysia	1	1	1	2	-	1	2	2	-	-
Myanmar	3	2	3	3	3	1	3	3	3	3
Pakistan	3	2	3	3	3	1	3	3	-	-
Papua New Guinea	3	2	3	-	-	1	-	-	-	-
Sri Lanka	3	2	3	-	-	1	3	-	-	-
Philippines	1	1	1	1	-	1	3	3	2	2
Turkey	3	3	3	2	-	1	-	-	2	2
Total Asia	**13**	**13**	**12**	**9**	**6**	**13**	**10**	**8**	**7**	**7**
Algeria	3	2	3	3	1	1	-	1	1	1
Ethiopia	1	2	1	1	1	1	-	-	-	-
Kenya	3	2	3	3	-	1	-	-	-	-
Nigeria	1	1	2	2	-	-	2	2	-	-
Togo	-	-	-	-	-	1	-	-	-	-
Total Africa	**4**	**4**	**4**	**4**	**2**	**4**	**1**	**2**	**1**	**1**
Brazil	-	-	-	-	-	1	-	-	-	-
Chile	1	-	1	1	1	1	2	2	-	-
Ecuador	2	1	2	-	2	1	3	3	-	3
Mexico	-	-	1	-	-	1	-	-	-	-
Total Latin America	**2**	**1**	**3**	**1**	**2**	**4**	**2**	**2**	**0**	**1**
Total no. of country reports	**19**	**18**	**19**	**14**	**10**	**21**	**13**	**12**	**8**	**9**
Percentage of total no. of participating countries	**86**	**82**	**86**	**64**	**45**	**95**	**59**	**55**	**36**	**41**

Note: The numbers 1, 2 and 3 for each country and category indicate the number of reporting years for which data were provided. The regional totals indicate how many countries provided information for each table for at least one reporting year.

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

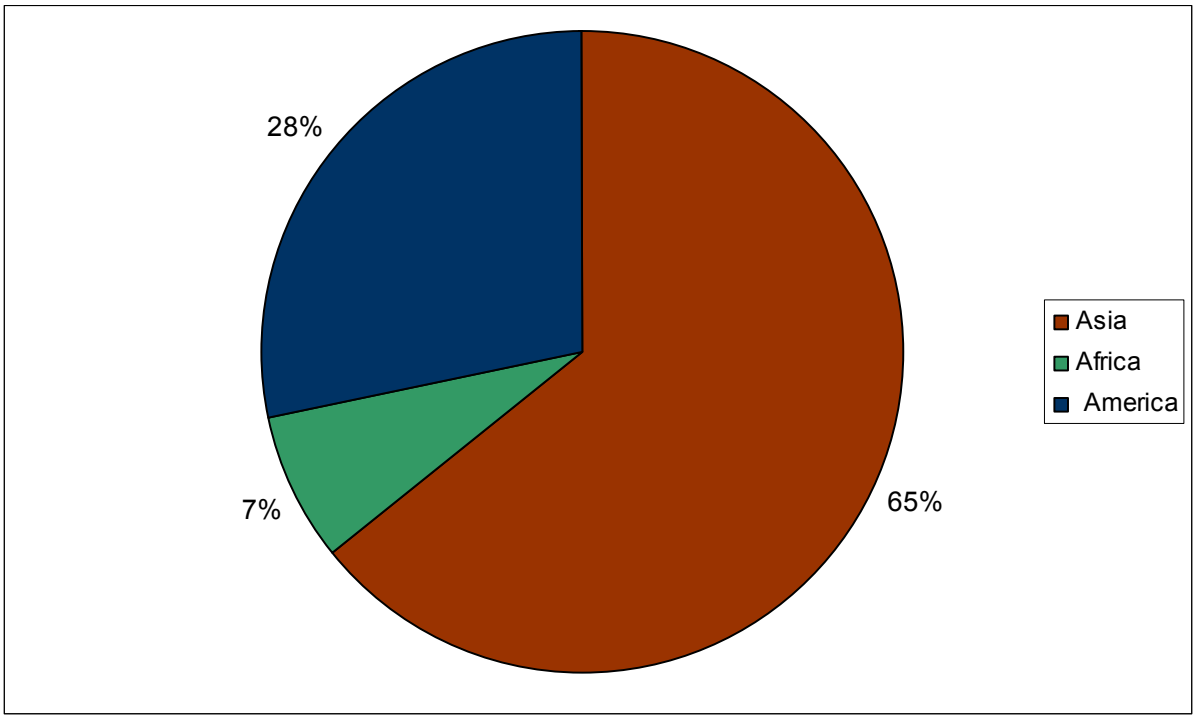


Table 4 presents the distribution of the bamboo resources by countries. The table shows that bamboo may total more than 36 million hectares worldwide or an average of 3.2 percent of the total forest area in the reporting countries if bamboo outside forest land is included. Sixteen countries in Asia together 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	2005	
Bangladesh	90	86	83	871	9.5
Cambodia[a]	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[a]	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	1902	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[a]	261	261	261	14 520	1.8
Viet Nam[a]	813	813	813	12 931	6.3
Total Asia	**21 230**	**22 499**	**23 620**	**533 076**	**4.4**
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[a]	67	67	67	3 627	1.8
United Republic of Tanzania[a]	128	128	128	35 257	0.4
Total Africa	**2 758**	**2 758**	**2 758**	**66 495**	**4.1**
Brazil	-	9 300	9 300	447 698	2.1
Chile	-	900	900	16 121	5.6
Ecuador	-	9	9	10 853	0.1
Peru[a]	-	190	190	68 742	0.3
Total Latin America	**-**	**10 399**	**10 399**	**543 414**	**1.9**
Grand Total	**23 988**	**35 656**	**36 777**	**1 142 985**	**3.2**

[a] 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. tuldoides*, *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

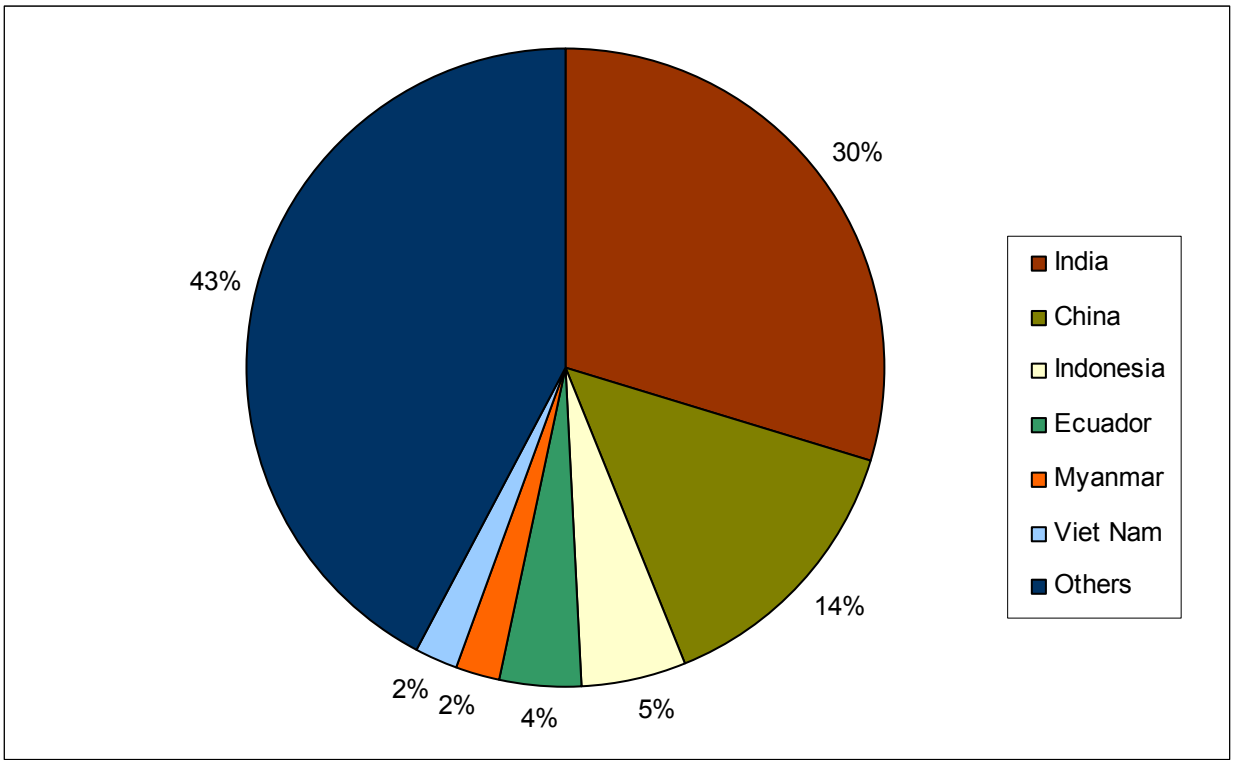
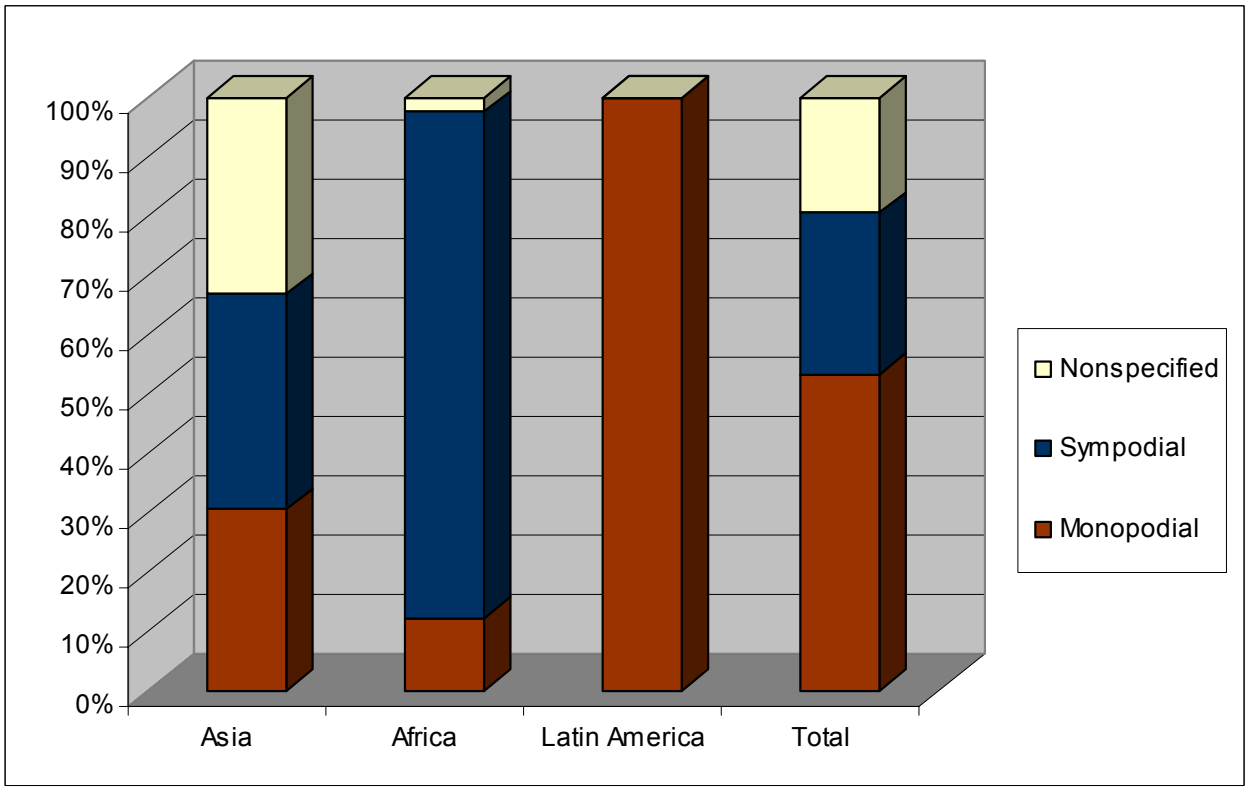


FIGURE 4
Composition of bamboo types by continent 2005



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 Mandibhaudin 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. heterocycla* 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, Ssenteza 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
Total Asia	**18 511**	**19**	**81**	**19 780**	**27**	**73**
Ethiopia	849	2	98	849	2	98
Kenya	124	0	100	124	0	100
Nigeria	1 590	100	0	1 590	100	0
Total Africa	**2 563**	**63**	**37**	**2 563**	**63**	**37**

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

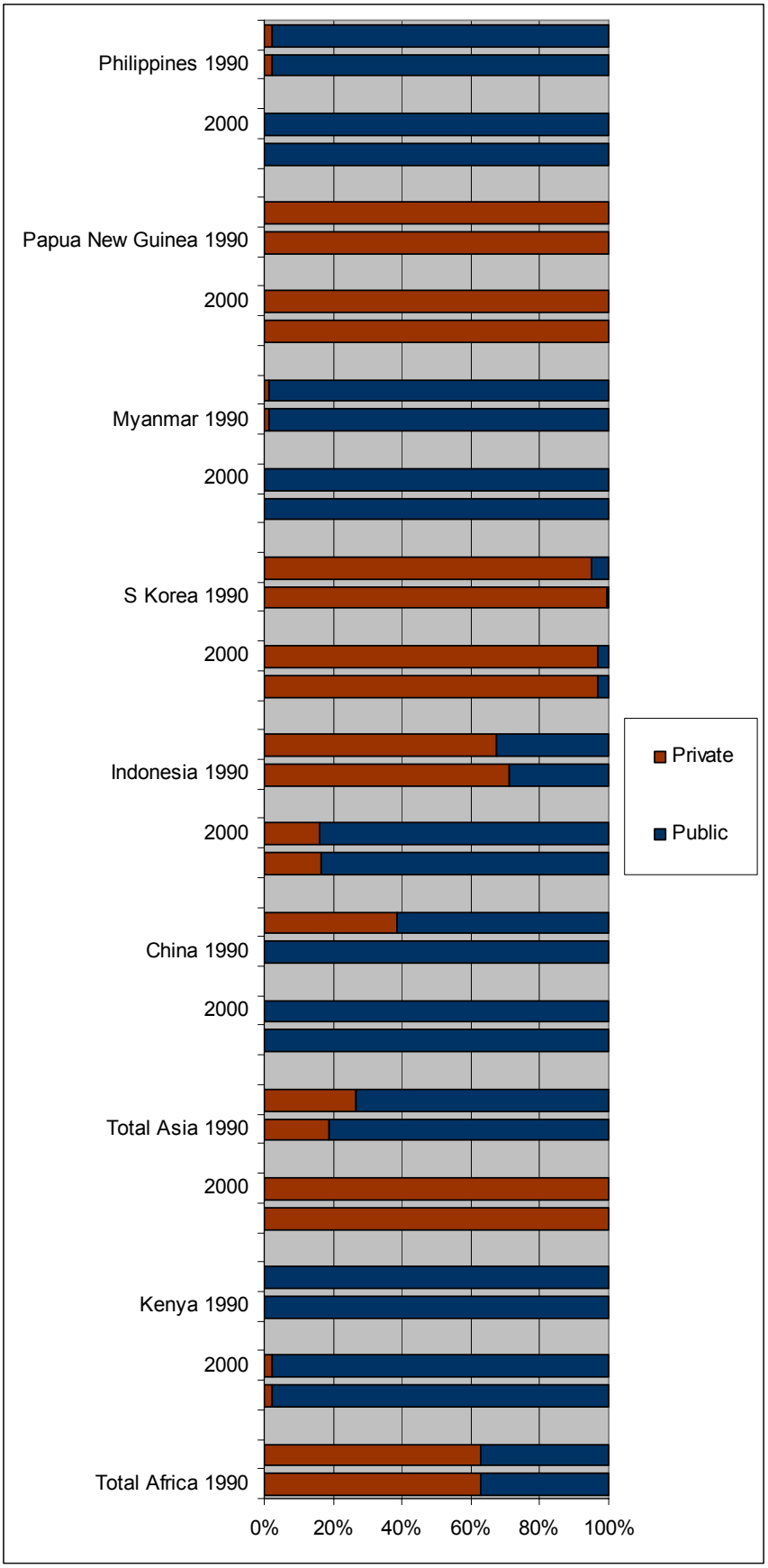
China. An important distinction was made between the ownership of land and the ownership of trees. The land is public, but cultivated bamboo may belong to farmers if the land is leased. Land can be leased to private entities for up to 50 years. Public ownership includes both land and trees owned by public 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.

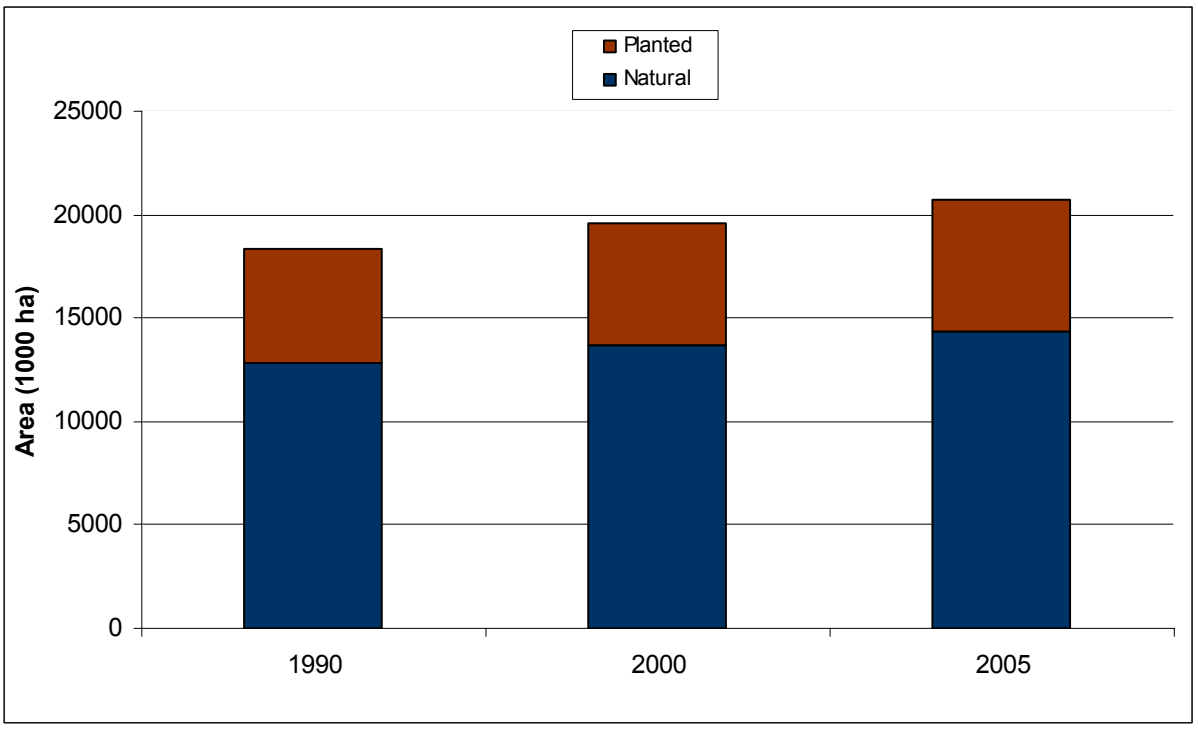
Approximately 30 percent of the total area of bamboo in Asia is planted (Table 6). This percentage has remained rather stable over the reporting period, although there has been a slight increase in recent years. Most of the reporting countries provided data for both naturally regenerated and planted 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
Total	**12 857**	**5 503**	**18 360**	**13 663**	**5 960**	**19 623**	**14 321**	**6 427**	**20 748**
% of total	**70**	**30**	**100**	**70**	**30**	**100**	**69**	**31**	**100**

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 membranaceous, 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
Total Asia	**257**	**18 329**	**14**	**307**	**19 579**	**15**	**332**	**20 697**	**16**
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
Total Africa	**57**	**2 758**	**21**	**57**	**2 758**	**21**	**57**	**2 758**	**21**
Total	**314**	**21 087**	**15**	**364**	**22 337**	**16**	**389**	**23 455**	**17**

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 culeou* 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 acuminate* 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, Crematogoster* 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)
Asia			
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)
Africa			
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	
South and Central America			
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

3. Bamboo products and trade

BAMBOO PRODUCT STATISTICS

OVERVIEW

Forest resources are experiencing increasing pressure due to the growing world population and improving living standards. Bamboo is the most important non-wood forest product and in India is known as the 'poor man's timber'. In China, it is the valuable raw material for the booming bamboo industry.

During the last 15–20 years, bamboo has developed as an exceptionally valuable and often superior substitute for wood. Bamboo-based panels and boards are hard and durable and may successfully substitute for hardwood products. Bamboo may replace wood in many industrial applications and thereby contribute to the saving and restoration of the world's forests.

Bamboo is a major construction material in many countries, particularly in rural areas. It can be used for almost all parts of houses, including posts, roofs, walls, floors, beams, trusses and fences. People also use bamboo to produce mats, baskets, tools, handles, hats, traditional toys, musical instruments and furniture. In the food sector, bamboo shoots are becoming more popular. Bamboo has a tremendous potential for economic and environmental development and international trade.

Bamboo raw materials
Bamboo is a non-durable resource. Its use in exposed conditions requires prior treatment (Liese and Kumar, 2003), while its use can be further enhanced through the application of modern engineering techniques. Bamboo can be processed into modern products (engineered bamboo) that may successfully compete with wood products in price and performance. Use of bamboo in composite panels and boards overcomes differences in quality related to the culms and allows the production of homogeneous products. Engineered bamboo may well replace wood, steel and concrete in many uses.

Bamboo charcoal
Bamboo charcoal is traditionally used as a substitute for wood charcoal or mineral coal. It can serve as a fuel, absorbent and conductor. The calorific value of bamboo charcoal is almost half that of oil of the same weight. Activated bamboo charcoal can be used for cleaning the environment, absorbing excess moisture and producing medicines. The absorption capacity of bamboo charcoal is six times that of wood charcoal of the same weight. China is a leader in its production. At present, Japan, the Republic of Korea and Taiwan Province of China are the main consumers, but its importation is rapidly expanding in Europe and North America. There are three main reasons contributing to the success of bamboo charcoal in international trade: 1. bamboo grows faster and has a shorter rotation compared with tree species; 2. the calorific value and absorption properties of bamboo charcoal are similar to or better than those of wood charcoal; and 3. it is cheaper and easier to produce.

Bamboo housing
There are three main types of bamboo housing: 1. traditional houses, which use bamboo culms as a primary building material; 2. traditional *bahareque* bamboo houses, in which a bamboo frame is plastered with cement or clay; and 3. modern prefabricated houses made of bamboo laminated boards, veneers and panels. Experts estimate that over one billion people live in traditional bamboo houses. These buildings are usually cheaper than wooden houses, light, strong and earthquake resistant, unlike brick or cement constructions. New types of prefabricated houses made of engineered bamboo have certain advantages. They can be packed flat and transported long distances at a reasonable cost. They are better designed and environmentally friendly. Bamboo materials are widely available and can be cultivated at a low cost.

Bamboo pulp, paper and cloth
Several bamboo-producing countries, such as China and India, use bamboo in pulp, paper and more recently cloth. Bamboo paper has practically the same quality as paper made from wood. Its brightness and optical properties remain stable, while those of paper made from wood may deteriorate over time. The morphological characteristics of bamboo fibres yield paper with a high tear index, similar to that of hardwood paper. The tensile stiffness is somewhat lower compared with softwood paper. The strain strength is between that of hardwood and softwood papers. The quality of bamboo paper may be improved by refining the pulp.

Bamboo panels
China started producing bamboo panels in the early 19th century. At present more than 20 different types of panels are produced in Asia. Bamboo fibre is longer than wood fibre, which gives bamboo some technological advantages. The panels are widely used in modern construction as structural elements or as forms for concrete moldings. They are also used for flooring, roofing, partitions, doors and window frames. Bamboo panels have some advantages over wooden boards due to their rigidity and durability. Various types of bamboo veneers, panels and boards can be broadly classified as follows: veneers, stripboards, matboards, fibreboards, particle boards, medium density boards, combinations of these, and combinations of these with wood and other ligno-cellulose materials and inorganic substances.

Bamboo flooring
Bamboo flooring is a quality product that can be used widely and has a large, global consumer market. It has certain advantages over wooden floors due to its smoothness, brightness, stability, high resistance, insulation qualities and flexibility. Bamboo flooring has a soft natural luster and maintains the natural gloss and elegance of bamboo fibre. This flooring is attractive to the demanding markets in Europe, Japan and North America. The estimated annual production of bamboo flooring in China was 17.5 million m^2 in 2004. Exports account for some 65 percent of total production (Customs General Administration of China, 2004).

Bamboo weaving products and crafts
Bamboo crafts and woven mats are traditional products in China, India, Malaysia, the Philippines and Thailand. The technique has been known for several thousand years. These diverse products have become an indispensable part of daily life, literature and art. There are nearly 20 categories of woven bamboo products in Asia, including fruit baskets, trays, bottles, jars, boxes, cases, bowls, fans, screens, curtains, cushions, lampshades and lanterns.

Bamboo fuel
Through pyrolysis, bamboo can be converted into three valuable products: bamboo charcoal, oil and gas. Changing the pyrolysis parameters can change the product shares depending on the purpose and market conditions. Bamboo extracts contain valuable elements and can be used in pharmaceuticals, creams and beverages. Bamboo gas can be used as a substitute for petroleum. Bamboo charcoal is an excellent fuel for cooking and barbequing. Activated charcoal is used as a deodorant, purifier, disinfectant, medicine, agricultural chemical and absorbent of pollution and excessive moisture.

Bamboo shoots
About 200 species of bamboo can provide edible and palatable bamboo shoots, including: 1. monopodial bamboos: *Acidosasa edulis*, *Chimonobambusa quadrangularis*, *Phyllostachys heterocycla* var. *pubescens*, *P. praecox*, *P. dulcis*, *P. iridescens*, *P. makinoi*, *P. nuda*, *P. prominens*, *P. sulphurea* cv. *viridis*, *P. vivax*, *Pleioblastus amarus* and *Qiongzhuea tumidinoda*; and 2. sympodial bamboos: *Bambusa rigida*, *B. pervariabilis*, *Dendrocalamus latiflorus*, *D. asper*, *D. brandisii*, *D. hamiltonii*, *Dendrocalamopsis oldhami, D .beecheyana, D. beecheyana* var. *pubescens, D. stenoaurita, D. vario-striata* and *Schizostachyum funghomii*. Fresh bamboo shoots are delicious and healthy, with a high fibre content. Bamboo vegetables can be found in Chinese grocery stores and restaurants

worldwide. After cooking the shoots are still crisp, because cooking does not destroy their texture. Cooked bamboo shoots can be stored in containers and shipped worldwide.

Bamboo furniture
Traditional bamboo furniture uses natural round or split bamboo. A new type of 'pack-flat,' 'knock-down' furniture uses glue-laminated bamboo panels. Unlike the traditional design, this furniture may be shipped in compact flat packs, to be assembled on the spot. The new design overcomes many of the problems of traditional bamboo furniture, such as high labour and transportation costs, low productivity, instability, varying quality and susceptibility to insects and fungi. At the same time, it retains the distinct physical, mechanical, chemical, environmental and aesthetic features of bamboo. Export of laminated bamboo furniture is growing rapidly. However, trade statistics currently do not capture the value, owing to the absence of a special code for bamboo furniture. It is usually classified as wooden furniture.

Bamboo and culture
Bamboo is an important resource, which was discovered, adopted and developed by humans in ancient times. The first scripts were written in China on strips of bamboo more than 6 000 years ago, during the Neolithic period. Bamboo pens, brushes and musical instruments were invented 3 000 years ago. The first paper was produced from bamboo in China in the ninth century. Bamboo culture is an essential part of human history and civilization, especially in Asia.

Bamboo and the environment
Bamboo protects steep slopes, soils and water ways, prevents soil erosion, provides carbon sequestration and brings many other ecosystem benefits.

BAMBOO REMOVALS

OVERVIEW

About 2.5 billion people in the world depend economically on bamboo (INBAR, 1999), and international trade in bamboo amounts to about US$2.5 million (INBAR, 2005). National and local trade is likely a few times higher. There are other numerous examples of the importance of bamboo for national economies and international trade. However, reliable statistics are still lacking. Most of the economic activities related to bamboo are not recorded officially. They are site-specific, highly diverse and present challenges for official data collection (FAO, 2001a).

Non-wood forest products, including bamboo, do not have standard classifications. They are usually classified according to their structure (roots, leaves, bark) or the end use (medicine, food, beverages, utensils, etc.). Bamboo product classification is even more complicated due to the multifunctionality. Bamboo can be attributed to almost all NWFP categories. It can be used for construction, pulp, board, cloth, food, fuel, medicine, utensils and crafts.

The growing industrial and environmental importance of bamboo requires development of more comprehensive statistics on bamboo resources, utilization and trade. In 2005 the World Customs Organization (WCO) approved an FAO/INBAR proposal to introduce 16 new Harmonized System codes, including bamboo pulp, panels, furniture and shoots. The new codes will take effect in 2007 and will have a profound long-term effect on bamboo statistics and the facilitation of bamboo trade and development (Annex 5).

TABLE 10
Bamboo removals, bamboo products and their value

	Quantity (1 000 tonnes)			Value (million US$)		
	1990	2000	2005	1990	2000	2005
Bamboo removals						
Bangladesh	993	-	-	-	-	-
Chile	-	6	13	-	1	3
China[a]	260 000	610 000	1 230 000	173	762	
Ecuador	35	36	53	1	1	3
Ethiopia (fuelwood)	-	6	-	-	-	-
India	-	-	14 615	-	-	409
wood	-	-	13 470	-	-	409
fuelwood	-	-	1 145	-	-	-
Indonesia	44	215		3	4	-
Japan	200	60	40	53	20	12
Malaysia	10	4	-	n.s	n.s	-
Myanmar	7 753	8 481	9 803	660	357	261
Nigeria	-	6 900	7 320	-	65	96
Pakistan	61	95	136	15	23	32
Philippines	16	19	21	n.s	n.s	n.s
Sri Lanka[a]	271	1 000	1 500	-	-	-
Other bamboo products						
China						
bamboo shoots	82	346	467	193	539	
bamboo building timber[b]	165	400	-	39	-	-
bamboo pulp	177	300	500	-	-	-
utensils[c]	90 880	-	-	10		
India						
bamboo shoots	-	-	8	-	-	1
utensils	-	-	6	-	-	-
other plant products	-	-	4	-	-	13
Indonesia (bamboo shoots)	-	1	-	-	n.s	-
Republic of Korea	2	1	-	n.s	2	-
Myanmar	11 992	20 418	73 988	49	25	47
bamboo shoots	n.s	1	1	n.s	n.s	n.s
utensils	354	296	459	47	20	20
other plant products (pulp)	11 638	20 121	73 528	2	5	27
Philippines (utensils)[c]	45	72		2	3	-
Turkey (ornamental plants)[c]	-	3	4	-	n.s	n.s

[a] 1 000 culms.
[b] 1 000 m^3.
[c] 1 000 pieces.

The issue of statistics was addressed in a study on the bamboo and rattan database for Asia (Pabuayon and Espanto, 1997) and in a series of studies of production-to-consumption systems (INBAR, 1999). The most comprehensive information comes from countries in which bamboo is an important economic asset. The main examples are China, India and Japan. The latest data from China indicate that the Chinese bamboo industry created a value of US$5.5 billion in 2004. The bamboo-based GDP grew by 120 percent from 2000 to 2004, while export earnings reached US$600 million, a 20 percent increase (ITTO, 2006).

Table 10 represents a summary of the bamboo removals, products and value presented in the country reports. The submitted data are scattered and incomplete and reflect the current status of bamboo statistics. Country data were collected using various methodologies.

Bamboo is recognized as a wood substitute for its potential to reduce pressure on naturally regenerated forests. According to FRA 2005, 40% of the recorded removals from forest were for fuelwood or charcoal.

ASIA

Bangladesh. The report provides data on bamboo removals extracted from studies published between 1981 and 2000. The studies indicate that over 700 million bamboo culms are removed annually (corresponding to almost 1 million tonnes). Approximately 200 million culms come from state forests and 500 million are logged in village forests. The information on bamboo production did not include explanatory notes. Categories reported include food, medicine, ornamentals, crafts, utensils, construction, basketry, furniture, tools, fuel and fodder.

China. The National Forestry Statistical Yearbook includes yearly data on removals and value of bamboo products. China represents an outstanding exception in terms of accuracy and amount of recorded data. The yearly figures were calibrated for three time periods, including projections for 2005. The value of bamboo culms and products was calculated according to the market price. The Chinese report is the most comprehensive, although it has a number of information gaps. The figure for bamboo poles reported in Table 10 does not include the small bamboo used for pulp and crafts (135 million tonnes in 2003).

India. The data provided in the country report did not include explanatory notes. The National Mission on Bamboo Technology and Trade Development, Government of India, was cited as the main information source. Further information from an INBAR study indicates that the annual bamboo harvest (poles and shoots) was slightly over US$23 million (Pabuayon and Espanto, 1997). Uncertainty regarding the methodologies used does not allow a comparison between the official and research data.

Indonesia. A conversion coefficient (7.5 kg/culm) was used to convert harvested culms into dry weight. The amount and value of bamboo removals are likely to be underestimates of the real volumes. Contribution of bamboo to the domestic market is probably much more substantial. The amount and value of the bamboo shoots produced does not include rural consumption at the local level.

Malaysia. Bamboo removals were reported in culms and weight, with a conversion factor of 12.5 kg per 6 m of culm. The harvest of 1990 was estimated based on royalty collection. The harvest of 2000 was obtained from a country report to FAO (Malaysia, 2003). The data do not include removals outside of forests, which are not subject to royalty payments.

Myanmar. The Forest Department Planning and Statistics Division compiled the report based on regional data. The number of stems was converted into tonnes with a conversion coefficient of 400 stems per tonne for monopodial and 120 stems per tonne for sympodial bamboo. The reporting table includes private trade and household use, and the figures of removals reported include 100 tonnes of fuelwood in each reference year . The Ministry of Forestry and Ministry of National Planning and Economic Development estimated bamboo consumption per average household. According to this report, bamboo use for pulp and paper amounted to 43 245 tonnes in 1990, 103 597 tonnes in 2000 and 60 412 tonnes in 2004. Supply lagged behind demand. The average export price ranged from US$24 to US$150 per tonne. There was no export in 1990/91. Bamboo charcoal export in 2000 reached US$16 852. Bamboo shoot production data were collected from some states and estimates were made for the other areas. The reporting unit *viss* was converted to tonnes by using a conversion coefficient of 612.3952 *viss* per tonne. Raw material for utensils, crafts and construction constitutes 30 percent of total bamboo stem production. On average, 170 tonnes of bamboo shoots are exported annually, with a

market price of US$210–600/tonne. The value of annual exports of chopsticks, bamboo wares, etc. varied from US$880 000 to US$1 120 000 during 2001–2003.

Pakistan. The figures reported for bamboo removal are the same as those reported for commercial growing stock. However, it is arguable whether all commercial stock is actually removed, so the data should be interpreted as the value of the standing commercial stock. The value indicated was obtained with the assumption that one culm weighs on average 14-15 kg and can be sold at 200 Rs. One US$=60 Rs.

The Philippines. The data provided were obtained from the Philippine Forestry Statistics Yearbook under the category 'Selected non-timber-forest-products export' for 2001.

Republic of Korea. The data on bamboo shoots were obtained from the Korea Forest Service. Its annual report attributed the increasing value of bamboo to increased prices and exchange rates.

Sri Lanka. The table refers to a single species (*Bambusa vulgaris),* which is in high demand as a raw material for construction. The figures were derived from state-issued permits for bamboo transportation. In rural areas, however, most bamboo is harvested and used without records.

AFRICA

In Africa, the share of removals from forests used for fuel is substantially higher (FAO, 2006). Although little quantitative information was presented on bamboo removals and products, several countries indicated that bamboo energy use is substantial in rural areas.

Lack of knowledge of bamboo management and utilization is indicated as the main obstacle to developing the bamboo sector on the continent.

LATIN AMERICA

From this region, Chile and Ecuador provided information. Chile estimated that 4.5 million culms were traded in the country in 2000 and over 10 million culms in 2005 (corresponding to approximately 6 000 tonnes in 2000 and 13 000 in 2005), with a market value of US$3 million in 2005. Most of the bamboo trade is not formally recorded. Ecuador harvested 36 000 tonnes in 2000 (US$1.2 million) and 53 000 tonnes in 2005 (US$3 million). These figures reflect the annual allowable cuts of bamboo issued by the Ministry of the Environment.

BAMBOO TRADE

Statistics on bamboo include four main elements: resources, production and national and international trade. The last are likely the most complete, but are still far from perfect.

The most recent and comprehensive information on international bamboo trade is collected in INBAR's online International Bamboo and Rattan Trade Database. The database has been tracing bamboo and rattan international trade since the early 1960s. It is based on the COMTRADE statistics of the United Nations Statistical Divison, which rely on the WCO six-digit Harmonized System (HS) codes (World Customs Organization, 2002). The codes may include some other commodities mixed with bamboo, such as osier, willow and vegetables. However, as mentioned, they do not capture the rapidly growing trade in new industrial commodities, such as bamboo pulp, paper, boards, panels, parquet floors, furniture, charcoal, medicines, cosmetics, etc. In 2005, as mentioned earlier, WCO approved the joint FAO/INBAR proposal to introduce a new series of six-digit codes for recording the international trade in bamboo and rattan.

According to INBAR's trade database, the annual export of bamboo in 2000 was valued at about US$2.5 billion (Table 11). China, Indonesia and Viet Nam were the major bamboo producers and exporters

in Asia. The total value of exports of raw bamboo is about US$89 million. China exported some US$25 million worth of raw bamboo, roughly a third of the world total. It was followed by Indonesia (US$10.6 million, 12 percent) and Viet Nam (US$7.7 million, 8.6 percent). Singapore and Hong Kong were important bamboo and rattan processing centres and exporters. There was a US$18.6 million trade of bamboo raw materials in Singapore, which accounted for over 20.9 percent of world trade. Hong Kong's annual trade value was US$4.69 million, which accounted for 5.3 percent of the world total.

TABLE 11
Export of bamboo products in 2000 (*million US$)*

	Africa	Asia	Europe	North and Central America	Oceania	South America	Total
Bamboo products	29	1 554	739	120	8	5	2 455
Market share %	1.2	63.3	30.0	4.9	0.4	0.2	100.0

The main importers together make up some 80 percent of the world bamboo import trade (Table 12). The European Union, Hong Kong, Japan and the United States were the major markets for bamboo products, collectively accounting for 71 percent of the total market share.

TABLE 12
Main importers of bamboo products in 2000 (*million US$)*

	USA	UK	Netherlands	Germany	France	Japan	Hong Kong	Others	Total
Bamboo import	899	125	106	169	169	349	163	475	2 455
Market share %	36.6	5	4.3	6.9	6.9	14.2	6.6	19.3	100.0

According to Chinese customs statistics, the total trade value of nine bamboo commodities (identified by country-specific, eight-digit codes) was over US$517 million in 2002 (Table 13). This is 9.4 percent more than the average for the previous four years, 1998–2001.

TABLE 13
Bamboo export value in China 1998–2002 (*1 000 US$*)

	Products	Average 1998–2001	2002
07099010	Bamboo shoots, fresh or chilled	4 874	4 957
07119031	Bamboo shoots, in brine	6 376	7 346
07129010	Bamboo shoots, dried	10 469	11 359
14011000	Bamboo, used primarily for plaiting	26 486	25 665
20059030	Boiled bamboo shoots in airtight containers	123 406	116 989
46012090	Mats, matting and screens made of bamboo	20 204	41 424
46021030	Basketwork, wickerwork and other articles of bamboo	103 916	138 199
94015000	Seats of cane, osier, bamboo or similar materials	19 999	21 157
94038010	Other furniture of cane, osier, bamboo or similar materials	34 007	33 627
Total		**473 149**	**517 719**

Source: Customs General Administration of China, 2003.

Bamboo serves numerous small users around the globe, but international trade statistics show that it has also become a very competitive resource in the international arena. Small, medium and large-scale industries should be promoted further to more effectively facilitate poverty reduction and sustainable economic and environmental development in the developing world. With modern techniques and technology, bamboo can be processed into a wide range of commodities. Engineered bamboo successfully competes with wood and other raw materials in highly demanding international markets. Trade statistics are important not only for market analysis, but also for assessment of the sustainability of bamboo resources.

4. Conclusions and recommendations

The current study represents a joint FAO/INBAR initiative to incorporate bamboo into the FAO Global Forest Resources Assessment programme. It is a first attempt at systematic reporting of the best available information on bamboo resources and utilization at the global level. The study has developed a methodology for monitoring and reporting on bamboo resources and has proved its feasibility. The initiative thus provides bamboo-producing countries with an opportunity to include bamboo in their national forest inventory programmes.

The study was preceded by preparatory work, global and regional expert consultations, meetings, workshops and pilot studies. Outlines and guidelines were created and tested with forest departments and FAO national correspondents in China, India and Indonesia. The tests were successful and demonstrated data availability.

Twenty-two countries responded to the FAO/INBAR call for information and voluntarily submitted reports following a standardized format. Interestingly, about one-third of the countries responding were not INBAR member states. Review of the reports confirmed that data on bamboo resources were available in many countries and could be collected through national statistics. Where the data were not available, expert estimates helped bridge the gaps. Country maps were submitted and provided valuable information. This study represents an overview of the current situation of bamboo resource statistics in the world.

Data quality varied significantly among countries and regions. In many Asian countries, where bamboo was included in national forest inventories, the data quality was reasonably good. Africa and Latin America relied primarily on remote sensing, limited pilot studies and expert estimates. Information is still fragmented due to the absence of a standardized methodology. Many inconsistencies stemmed from differing definitions as well.

Varying methodologies and the quality and reliability of the presented data are a matter of concern. In many cases, the data in country reports were validated using previous FRA assessments, literature searches, studies, remote sensing information and interviews with experts. Where needed, the figures were calibrated for consistency using FRA methodological approaches and interpolation/extrapolation methods.

The study results are timely and demonstrate the importance of bamboo resources as a valuable economic asset in growth and development. The total export value of bamboo commodities reaches US$2.5 billion. Bamboo has become a valuable and often superior substitute for wood. It can be especially successful in countries that have exhausted their forest resources. Development of bamboo can help fight deforestation, illegal logging and forest degradation (bamboo is one of the first pioneers occupying open spaces in degraded forests). The present report indicates that the total area of bamboo forest resources might well exceed the earlier estimated 1 percent of total area of tropical and subtropical forest. Further clarifications from the countries are needed to confirm these findings.

Finally, the study makes the following recommendations to:

- incorporate bamboo as an integral part in the FAO FRA framework for future global forest resources assessments;
- encourage bamboo-producing countries to include bamboo in their national inventories and to provide the necessary methodological and organizational support;
- further develop the methodology for bamboo resource reporting, including clear definitions, formulas, guidelines and reclassification approaches;
- introduce standard, international manuals for ground and remote-sensing assessment of bamboo resources;

- establish a global database of information on bamboo resources, with periodic, systematic updates;
- strengthen international partnerships and collaboration in bamboo resource assessment by governments, agencies and international organizations, including FAO, INBAR, UNEP, USGS and others.

1. Bamboo shoot (Thomas Froese)

2. Bamboo culms (Thomas Froese)

3. Mat making in Assam, India (Marco Piazza)

4. Bamboo forest (Thomas Froese)

5. Bamboo forest (Thomas Froese)

6. Collecting bamboo poles (FAO Photo Database)

7. Transporting bamboo poles, Assam India (Marco Piazza)

8. Bamboo products (Jessica Savarese)

9. Basket weaving (FAO Photo Database)

10. Prefabricated bamboo house, India (INBAR)

11. Bamboo mats (Jessica Savarese)

12. Bamboo scaffolding (Jessica Savarese)

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Annex 1
Global bamboo resources assessment: tables and definitions

Table	Title	Definition	Unit
1	Extent of bamboo forest	Total bamboo area on forest land. Contribution of monopodial or sympodial bamboo species.	1 000 hectares
2	Ownership of bamboo forest	Ownership status of the bamboo forest area. Categories: private, public or other.	1 000 hectares
3	Characteristics of bamboo forest	Characterization of the bamboo forest area: natural forest or plantation.	1 000 hectares
4	Bamboo growing stock	Total weight of the bamboo resource.	tonnes
5	Bamboo biomass	Total weight of bamboo biomass: above-ground and below-ground contribution.	tonnes
6	Diversity of bamboo tree species	Occurrence of bamboo species: native, introduced, endangered, or vulnerable.	number of species
7	Bamboo wood removals	Amount of bamboo resource removed: bamboo timber and fuelwood.	million tonnes
8	Value of bamboo wood removals	Monetary value of resource removed: bamboo timber and fuelwood.	million US$
9	Other bamboo products	Amount of non-wood products: plant products/raw material (bamboo shoots, raw material for medicine and aromatic products, utensils, crafts and construction, ornamental plants, other plant products).	various units
10	Value of other bamboo products	Value of non-wood products: plant products/raw material (bamboo shoots, raw material for medicine and aromatic products, utensils, crafts and construction, ornamental plants, other plant products).	million US$

Annex 2
Contributors

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Annex 3
Bamboo classes in national forest classifications

Region and country	Definition of the specific class for bamboo within national forest classifications as reported in FRA 2005
ASIA	
Bangladesh	No class is defined. Data on bamboo resources are reported.
Cambodia	Bamboo. Large areas of dense bamboo are usually discernible due to their pink and orange color and typical texture. It was decided to map all visible bamboo into one class. Sparse bamboo coverage or smaller bamboos will not be visible and will remain in one of the other classes. Small lots of bamboo as a result of the degradation of mixed deciduous or evergreen forests also will not be included in this class.
China	Bamboo forest. Forest land spanning more than 0.067 ha (one Chinese *moo*), growing bamboo species with a diameter at breast height of over 2 cm.
India	n/a
Indonesia	n/a
Japan	Bamboo forest. Forest that does not fall under 'forest with standing trees' and is dominated by bamboo (excluding bamboo grass).
Lao People's Democratic Republic	Bamboo (B) within the class of 'potential forest area'. Bamboo is also mentioned as occurring within the 'upper mixed deciduous and lower mixed deciduous'. If an area is covered with bamboo and the overstorey has a crown cover of less than 5%, it should be classified as bamboo. Abandoned areas are often occupied by bamboo. Some species may live for many years. Bamboo may vary in height from 2 to 25 m depending on the species. If the bamboo represents less than 80% of the total vegetation cover of the understorey, the vegetation type should not be classified as bamboo.
Malaysia	n/a
Myanmar	n/a
Pakistan	n/a
Papua New Guinea	Scrub. This class contains subclasses: scrub (Sc) – scrub is a community of dense shrubs up to 6 m in height, with or without low, scattered trees. Scrub with *Bambusa* and *Cyathea* (ScBc) – occasional low trees may be present, but for the most part the scrub is comprised of the tree-fern *Cyathea,* with a tangled mass of scrambling *Bambusa*.
Philippines	Bamboo/palm-formations forest, of which over 75% of the crown cover consists of tree species other than coniferous or broad-leaved species (e.g. tree-form species of bamboo, palm and fern families).
Republic of Korea	No class specified, however bamboo forest is defined as a forest with bamboo covering over 75% of the unit area.
Sri Lanka	n/a
Thailand	n/a
Viet Nam	Forest. A site of at least 0.5 ha, with trees higher than 3 m and canopy cover of 30% or growing stock over 30 m^3/ ha. It includes planted forests. Bamboo with the cited canopy cover and at least 5 000 stems per hectare.

AFRICA	
Algeria	n/a
Ethiopia	n/a
Kenya	Indigenous forests. A group of trees whose crowns are broad-leaved and are largely contiguous. The canopy cover is over 10% and the canopy is made up essentially of naturally regenerated indigenous tree species, excluding planted indigenous forests. The area includes mangrove and bamboo ecosystems. Within the Global Bamboo Resource Assessment: definitions in terms of proportional ratio of bamboo in the other vegetation types: pure bamboo. 100% bamboo; bamboo with trees. 50% of area occupied by bamboo; shrubs with bamboo. 50% of area occupied by bamboo; bamboo with trees and shrubs. 30% of area occupied by bamboo; alpine vegetation. 20% of area occupied by bamboo.
Nigeria	Bamboo on forest land. Defined in Global Bamboo Resource Assessment as bamboo species with diameter at breast height of 2 cm extending over 0.0221 km^2.
Togo	n/a
Uganda	n/a
United Republic of Tanzania	n/a
CENTRAL AND SOUTH AMERICA	
Argentina	n/a
Bolivia	n/a
Brazil	n/a
Chile	Bamboo forest is defined in terms of relative dominance within the forest structure: Type I. Bamboo is present as dominant species in forest and occupies at least 25% of canopy cover. Up to six dominant species are identified in cadastral survey. Type II. Bamboo is present as second most dominant species in forest. Type III. Bamboo is present as third most dominant species in forest.
Colombia	n/a
Costa Rica	n/a
Ecuador	n/a
Paraguay	*Bosque de bambúes*. Defined as belonging to the class '*Bosques'*
Peru	*Pacales*, (Guadua sp.) within the '*Areas no forestales'*: *Pacales*. This formation is characterized by the presence of significant cane associations that form a mixture with the arboreal associations in different levels and proportions. The characteristic appearance of this cane (a *Guadua* sp.), known as *paca* or wild bamboo, differs noticeably from the surrounding arboreal mass, thus allowing its definition from satellite images. These canes are smaller than the trees, generally reaching an average height of 20 m (in the zone of the Urubamba River) and a maximum diameter of

	10 cm. In the areas where *paca* concentrates, it becomes impassable. Some authors affirm that it is an invasive species that occupies natural openings in the forest, mainly due to landslides occurring in disturbed, harvested or abandoned areas. Humid forest with mountain bamboo. In the tropical humid forest (*Semicálido*), the vegetation cover is luxuriant, dense and heterogeneous. The forest is associated with *paca*, and the proportion of trees to *paca* varies from an even balance to the predominance of either one. Humid temperate forest (*Ceja de selva*). The forest consists of thin trees, luxuriant, dense and very heterogeneous, associated with *paca*. The proportion of trees to *paca* varies from an even balance to the predominance of either one. Tropical humid forest with low-terrace bamboo. This is an evergreen, luxuriant, dense high forest, with a certain diversity of commercial trees, and associated with *paca*. The stock varies from low (less than 60 m^3/ ha) to good (80–100 m^3/ ha). The value of this type of forest is higher in association with *paca*, which is very valuable for housing, crafts, pulp and paper. Tropical humid forest with mid-terrace bamboo. This is a high, evergreen, luxuriant, dense primary forest, with a certain diversity of commercial trees, and associated with *paca*. The stock varies from low to good. Tropical humid forest with high-terrace-bamboo. This is a high, evergreen, luxuriant forest of various proportions, associated with *paca*. The commercial value in terms of volume of total wood is, on average, relatively low. In terms of quality, there are high-quality species such as cedar and mahogany. Tropical humid forest with hill bamboo. This is a high, evergreen, luxuriant forest, associated with *paca* in varying proportions. Humid tropical forest with foothill bamboo: This is a high, evergreen, luxuriant, dense and very heterogeneous forest, associated with *paca*. The proportion of trees to *paca* varies from an even balance to the predominance of either one. Tropical humid forest with high-hill bamboo. This is an evergreen forest, luxuriant, dense and very heterogeneous, associated with *paca*. The proportion of trees to *paca* varies from an even balance to the predominance of either one.
Mexico	n/a

Annex 4
Extent of bamboo forest by type *(1 000 hectares)*

Countries	1990				2000				2005				Forest Area FRA 2005	
	Mono podial	Sym podial	Nonspe cified	Total	Mono podial	Sym podial	Nonspe cified	Total	Mono podial	Sym podial	Nonspe cified	Total		%
Bangladesh	-	-	90	90	-	-	86	86	-	-	83	83	871	9.5
Cambodia	-	-	32	32	-	-	34	34	-	-	29	29	10 447	0.3
China	2 666	-	1 189	3 855	3 388	-	1 481	4 869	3 791	-	1 653	5 444	197 290	2.8
India	2 955	6 002	1 754	10 711	3 006	6 103	1 754	10 863	3 170	6 437	1 754	11 361	67 701	16.8
Indonesia	-	1 527	624	2 151	-	1 414	690	2 104	-	1 358	723	2 081	88 495	2.4
Japan	-	-	149	149	-	-	153	153	-	-	154	154	24 868	0.6
Lao People's Democratic Republic	-	-	1 612	1 612	-	-	1 612	1 612	-	-	1 612	1 612	16 142	10.0
Malaysia	-	-	422	422	-	-	592	592	-	-	677	677	20 890	3.2
Myanmar	260	703	-	963	242	653	-	895	232	627	-	859	32 222	2.7
Pakistan	-	9	-	9	-	14	-	14	-	20	-	20	1 902	1.1
Papua New Guinea	-	-	23	23	-	-	38	38	-	-	45	45	29 437	0.2
Philippines		127		127		156		156		172		172	7 162	2.4
Republic of Korea	8	-	-	8	6	-	-	6	6	-	-	6	6 265	0.1
Sri Lanka	-	-	3	3	-	-	3	3	-	-	3	3	1 933	0.2
Thailand	-	-	261	261	-	-	261	261	-	-	261	261	14 520	1.8
Viet Nam	-	-	813	813	-	-	813	813	-	-	813	813	12 931	6.3
Total Asia	**5 889**	**8 368**	**6 971**	**21 228**	**6 642**	**8 340**	**7 516**	**22 498**	**7 199**	**8 614**	**7 807**	**23 620**	**533 076**	**4.4**
% of total	**28**	**39**	**33**	**100**	**30**	**37**	**33**	**100**	**30**	**36**	**33**	**100**		
Ethiopia	149	700	-	849	149	700	-	849	149	700	-	849	13 000	6.5
Kenya	124	-	-	124	124	-	-	124	124	-	-	124	3 522	3.5
Nigeria	-	1 590	-	1 590	-	1 590	-	1 590	-	1 590	-	1 590	11 089	14.3
Uganda	-	-	67	67	-	-	67	67	-	-	67	67	3 627	1.8
United Republic of Tanzania	64	64		128	64	64		128	64	64		128	35 257	0.4

Total Africa	**337**	**2 353**	**67**	**2 757**	**337**	**2 353**	**67**	**2 757**	**337**	**2 353**	**67**	**2 757**	**66 495**	**4.1**
Ratio, %	**12**	**85**	**3**	**100**	**12**	**85**	**3**	**100**	**12**	**85**	**3**	**100**		
Brazil	-	-	-	-	-	-	9 300	9 300	-	-	9 300	9 300	447 698	2.1
Chile	-	-	-	-	-	-	900	900	-	-	900	900	16 121	5.6
Ecuador	-	-	-	-	-	-	9	9	-	-	9	9	10 853	0.1
Peru	-	-	-	-			190	190	-	-	190	190	68 742	0.3
Total Latin America	-	-	-	**-**	-	-	**10 399**	**10 399**	-	-	**10 399**	**10 399**	**543 414**	**1.9**
% of total	-	-	-	**-**	-	-	**100**	**100**	-	-	**100**	**100**	-	
Grand Total	**6 226**	**10 721**	**7 038**	**23 985**	**6 979**	**10 693**	**17 982**	**35 654**	**7 536**	**10 967**	**18 273**	**36 776**	**1 142 985**	**3.2**
% of total	**26**	**45**	**29**	**100**	**20**	**30**	**50**	**100**	**20**	**30**	**50**	**100**		

Annex 5
Current and newly introduced Harmonized System codes for bamboo and rattan commodities

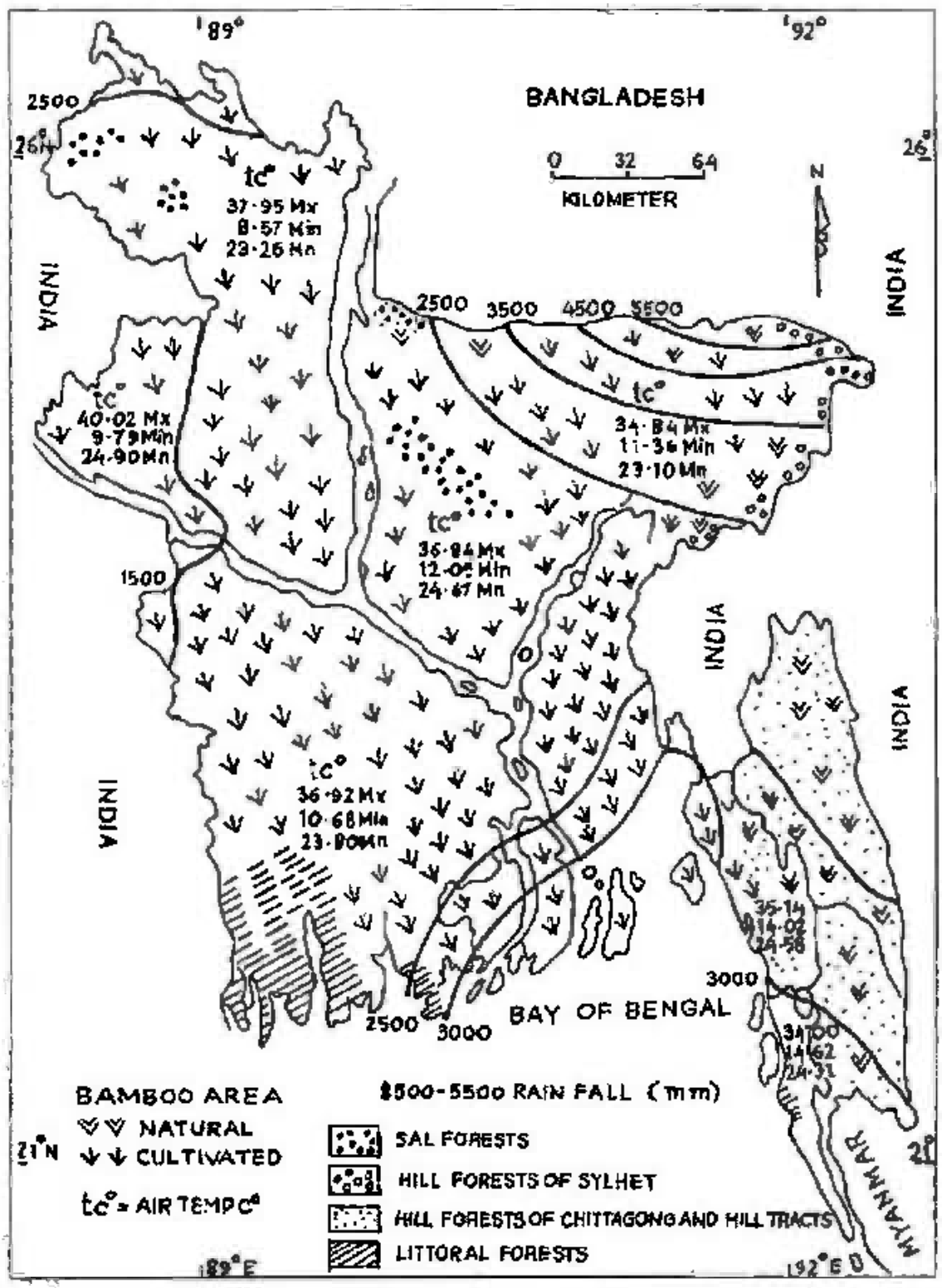
Codes	Description
	Current codes in the INBAR database (www.inbar.int)
	1. Vegetable plaiting materials:
140110	Bamboo used primarily for plaiting (BAMBO)
140120	Rattan used primarily for plaiting (RATAN)
140190	Vegetable materials nes (not elswhere specified), used primarily for plaiting (OVPMT)
	2. Manufacture of plaiting materials:
460110	Bamboo used primarily for plaiting (BAMBO)
460120	Mats, matting and screens, vegetable plaiting material (PPMAT)
460191	Plaited vegetable material articles not mats or screen (PNMAT)
460210	Basketwork, wickerwork products of vegetable material (BSKWK)
	3. Furniture of plaiting materials:
940150	Seats of cane, osier, bamboo or similar materials (SEATC)
940380	Furniture of cane, materials nes (FURNC)
	4. Vegetables:
070990	Vegetables, fresh or chilled nes (VEGCH)
071190	Vegetables nes and mixtures provisionally preserved (VEGPP)
071290	Vegetables nes and mixtures, dried, not further prepared (VEGDR)
200590	Vegetables nes, mixed, prepared/preserved, not frozen/vinegar (VEGPR)
	New codes (effective in 2007):
200591	Bamboo shoots
440210	Bamboo charcoal (including shell or nut charcoal), whether or not agglomerated
440930	Bamboo continuously shaped products, other than flooring (under heading 4402 in the Harmonized System)
441210	Bamboo veneered panels and similar laminated bamboo
442213	Bamboo strips and friezes for parquet flooring, unassembled and assembled parquet panels
460121	Bamboo plaits and similar products of plaiting materials, whether or not assembled into strips; plaiting materials, plaits and parallel strands or woven, in sheet form, whether or not finished articles (e.g. mats, matting, screens)
460122	Of rattan
460192	Of vegetable materials, of bamboo
460193	Of vegetable materials, of rattan
460211	Basketwork, wickerwork and other articles made directly to shape from plaiting materials or

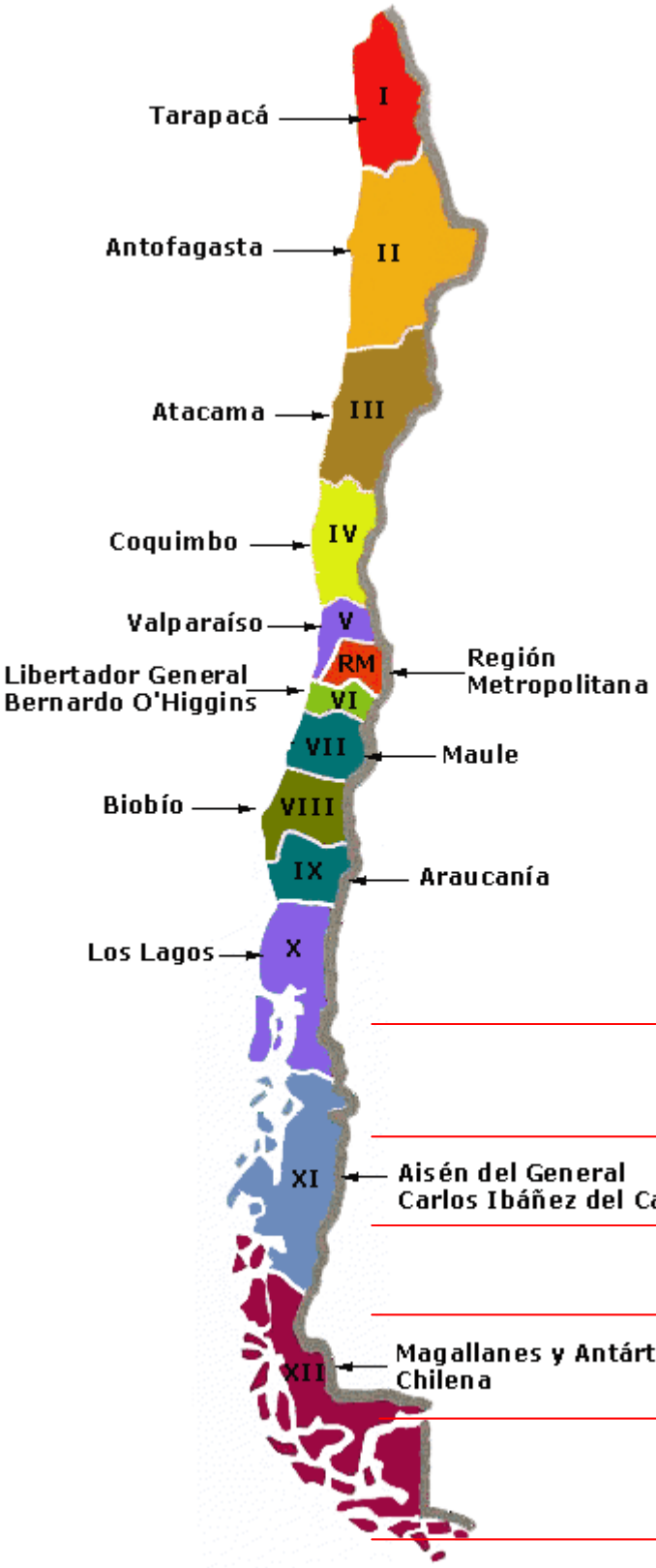
	made from goods under heading 4601; articles of loofah, of bamboo
460212	Of rattan
470630	Pulp of fibres derived from recovered (waste or scrap) paper or paperboard or other fibrous, cellulosic material of bamboo
482361	Other paper, paperboard, cellulose wadding and webs of cellulose fibres, cut to size or shape; other articles of paper pulp, paper, paperboard, cellulose wadding or webs of cellulose fibres of bamboo
940151	Seats of bamboo and rattan
940381	Furniture of bamboo and rattan

Source: WCO 2002

Annex 6
Country maps

Bangladesh





Concentration of native bamboo per region (total: 899 000 ha)

4%

3%

1%

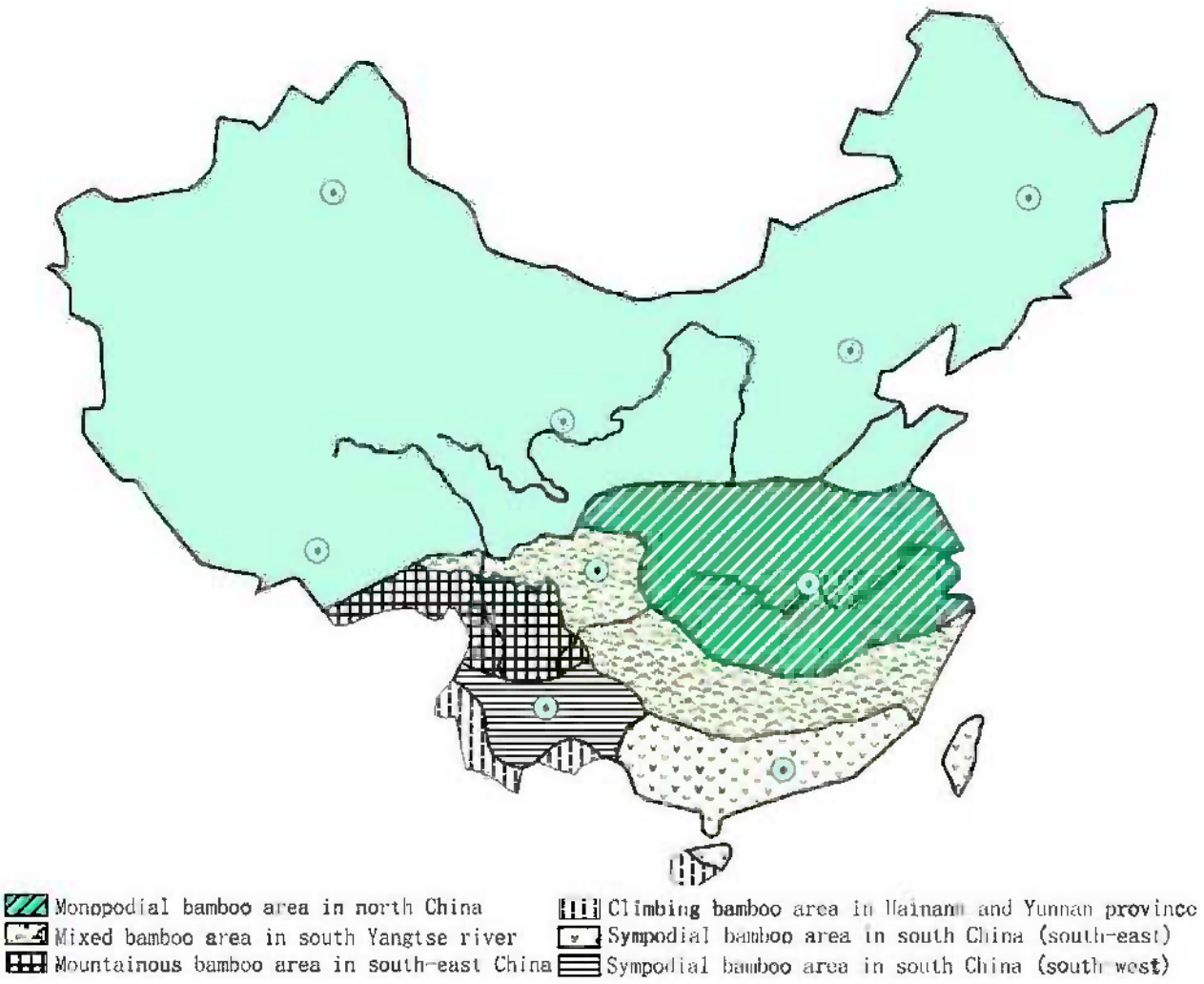
10%

34%

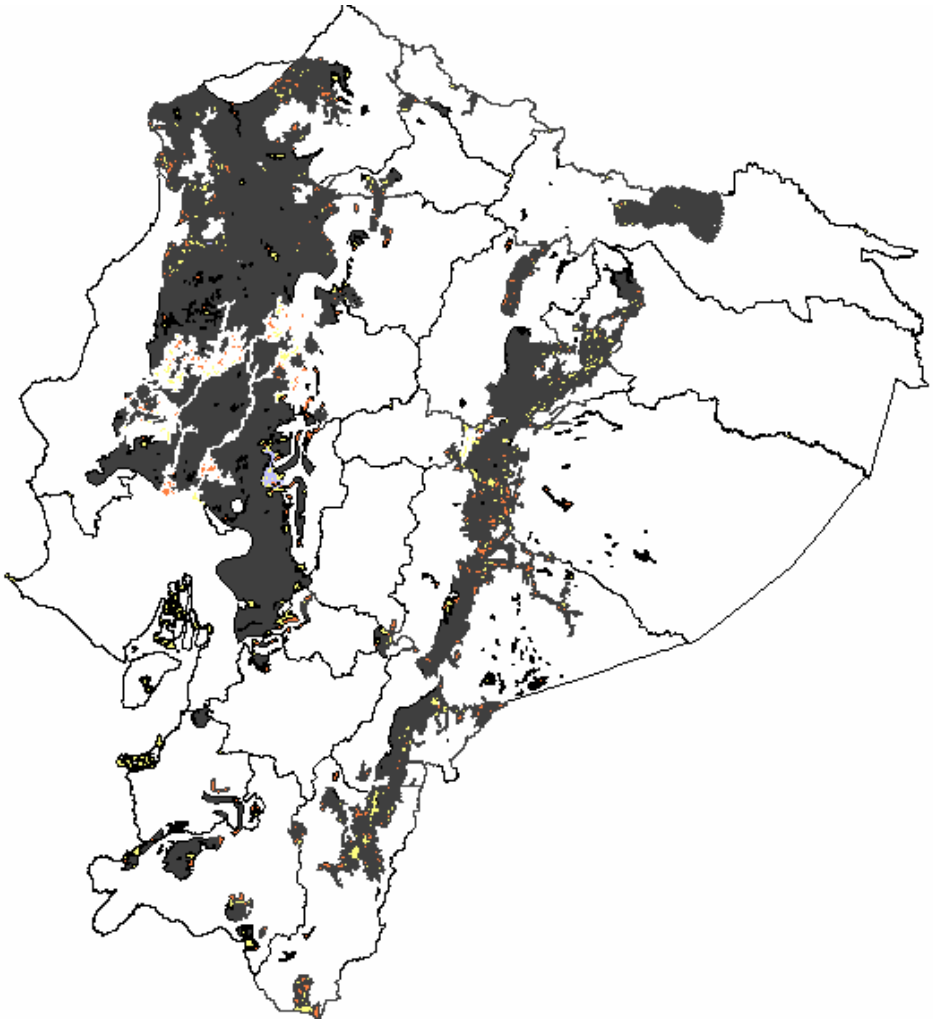
29%

19%

China


Monopodial bamboo area in north China
Mixed bamboo area in south Yangtse river
Mountainous bamboo area in south-east China
Climbing bamboo area in Hainan and Yunnan province
Sympodial bamboo area in south China (south-east)
Sympodial bamboo area in south China (south west)

Ecuador



The potential areas for *Guadua angustifolia* in Ecuador were identified based on the following conditions:

- Altitude between 400 and 1800 m above the sea level
- Temperatures between 18 and 28 C°
- Annual precipitation over 1200 mm

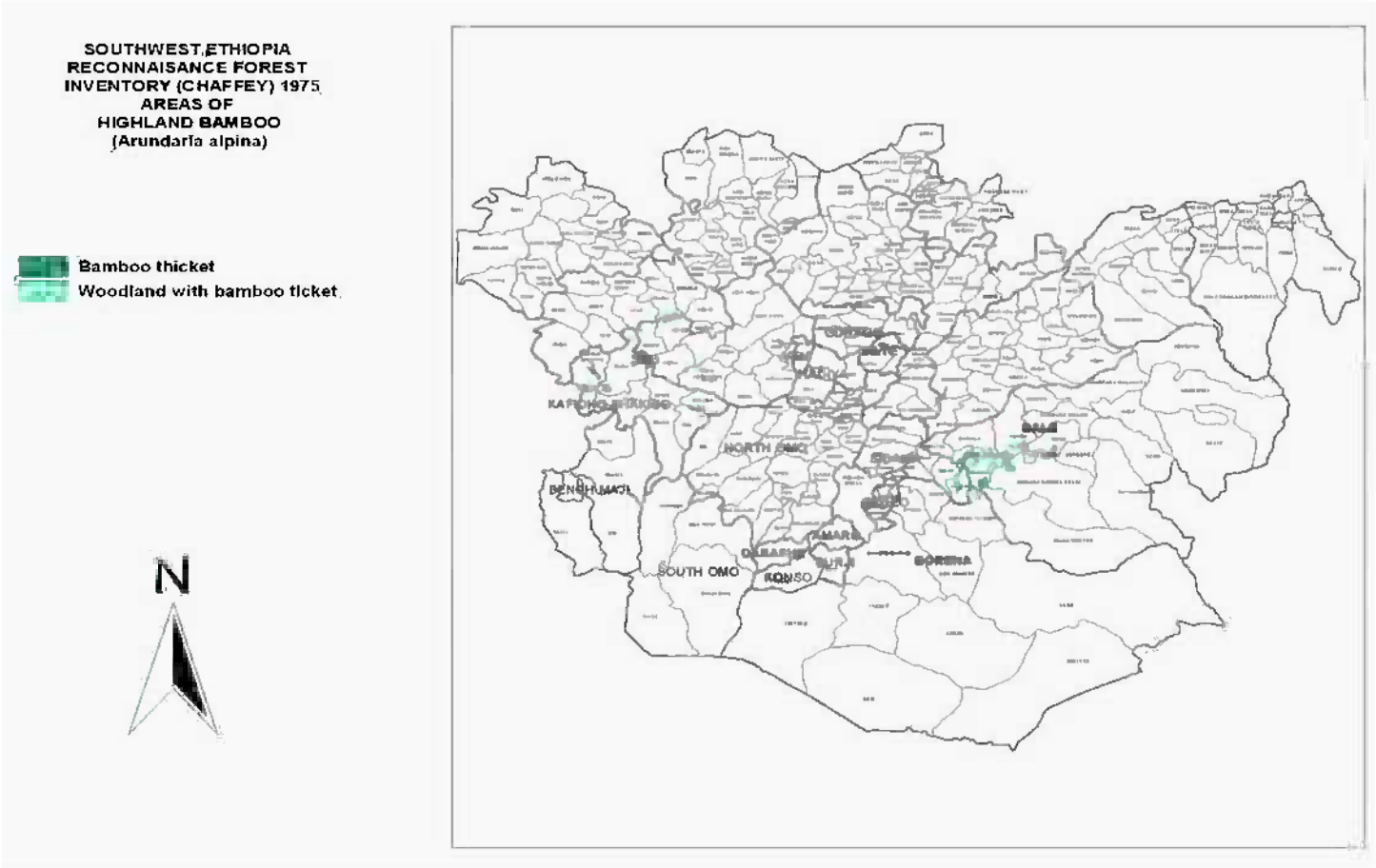
The results are shown on the above map and identify two possible regions with *Guadua*:

- The Pacific coast has the largest potential, except for the coastal regions with dry tropical forests.
- The other region with potential is in eastern slopes of the Andes, towards the Amazon basin (Klop et al. 2003)

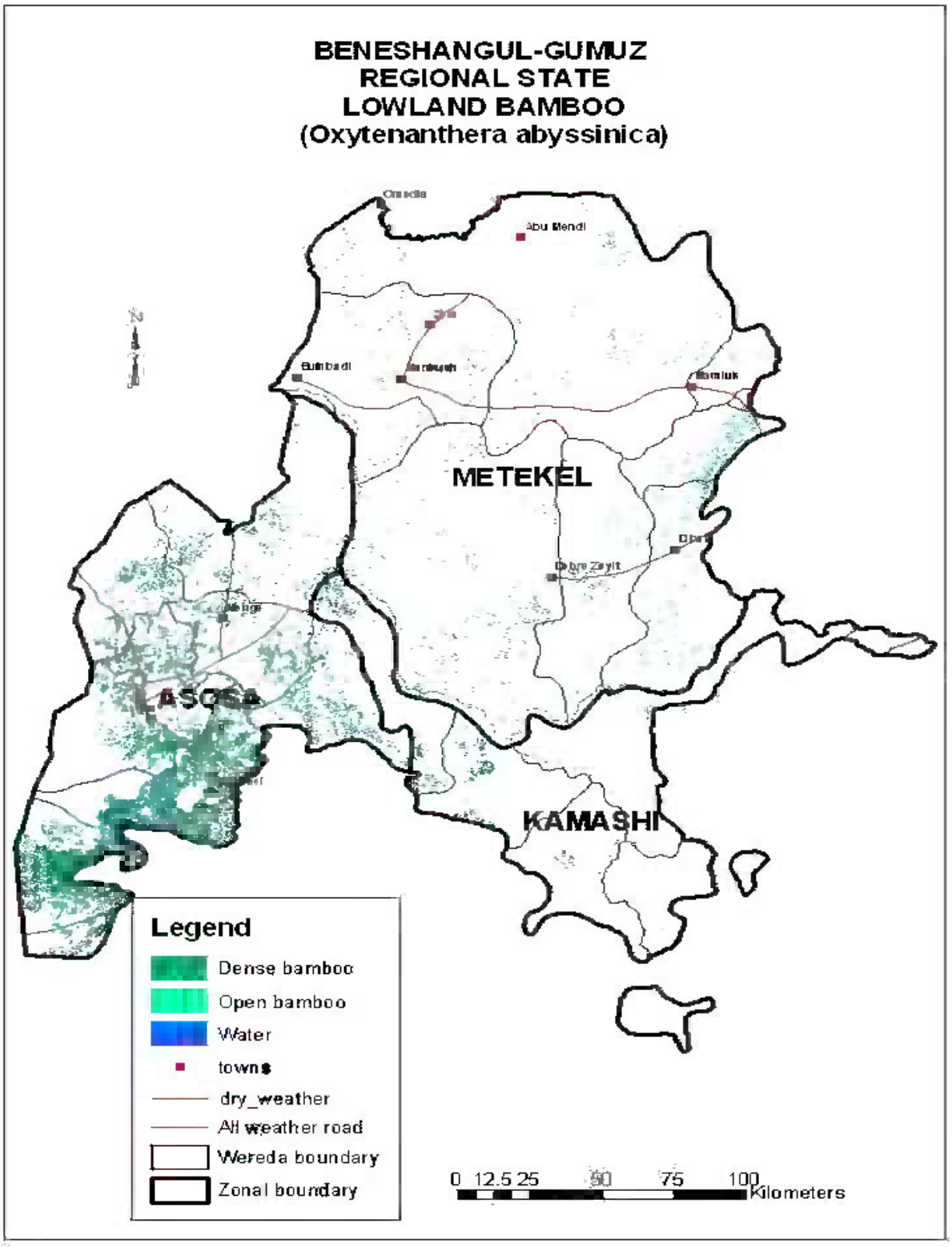
This map excludes the highlands or Andean regions with "highland bamboos" (genera *Chusquea, Aulonemia, Neurolepis, Rhipidocladum, Arthroslidium*). There are no maps for these bamboos.

Ethiopia

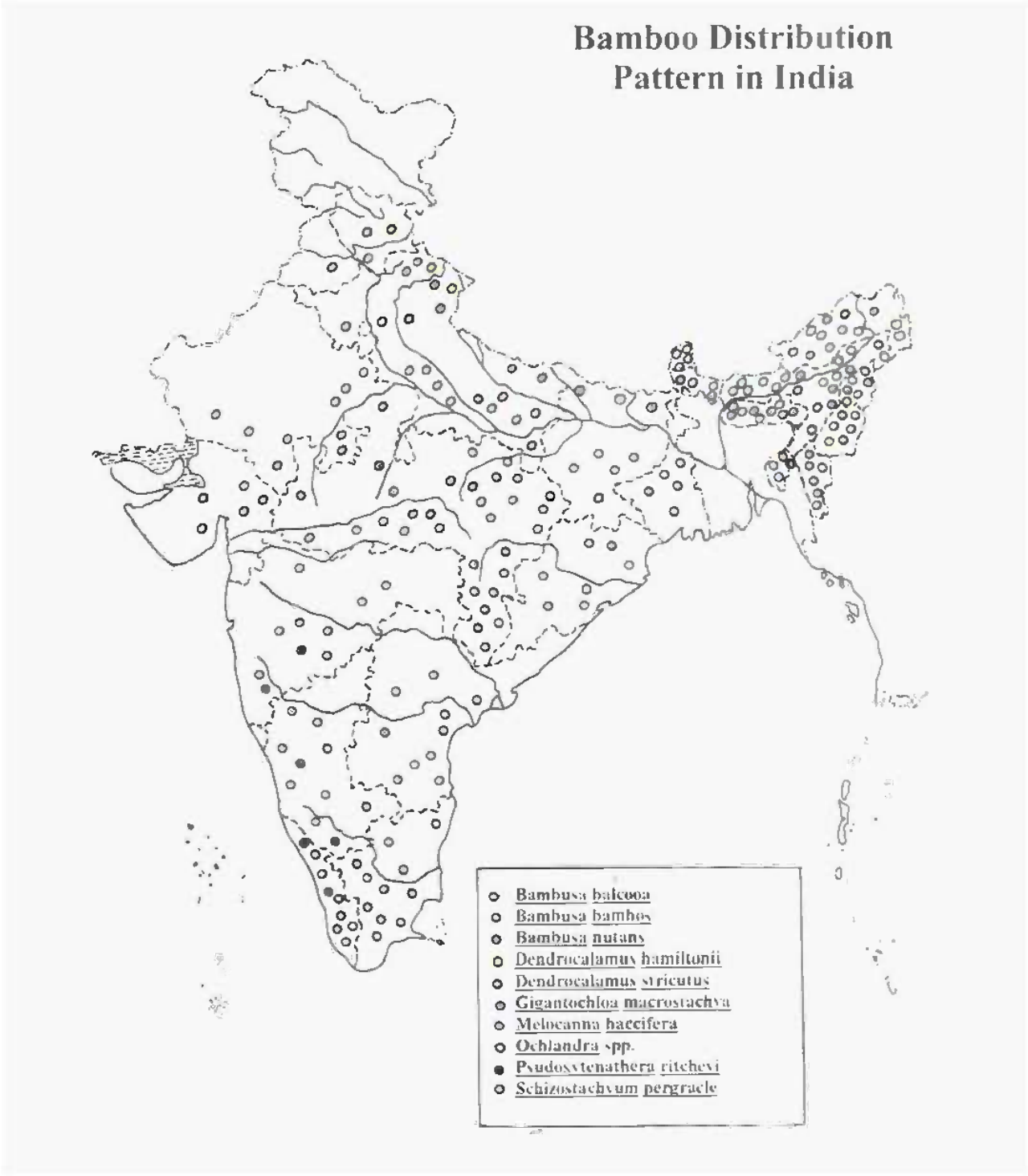
1. South West Ethiopia reconnaissance forest inventory- areas of highland bamboo land cover



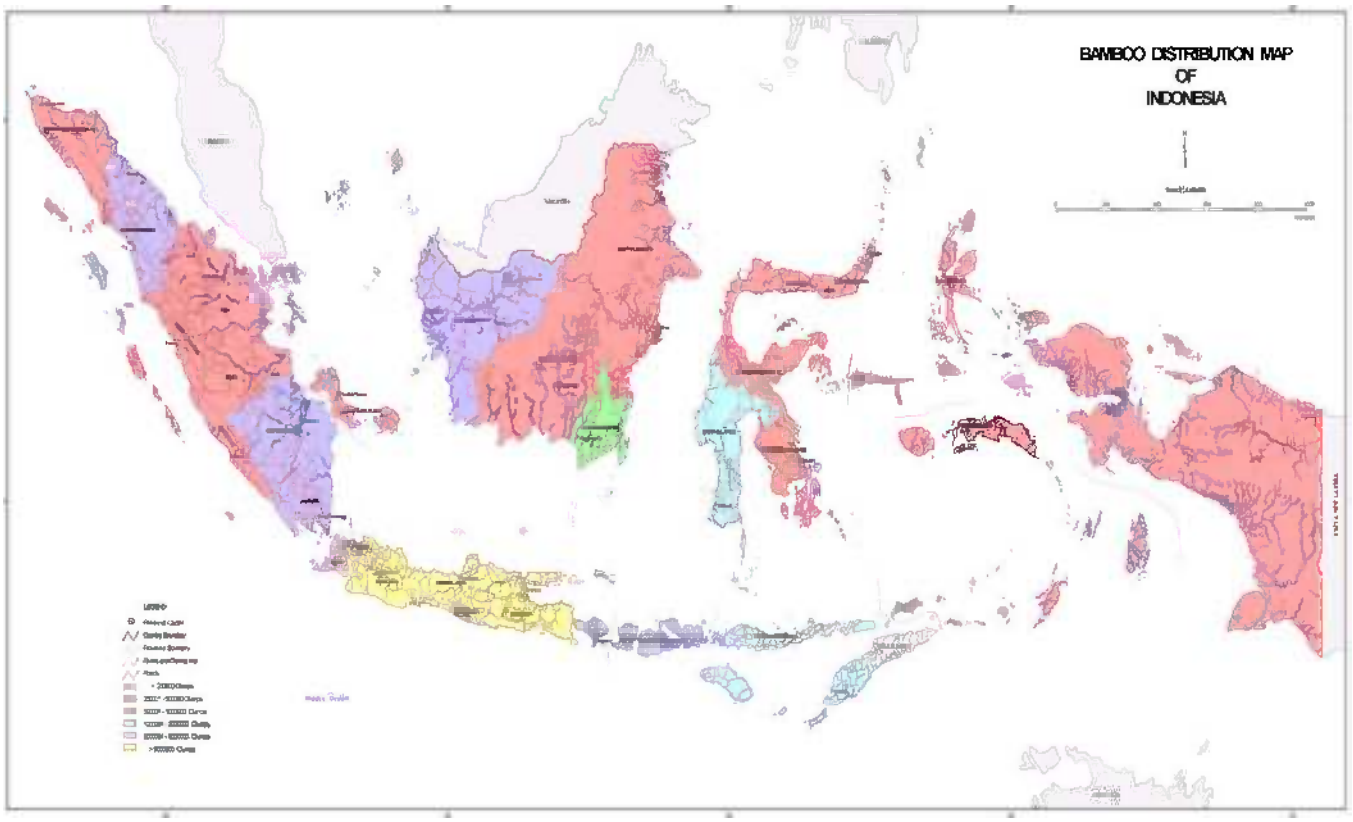
2. Ethiopia Benshangul Gumuz Regional State, areas of lowland bamboo (LUSO 1997)



India


Bamboo Distribution
Pattern in India
Bambusa balcooa
Bambusa bambos
Bambusa nutans
Dendrocalamus hamiltonii
Dendrocalamus strictus
Gigantochloa macrostachya
Melocanna baccifera
Ochlandra spp.
Pseudoxytenathera ritchevi
Schizostachyum pergracle

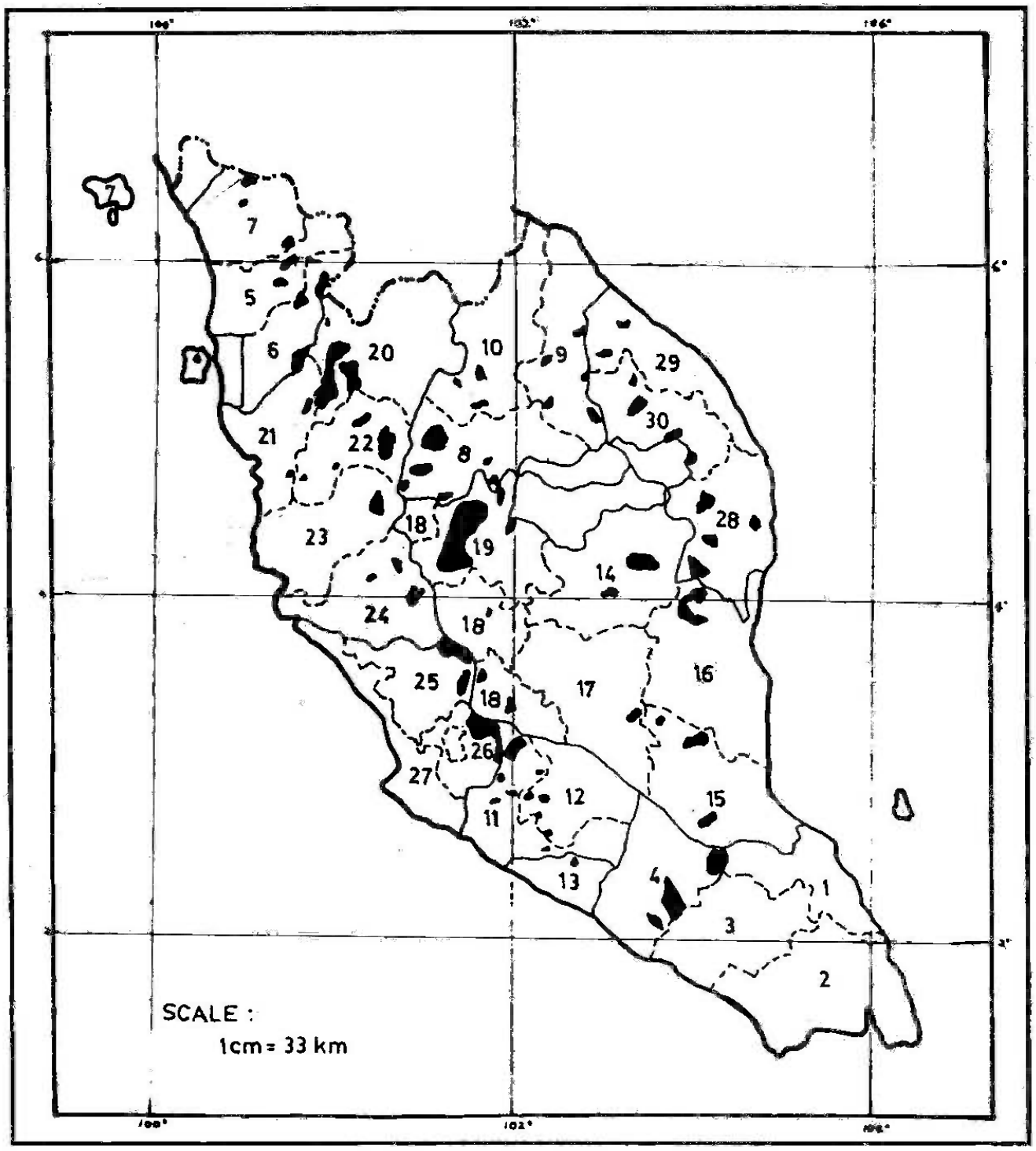
Indonesia



The map is based on the agriculture survey by the Central Board of Statistics and shows the density of bamboo clumps in each province.

Malaysia

Distribution of bamboo by Forest District in Peninsular Malaysia

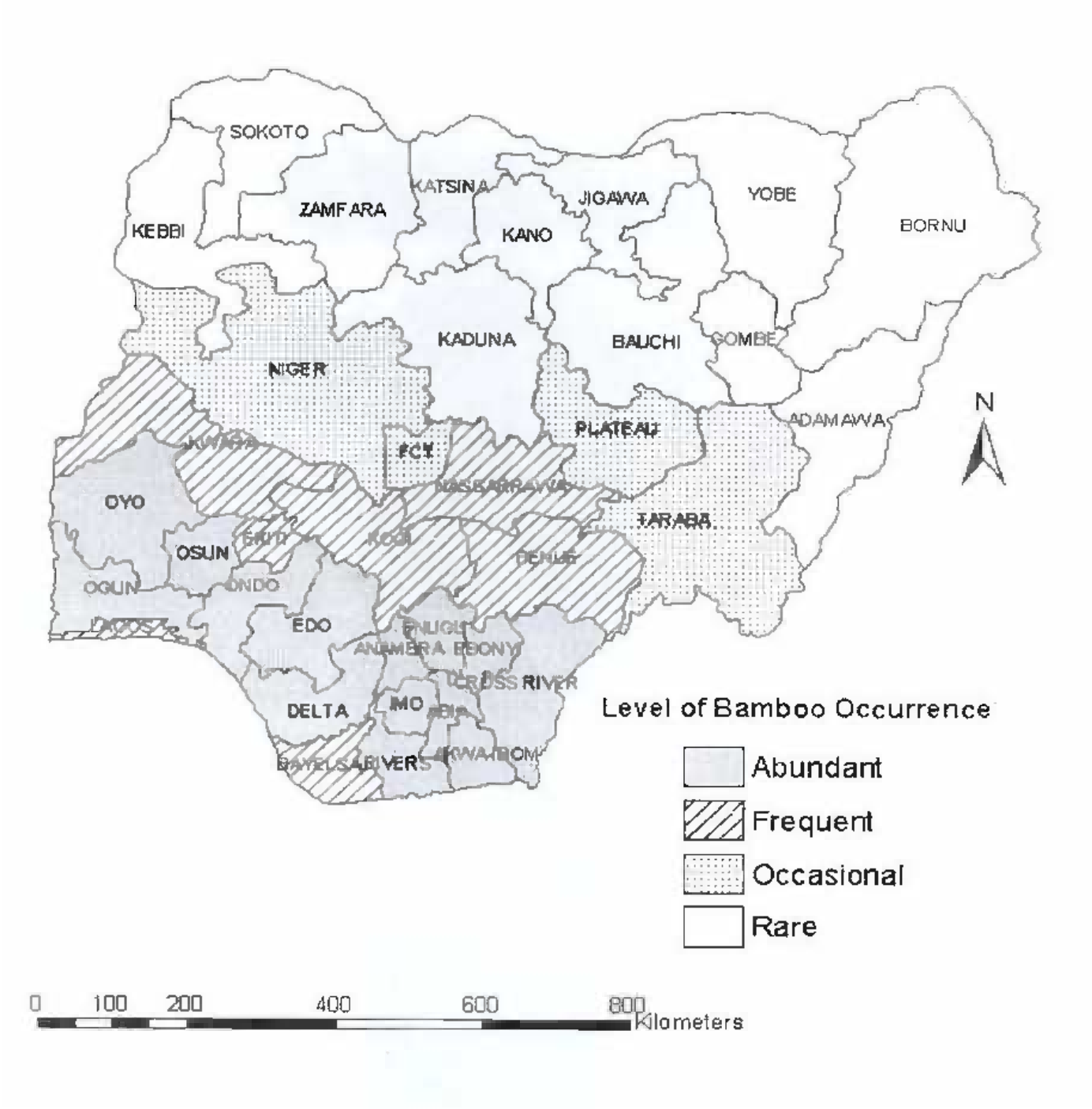


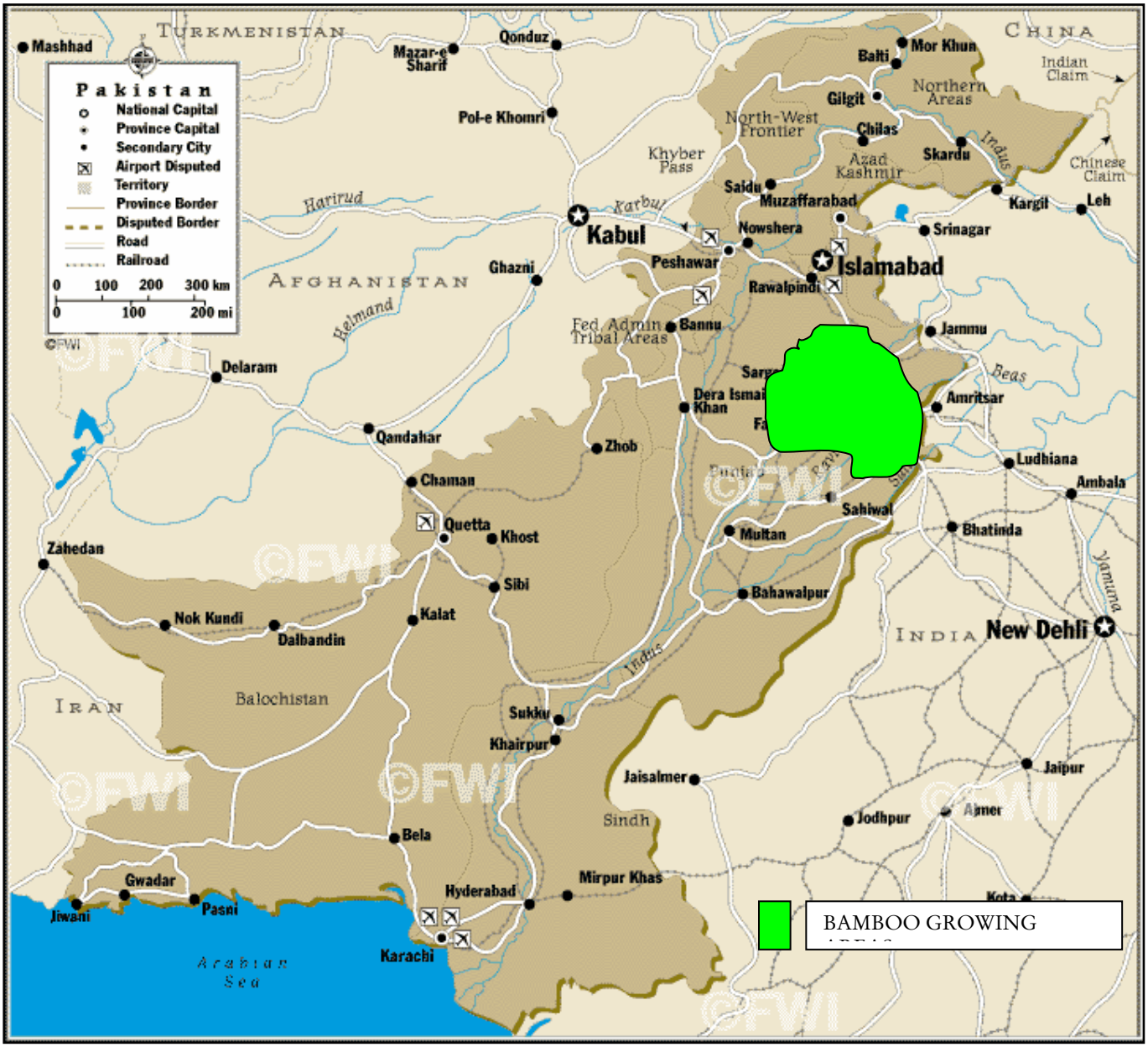
Mexico

Legend	Bamboo distribution
1	States with greater representation of the native species of bamboo in Mexico, and in which the commercial plantations are located
2	States with less representation of the native bamboo species
3	States with little or no representation of species of bamboo

Nigeria

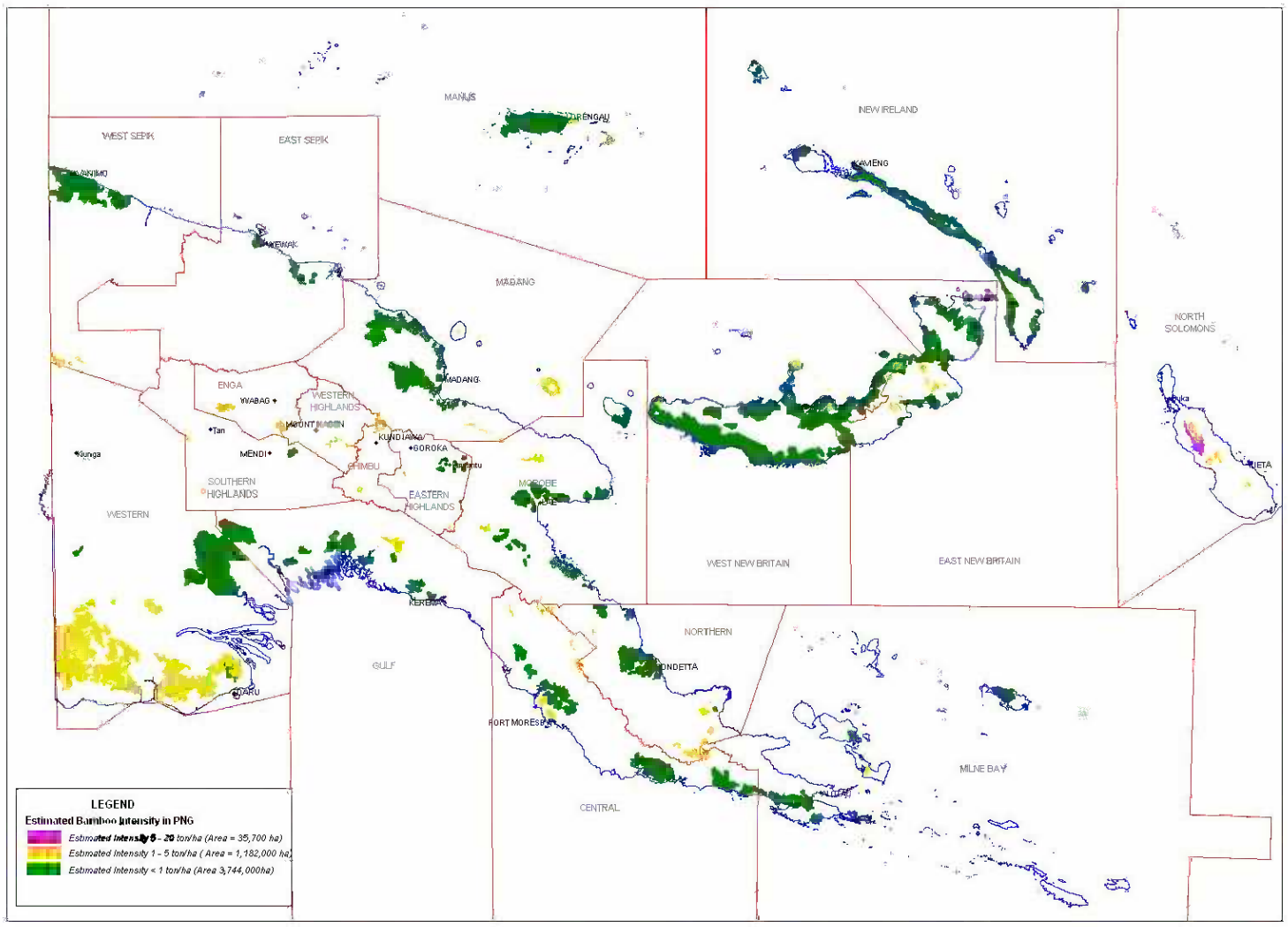
Map of Nigeria showing the level of bamboo occurrence





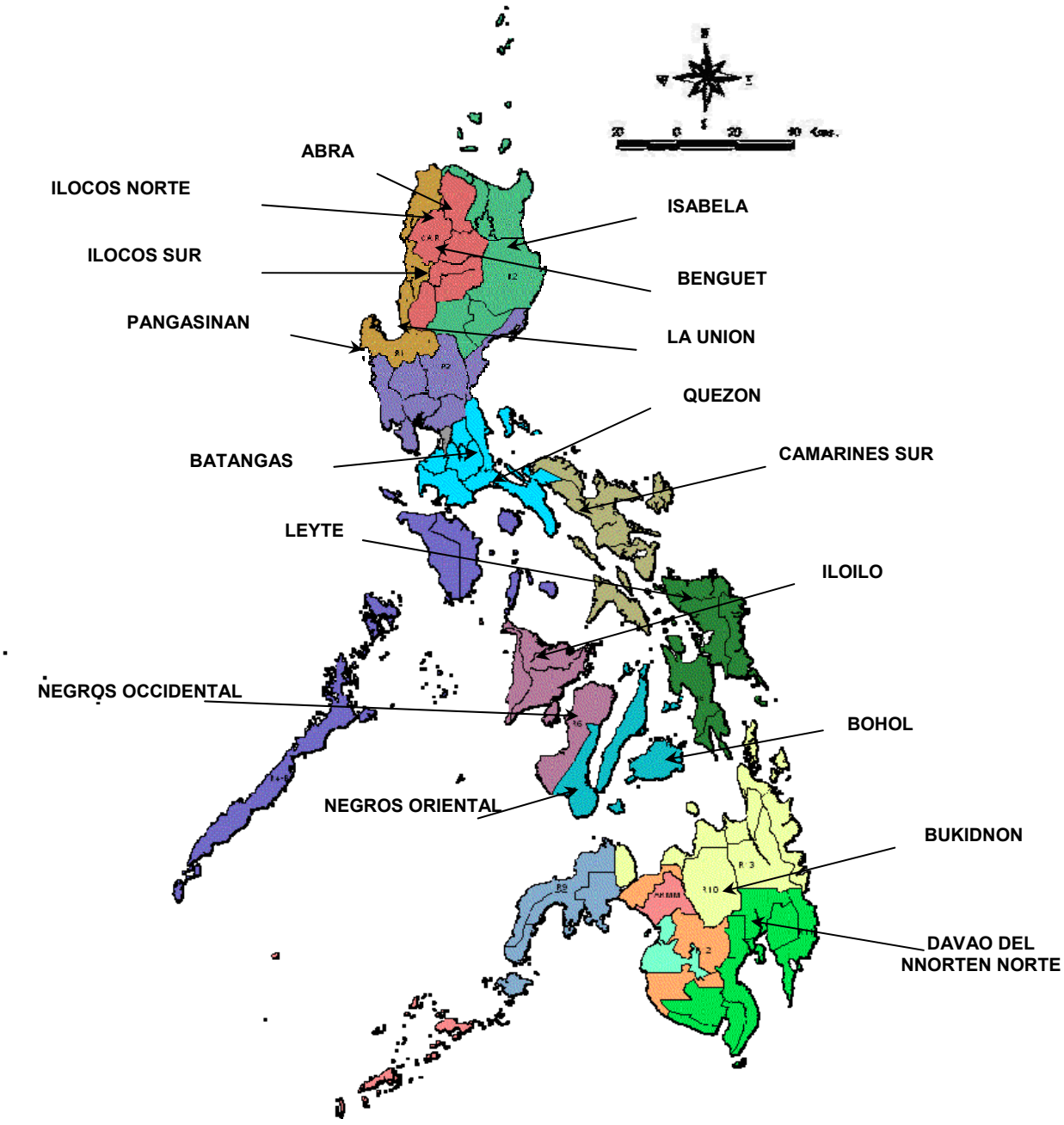
Bamboo plantations are in Sargodha, Mandi Bhaudin, Kasur, Lahore, Khusab and Jhang areas of Pakistan. Most of the plantations are agroforestry systems on private farms.

Papua New Guinea

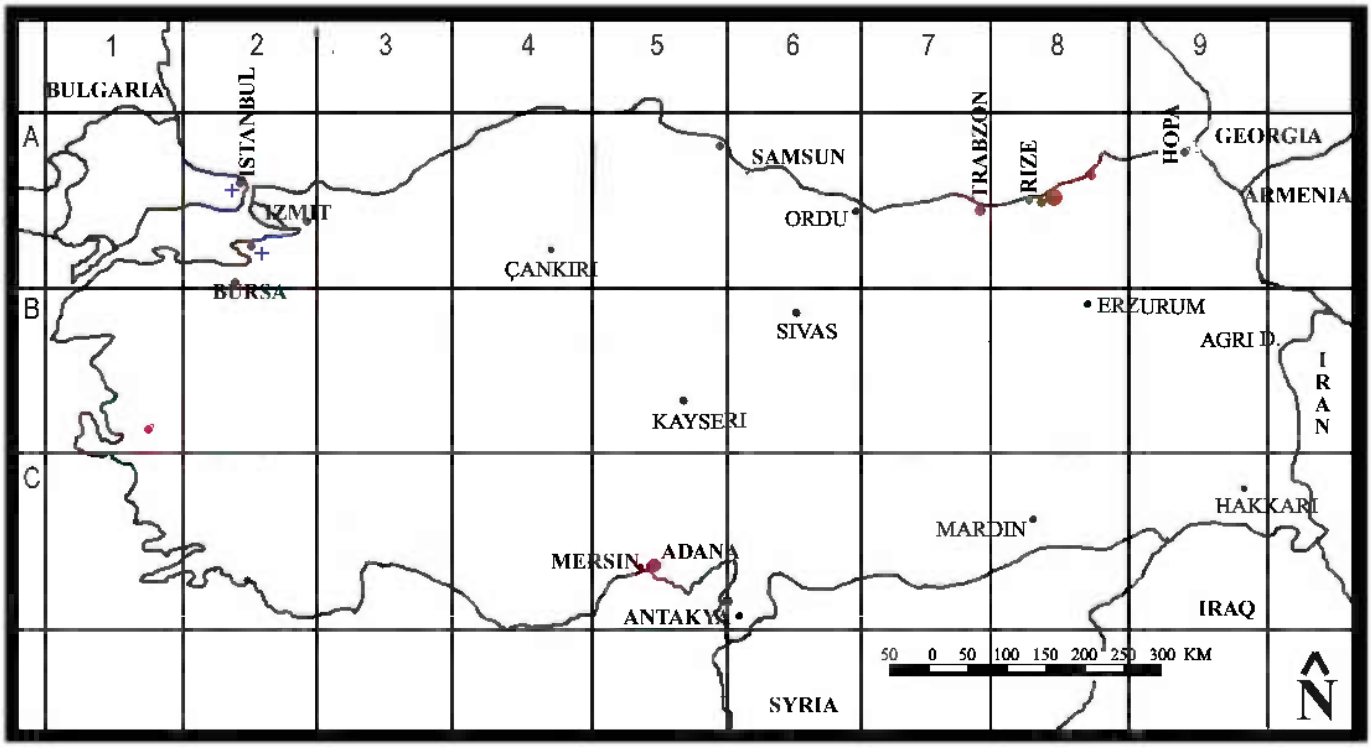


Philippines

Major sources of bamboo



Turkey



●	*Phyllostachys bambusoides* Sieb. & Zucc. (A2,A5,A7,A8,A9)
	Phyllostachys pubescens Mazel ex H de leh (A8)
●	*Pleioblastus simonii* Nakai, (A8)
O	*Phyllostachys nigra* var. *Henonis* Muroi. (A7,A2)
+	*Sasa veitchii* Rchd. (A2)

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This study is a joint FAO/INBAR initiative to incorporate bamboo into the FAO Global Forest Resources Assessment (FRA) programme. It was undertaken as one of seven thematic studies within the FRA 2005 process and is a first attempt at systematic reporting of the best available information on bamboo resources and utilization at the global level. Bamboo – a major non-wood forest product – is an ancient woody grass widely distributed in tropical, subtropical and mild temperate zones. It is an integral part of forestry, but is also widely spread outside forests, including farmlands, riverbanks, roadsides and urban areas. Bamboo is quickly changing its image from the "poor man's tree" to a high-tech, industrial raw material and substitute for wood. A total of 22 countries responded to the FAO/INBAR call for information and submitted national reports. Although data availability and quality are often weak, the main value of the study is that it has established a systematic methodology and has launched the most comprehensive assessment of global bamboo resources to date.

ISBN 978-92-5-105781-0 ISSN 1020-3370

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TC/M/A1243E/1/08.07/1500