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STATUS OF BAMBOO RESOURCE DEVELOPMENT, UTILISATION AND RESEARCH IN ETHIOPIA: A REVIEW

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ABSTRACT

Bamboos have a long history as an exceptionally versatile and widely used resource in the world. Ethiopia is known for its large amount of bamboo found in both highland and lowland areas of the country. The objective of this review paper is therefore to thoroughly review the current status of the bamboo resource, development, utilisation and research in the country. Though there are different estimates on bamboo coverage of Ethiopia, latest documents report that it is about 1 million ha, which is about 67% of African bamboo forest cover and 7% of the world's total. However, bamboo utilisation in the country has been customary and mainly limited to hut construction, fencing, making baskets, beehives, firewood, walking sticks, and various artifacts. Research on bamboo management and utilisation is scarce; forestry extension/development packages have not been including bamboo. Identified constraints are lack of awareness about the resource, scanty technologies/scientific knowledge, lack/absence of strong policy frameworks and institutional set- ups and depletion of the resource base. The major opportunities are the existing national and international interest in appropriate utilisation and development of bamboo. It is concluded that concerned offices/sectors such as development, research, conservation, non-governmental organisations, trade and investment, as well as industry and higher officials should put greater effort to develop and exploit the potential.

Key words*:* constraints, potentials, *Oxytenanthera abyssinica*, *Yushania alpina*

INTRODUCTION

Bamboo is a perennial plant belonging to the Poaceae (sometimes called Gramineae) family (Wong, 2004). It has a long history as an exceptionally versatile and widely used resource in the world (Ramanuja et al, 1988; Shanmughavel, 1997). The bamboo is also an eminently renewable resource. Under the right conditions, it displays prodigious rates of growth, Some species can produce culms 40 m high and 30 cm diameter in just four months (Ramanuja et al, 1988). Bamboos are multipurpose plants of high economic and

environmental value. They grow fast and mature early. Once successfully planted, they keep on rhizoming, shooting and maturing every year. The annual selective cutting and sustainable utilisation can be implemented without damaging ecological environment. Therefore, the development and exploitation of bamboo resources is considerably important (Qisheng et al, 2001)

Hence, developing countries that are suited for growing bamboo and aspiring for better welfare and faster rate of development need to produce and utilise such commodities. Ethiopia is known for its large amount of bamboo distributed in both highland and lowland areas including areas not suitable for other plants. However, unlike other countries, the economic return obtained from this species is very low. Given the role played by bamboo in the global economy, the country has not used it even to its minimal potential. Despite some starts in modern utilisation since very recently, the utilisation is so rudimentary and the protection is so unsustainable.

Considering the experience of countries that are utilising bamboo for big financial return and environmental protection, it is understandable that sustainable bamboo utilisation is a function of bamboo resource development, availability of new technologies and scientific information, production of bamboo products using the technologies, and marketing. For these issues to happen, availability of appropriate institutions, supporting policies, strategies and legislatives and their implementation is essential.

Consequently, this paper is initiated with the aim of reviewing all these issues and addressing to readers. The paper briefly describes the extent of bamboo, its description and distribution, its development, conservation and research in the country. Lastly, opportunities and constraints of bamboo development in the country are presented.

BAMBOO RESOURCES OF ETHIOPIA

Extent of bamboo

There are 70 genera and 1200 species of bamboo in the world which are widely distributed between 46^{o} N and 47^{o} S in the tropical, subtropical and temperate regions of all continents except Europe (Lobovikov, 2006). Ohrnberger (1999) reported the number of bamboo species in the world to be 1500 covering about 14 million ha of land. Geographically, bamboo distribution can be classified into

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three zones: the Asian Pacific zone, the American zone and the African zone (Lobovikov, 2006).

Africa possesses about 40 species on over 1.5 million ha of land (Kigomo, 1988) and two of these species are found in Ethiopia (Azene Bekele, 1993; Phillips, 1995; Kassahun Embaye, 2004). Though there are different estimates on natural bamboo coverage of Ethiopia, Kassahun Embaye (2003) reported that it is about 1 million ha, which is about 67% of the African bamboo forest cover and 7% of the world's total.

The two indigenous bamboo species in the country are *Yushania alpina* K.Schumann Lin (African alpine bamboo) and *Oxytenanthera abyssinica* (A. Rich) Munro (Azene Bekele, 1993; Kassahun Embaye, 2003). About 10 bamboo species, namely *Bambusa balcooa, Bambusa tulda, Bambusa vulgaris var. vitatta, Bambusa vulgaris var. Green, Dendrocalamus asper, Dendrocalamus brandisii, Dendrocalamus hamiltonii, Dendrocalamus membranaceus, Phyllostachys pubescence* and *Guadua amplexifolia* were introduced in 2007 and 2008 by the Ministry of Agriculture and Rural Development (MoARD) of Ethiopia through a project called "East African Bamboo Project". The species are under evaluation in different parts of the country including specific localities known as Assosa, Injibara, Hagere-Selam, Debre-Zeit and Wondo-Genet. One giant bamboo species namely *Dendrocalamus gigantus* is found well adapted within a limited forest area of Munesa Forest Enterprise since the past 20 years.

Various workers and institutes have attempted to estimate the area coverage of bamboo resources of Ethiopia. These include the studies made by Mooney (1959), Breitenbach (1963), Woldemichael Kelecha (1980) and LUSO consult GmbH (1997). These workers and organisations have made considerable contribution towards the understanding of the bamboo vegetation of Ethiopia (FAO and INBAR, 2005).

According to Mooney (1959), Breitenbach (1963) and Woldemichael Kelecha (1980), the total area of bamboo in Ethiopia was estimated to be 1.5 million hectares, of which the lowland bamboo, *Oxytenanthera abyssinica*, contributes the major portion (nearly one million hectares). A study made by LUSO Consult GmbH (1997) estimated the total bamboo area to be nearly 850,000 hectares. The estimated total area of sympodial bamboo is 700,000 ha, out of which only 481,000 ha was mapped and partially surveyed by LUSO Consult GmbH in 1997. Similarly, the total area of mapped naturally grown monopodial bamboo is 129,626 ha. The area planted by farmers is estimated to be about 19,000 ha. Together, the total amounts to 148,626 ha (FAO and INBAR, 2005).

There are more than 800,000 ha of lowland and 10,000 ha of highland natural bamboo forest in Ethiopia (LUSO Consult GmbH, 1997). Kasahun

Embaye (2003) has also reported that there are more than 800,000 ha and 100,000 ha of lowland and highland natural bamboo forest in Ethiopia.

Description and distribution of bamboos

Bamboo genera

The two bamboo genera found in Ethiopia are *Yushania* and *Oxytenanthera***.** *Yushania* is a large group of spreading, thornnless, and frost-hardy bamboo found in Taiwan, the Himalayas and Africa. While Oxytenanthera is a monotypic genus confined to Africa. The two Ethiopian bamboo species under these two genera are *Yushania alpina K.Schumann Lin* and *Oxytenanthera abyssinica* (A. Rich) Munro.

Kasahun Embaye (2005) and FAO and INBAR (2005) described *Arundinaria alpina* as the monopodial bamboo in its rhizome type. This species is regarded as monopodial bamboo by bamboo professionals in the contry, while, Kigomo (2007) described the species as a pachymorph species that under cultivation maintains very strong clumping characteristics. Phillips (1995) and Breitenbach (1963) also described this species as a robust clump-forming species. The rhizome habit of this species is not strictly defined by LUSO Consult GmbH (1997). Qisheng et al (2001), Recht and Wetterwald (1994) and Othman et al (1995) state that three are three bamboo rhizome types worldwide: monopodial, simpodial and amphipodial. In this regard, *Arundinaria alpina*, may preferably belong to the third type (amphipodial). This issue needs further investigation so as to ensure to which type the species can be grouped. The lowland bamboo of Ethiopia (*Oxytenanthera abyssinica*) is unequivocally under the sympodial type.

Vernacular names: *Mountain bamboo* (English), *Anini* (Agew), *Kekeha* (Amharic), *Kias* (Gamu), *Shineto/Shinato* (Kefigna), *Lemmen/Shimela* (Oromigna), *Shenbek'wa (Wolayita), lema (Konso*, Kembata, Sodo-Gurage, Sidamo), *werye/shikaro/Shinato* (Kefa), and *lewu* (Nuwer) is found in Woldemikael Kelecha, 1987; Azene Bekele, 2000; IBC and GTZ, 2003.

According to NPDC (2000) and Qisheng et al. (2001), the species belongs to Order Cyperales/graminales, Family Poaceae (Gramineae), Genus *yushania*, Species *Yushania alpina K.Schumann Lin***.** Highland bamboo is a monopodial/leptomorphic rhizome bamboo (Figure 1). It is a non-clump-forming (single-stemed) or running bamboo with hollow culms.

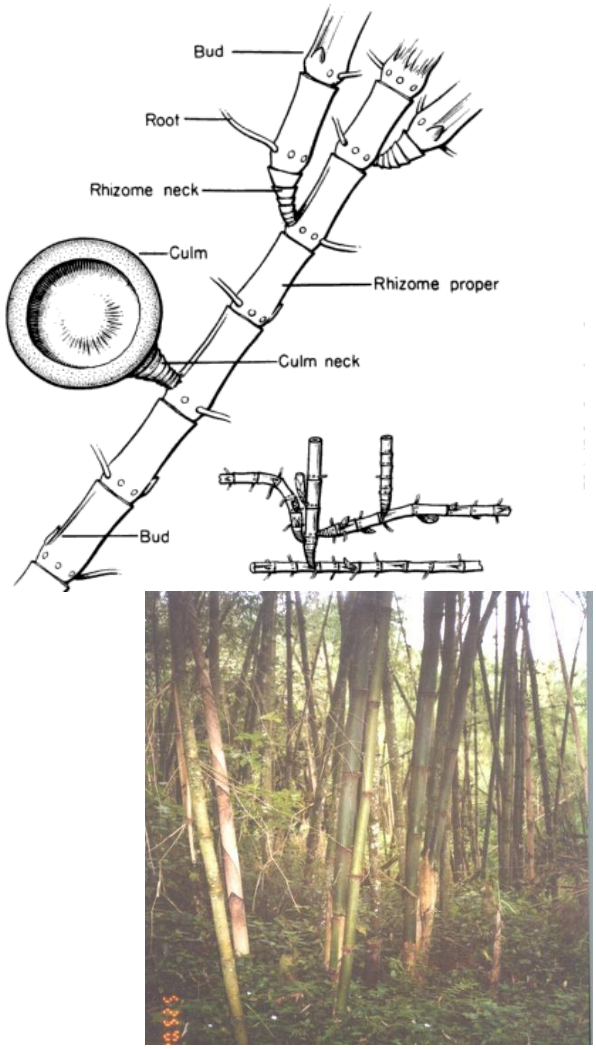

Figure 1. a) Basic forms of the subterranean parts of monopodial bamboo and their terminology, b) mature stand of *Yushania alpina* in Ethiopia

It is evergreen with a maximum diameter of 12.7 cm and a maximum height of 16.76 m (ABS, 2006). Phillips (1995) added that this species has a thick wall with clearly hollow and green colour later becoming yellow.

Under natural condition, it grows with a density of 6000 stems/ha and with a percentage death of 27 stems/ha. The above-ground biomass per ha is 51 t and with old to new shoot ratio of 5:1. Most seeds are empty (not viable) (Kasahun Embaye, 2003). The natural stand in Masha area of Ethiopia is reported to have

14,000 culms/ha. By comparison, in Kenya the culm/ha reaches upto 30,000 (Azene Bekele, 2000).

There are two types of bamboo in Masha, south-west Ethiopia. The stems exhibit different colours (LUSO Consult GmbH, 1997; Azene Bekele, 2000). About 60% of bamboo stands in Kosober, north-west Ethiopia, have dark green colour while about 40% are yellow-striped (personal observation). Colour variation is also recognised by the local craftsmen who use the stem for making local furniture and house materials (SIM, 2002). Still in Kosober area, there is a small-sized bamboo variety that is still not documented well (SIM, 2002). Hence, further investigation is necessary to ascertain whether there is another species, or whether it is a variety of highland bamboo, or whether it is a prolonged stem exposure to light which makes the stem of the highland bamboo turn into orange-yellow colour (Azene Bekele, 2000)

Arundinaria alpina flowered on Rungwe, Tanzania in 1986 and sporadic flowering continued on the adjacent Poroto mountains in 1989 (Lovett, 2006). After flowering the bamboo dies, leaving large gaps in the forest. Azene Bekele (1993) has also reported that this species flowers between 15 and 40 years and then dies out, so a local stand of the grass will be of even age and size.

This species is an upper montane grass. In Ethiopia, it is found in the Southern Nations, Nationalities and Peoples Regional State (Agere-Selam, Chencha, Indibir-Jembero, Jima-Ameya, Mizan Teferi-Kulish, Wushwush-Bonga, Bonga-Ameya, Masha, Shashemene), Oromiya National Regional state (Agaro, Gera, Bale Mountains, Shenen-Jibat Mountains, Gera, Gera-Lola), Amhara National Regional State (Injibara, Choke Mountains) (LUSO Consult GmbH, 1997). The species is also distributed in other East African mountains, namely Cameroon, Mt. Zaire (Kivu), Rwanda, Burundi, Sudan (Imatong Mts.), and Malawi (Nyika Plateau) (Phillips, 1995).

It grows on altitudes ranging between 2200 and 3200 m asl with mean annual rainfall of 1950 mm (Kassahun Embaye, 2003). According to Azene Bekele (2000), it covers a large area between Bale Mountain, Bonga and Metu in south-western part of the country and upto Dangla in the north. These bamboo stands are situated in important agricultural zones with former (high) forests, where rainfall is adequate. Azene Bekele (2000) also confirmed that bamboo grows on altitudes ranging between 2200 and 3500 m asl, with annual rainfall of 1500-2000 mm and temperatures ranging between 10 and 20^{o}C. The species can grow below its lower altitude limit but its growth vigour will be much lower. It is often found on volcanic soils and forming extensive pure stands, occurring with Podocarpus in upland and with Juniperus in drier forest, frequently planted along roads and villages at elevations of 2200-4000 m asl (Phillips, 1995).

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It is recognised that many of the National Forest Priority areas (FPAs) contain highland bamboo within Belete-Gera, Jibat, Kolbu, Munesa, Sigmo, Tiro-Boter-Baecho, Bonga, and Wofwasha National Forest Priority areas are worth mentioning for their highland bamboo (IBC and GTZ, 2004). Forests/agroforests of the northern highlands such as Denkoro Forest (South Welo), and the surroundings of Debre Tabor (South Gonder), Qendach (East Gojjam), Wofwasha (North Shoa) are also bamboo-growing areas (personal observation).

Oxytenanthera abyssinica (A. Rich*)* Munro (1868)

Common name and Vernacular Names: savana *bamboo/bamboo/plains bamboo* (English), *Bambou* (French), *bambu* (Italian), *shimel* (Amharic), *betre* (Sodo-gurage), *arkay* (Tigre, Amharic), *tamia* (Welayta), *sankara* (Woldemichael Kelecha, 1987; Azene Bekele, 1993; IBC and GTZ, 2003).

Synonym: Bambusa abyssinica A. Rich. (1850)-Type Ethiopia, *Oxytenanthera borzii Mattei* (1909), *Houzeaubambus brozii* (*Mattei* (1910)-Type-Eritrea, *Bambusa schimperana stead.ap.Murno* (Phillips, 1995).

According to NPDC ((2000), the species belongs to family Poaceae (Gramineae), genus Oxytenanthera Munro, and species *Oxytenanthera abyssinica* (A. Rich.) Munro -- Abyssinia oxytenanthera. *Oxytenanthera abyssinica* (*A.* Rich) Munro (1868) is a clump-formed bamboo which is classified under sympodial/pachy-morphy types since the apex of the rhizome has a node but no buds as stems protrude out of the ground and grow into a culm (Azene Bekele, 1993; Azene Bekele, 2000; Kasahun Embaye, 2003).

It grows in dense clumps usually on dry rocky hillsides in semi-humid lowland–savanna, thicket savanna, and dominant in lowland bamboo thickets, at altitudes of 500 to 1300 m asl; it is solid-stemmed bamboo with thick-walled stem (Breitenbach, 1963).

O. abyssinica is deciduous, bright green in colour. It has zigzag culms and no thorn (Kasahun Embaye, 2003; ABS, 2006). According to FAO and INBAR (2005), the major portion of Ethiopia's bamboo (85%) is the lowland bamboo found in the Combretum–Terminalia-Deciduous woodlands of western Ethiopia together with other associated grasslands. It emerges into the Savannah Woodlands of the Sudan. This species can attain a maximum diameter of 10.16 cm and maximum height of 9.14 m. In Ethiopia, this species is found between 1000 and 2100 m asl, with mean annual rainfall of 1150 mm (Azene Bekele, 2000). Under natural conditions, it grows at a density of 8000 stems/ha. The above-ground biomass is 20 t/ha. It has semi-solid to solid culm. Seeds are viable, having upto 100% germination rate starting from three days after sowing in laboratories (Phillips, 1995; Kasahun Embaye, 2003).

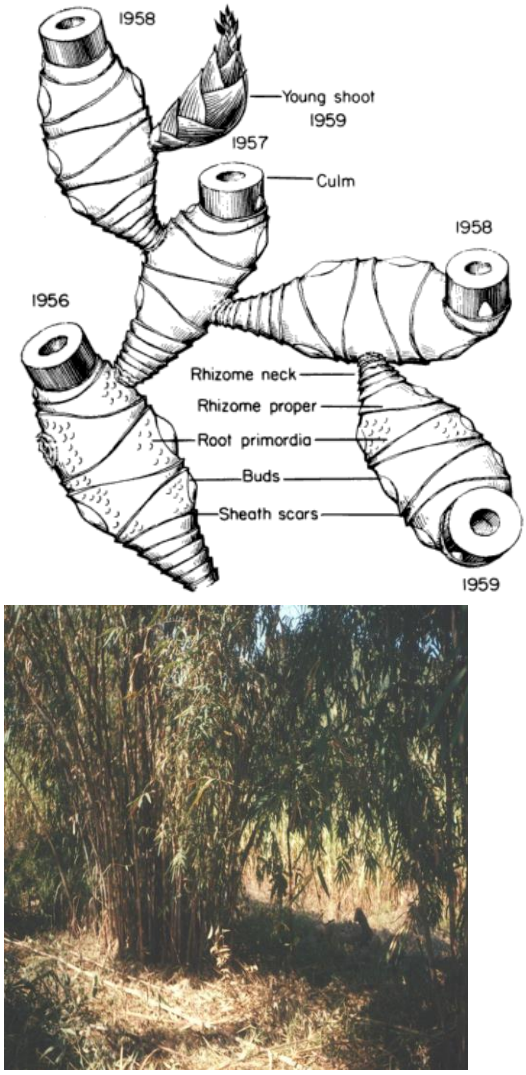

Figure 2. Sympodial bamboo a) basic forms of the subterranean parts and their terminology, b) mature stand of *Oxytenanthera abyssinica* in Ethiopia

It grows in dense clumps usually on dry rocky hillsides in semi-humid lowland–savanna, thicket savanna, and dominant in lowland bamboo thickets, at altitudes of 500 to 1300 m asl; it is solid-stemmed bamboo with thick-walled stem (Breitenbach, 1963).

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In Ethiopia, lowland bamboo occurs only in natural stands (it has not been planted so far). Not so in other African countries such as Sudan, Kenya and Tanzania where planting took place by local farmers and research organisations (FAO and INBAR, 2005). It is a hardy species and thus found on poor soils in dry vegetation formations. The species is able to tolerate poor rocky soils, erratic mean annual rainfall down to about 600 mm, and high temperatures of above 35^{O}C (Azene Bekele, 2000). Phillips (1995) described that the species is found in savanna woodlands favouring river valleys, often forming extensive stands. Westwards, it extends to Senegal and southwards to Zimbabwe. In Ethiopia, it is confined to the western side of the central highlands in moist and wet *koll*a agroclimatic zones, lying between 500 and 1600 m asl. (Azene Bekele, 1993). It grows in six regions in Ethiopia, namely the Southern Nations, Nationalities and Peoples Region in Gamo, Gaelebena, Hamer Baco, Bench-Maji, Majinal Goldiya; Gambela National Regional State; Amhara National Regional State in Chilga, Hinde, Wegera; Oromia Ntional Regional State in Gimbi, Guten, Kelkon, Leka; Tigray National Regional State in Shire; and Benishangul Gumuz National Regional State in Asosa, Bambesi, Begi, Demi, Guba, Dibate, Kamashi, Pawe.

BAMBOO UTILISATION IN ETHIOPIA

According to Zhaohua (2001), over 1500 distinct uses of bamboo have been recorded in the world. The number is growing rapidly with new development initiatives. Huge range of bamboo products that are excellent substitutes for timber-produced materials have also been innovated.

Based on the current bamboo industrial uses and the technical availability in the world, the commercial usages of bamboo resources at an industrial scale are categorised in the following serial of products: 1) bamboo flooring and furniture, 2) bamboo plywood for truck carriage and bamboo molding board for concrete, 3) bamboo charcoal and its side-product - bamboo acetum/vinegar, 4) Bamboo pulping and paper, 5) Edible bamboo shoots, 6) bamboo fibre and textile, 7)

bamboo chemical utilisation. Bamboo pipe-lines (length of more than 150 km) in Tanzania (Kigomo, 1988), bamboo housing in Costa Rica and other parts of Latin America, mat boards in India, composite panels such as oriented strand board (OSB) particleboard, fiberboard, and laminated bamboo composite in various countries (Qisheng et al, 2001; Seyum Kelemework, 2005) are also worth mentioning. Eco-tourism value of bamboo is also high. Total annual world export of bamboo and rattan is 5 billion USD as compared to 8 billion USD for tropical timber, 10.2 billion USD for coffee, 6.4 billion USD for hides and skin (Lobovikov, 2006).

Basic requirements of the raw bamboo material may vary according to the intended use. For instance, in China, *Phyllostachys pubescens* (the most extensive and highly cultivated bamboo) having breast height diameter (BHD) larger than 10 cm and bamboo with wall thickness after removal of outer and inner surfaces of bamboo strips greater than 5.5-6.5 mm (or minimum bamboo wall thickness at a node 4.5-5.0 meters from bottom thicker than 8.0 mm) has commercial value for industrial products (Qisheng et al, 2001).

Unlike other countries, bamboo utilisation in Ethiopia has been customary and mainly limited to hut construction, fencing and to a lesser extent production of handicrafts, furniture, containers for water transport, and storage, baskets, beehive, firewood, fodder, house utensils, various art-facts, and walking sticks (Kassahun Embaye, 2004). Although some people (particularly in Benshangul Gumuz National Regional State) use bamboo shoots in their diet, , there are no data available to quantify the exact amount used and the way of processing in this regard (FAO and INBAR, 2005).

Despite the multiple uses of bamboo in industrial applications, upto now Ethiopia is not getting the most economic advantage out of it. The utilisation is fully for domestic use. The low level of its utilisation among others entails lack/absence of processing technologies and technologies to protect bamboo products from biological and physical damages. Accordingly, it has got fewer acceptances by both potential investors and growers (FAO and INBAR, 2005). The potential of bamboo in substituting industrial wood, hence it's potential to narrow the gap between the demand and supply is not recognised yet.

BAMBOO DEVELOPMENT AND CONSERVATION

Various studies including Mooney (1959), WoldeMichael Kelecha (1980), Breitenbach (1961), EFAP (1994). studied Ethiopian bamboo coverage, management conditions and biomass production potential. Management and sustainable utilisation aspects as well as institutional issues (concerned

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stakeholders) were thoroughly studied and strengths and weaknesses identified. In many cases, lowland bamboo was proposed for utilisation of pulp and paper. The need to expand bamboo cover and properly manage the existing resource was outlined. The studies then made various proposals and recommendations. Sharing experience on bamboo processing was started more than 30 years ago through inter-governmental agreement between Ethiopia and China (BWEG, 1975). Different valuable bamboo materials produced during the practical training and publication of a manual by the Bamboo Weaving Experts Group (BWEG) are still found in the country, namely in the Federal Micro and Small Scale Enterprise Development Agency (FeMSEDA), as symbols of technical support between the two countries.

For various reasons, however, actions on the ground based on recommendations and proposals and scaling up of shared experiences are impaired. Institutions concerned with the development of the resource, based on the recommendations of studies and acquired experiences, include the Ministry of Agriculture and Rural Development (MoARD), the Institute of Biodiversity (IBC), Ministry of Trade and Industry (MoTI). The list also includes some non-governmental organisations (NGOs) whose mandate is to fill gaps in the development endeavour.

Development activities of MoARD include forests as one part among other agricultural disciplines. Both the development and conservation issues of forests are expected to be addressed here. Different forestry and agroforestry packages have been formulated and implemented under the office. However, to date, bamboo forests are not considered in the packages (Teshome Tessema, 2000). The utilisation of bamboo for income generation through the production of value-added products was unable to lead the resource development. The production of valuable bamboo products has been limited to piloting to the main bamboo-growing areas via the regional and probably district small-scale and micro-enterprise development bureaus.

MOARD'S commencement of bamboo resource management and utilisation at the grass-root level is a recent (since the last three-years) phenomenon., it is giving hope and creating awareness about the resource. The East African Bamboo Project, which is MOARD'S project, operates at selected village level in three selected regions namely Amhara, Benishangul and Southern Nations, Nationalities and Peoples National Regional States,.

The Institute of Biodiversity Conservation (IBC) considers bamboo in its conservation plans. IBC has carried out numerous vegetation inventories and socio-economic studies at identified conservation priority areas (IBC and GTZ, 2004). Forest inventory reports of the institute show that most highland natural forests contain highland bamboo. The Institute is exerting more effort on in-situ

and ex-situ conservation of forests. It has already delineated conservation sites at Asosa and Mandura areas of north-western Ethiopia and Masha area to conserve highland bamboo; however, deforestation continues unabated. Frequent fire, clearing for agricultural and grazing land are threatening bamboo stands.

Previously, most of the existing bamboo forests were found in remote areas of Ethiopia where they were preserved by their inaccessible location. However, now, they are accessible as new settlements have been established, especially in lowland bamboo-growing areas, and new roads have been built to connect the emerging villages (Kassahun Embaye, 2004). According to Kassahun Embaye (2004) currently, there is indiscriminate forest clearance; hence, the economically valuable bamboo resource will disappear before its economical and environmental advantage are appreciated, unless important reversing mechanisms take place.

There are a number of national policies, proclamations, and strategies of relevance to forest resources development and conservation in Ethiopia:

- The National Conservation Strategy (NCS) issued in 1994,
- the Regional Conservation Strategies issued in conformity with the NCS afterwards,
- the Environmental Policy issued in 1997, and
- the Biodiversity Policy issued in April 1998 are worth mentioning.

Proclamation 86/1994 is the currently used law concerning conservation, development and utilisation of forest resources. A new Forest Policy was also issued In the year 2008, Regional land use and mining laws (Proclamation no. 52/1993) are also regulatory tools. However, the various policies and laws developed based on forest conservation principle are not stopping deforestation nor have they encouraged development and conservation of forests as expected due to problems. The problem is basically related to implementation (Mesfin Bayou, 2002).

BAMBOO RESEARCH IN ETHIOPIA

Despite the fact that forestry research has been conducted in the country for the past 30 years, bamboo is still not considered as a research commodity; hence, there are no particular personnel and facilities assigned for it. Rather, it was treated together with other forest tree species. It is apparent that research on technology generation facilities such as laboratories, greenhouses, trial sites, machineries, vehicles, adequate staff and finance are made available for forestry research. Due to shortage of these facilities and infrastructure, to date, there are no

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comprehensive research technologies generated to support stakeholders engaged in bamboo industries, bamboo processing and manufacturing, management and retailers. Lack of experience-sharing with countries that cultivate and utilise bamboo has also considerably limited bamboo research. Comprehensive management and utilisation guidelines and manuals were not amply produced. In addition, absence of research-extension-farmer/industry linkage is a big hindrance for dissemination of the limited scientific knowledge generated so far.

Upto now, very limited research has been undertaken: vegetative propagation of highland bamboo (Kassa Oyicha, 1997; Tesfaye Hunde and Yohannes Adane, 2005), propagation of lowland bamboo by seed (Kassahun Embaye, 2003), suitability of *Yushania alpina* for oriented particle board (Seyum Kelemework, 2005, Seyum Kelemework, et al., 2007), utilisation of lowland bamboo stems as reinforcement steel (Melaku Abegaz, et al, 2005), seed production and seed characteristics of *O. abyssinica* (Demelash Alem, 2006), ecological aspects and resource management of bamboo (Embaye, 2000; Kassahun Embaye, 2001, Kassahun Embaye, 2003, Kassahun Embaye et al, 2003. Embaye et al, 2005), study on sustainable bamboo management (LUSO Consult GmbH., 1997), and Bamboo market and socio-economic studies (Ensermu Kelbessa et al., 2000; Birhanu Adinew, 2007). Bamboo Cottage Industry Manual (UNIDO, 2008(a)), Bamboo Industry Manual (UNIDO, 2008 (b)), and Bamboo Management Guideline (Kigomo, 2007) prepared for Kenya and Ethiopia are also recently produced manuals and guideline dealing with the utilisation and management aspects of bamboo. There is no research or service on pre-extension of research results so far. At this juncture, it is understandable how the absence of the research-extension linkages can limit the information and technology transfer.

CONSTRAINTS AND OPPORTUNITIES

Gaps/Constraints

Lack of awareness

Until recently, relevant institutions including the Forestry Department were hardly aware of the country's huge potential. This might have been due to the fact that bamboo is considered as a less-value-crop than a valuable forest resource (more focus was on timber tree species). Lack of awareness about the multiple uses of bamboo is the basis for delay of actions on development, research and conservation interventions. Problems related to depletion of bamboo forest for different uses arise because of attaching less priority to the resource. Had

awareness been created, developing strategies, policies and implementation guidelines/laws in the short term and long term could have been developed and realised.

Inadequate technologies and week technology transfer

Information on the extent, distribution, species diversity and rate of depletion of bamboo resources of Ethiopia is very limited. There is no accurate information on the stand dynamics that indicate growth and ecological interaction. Moreover, within and between species genetic diversity has not been investigated. Even physiological and morphological characteristics of the existing species are not fully studied. Their ecological requirements also need further investigation. Appropriate (cheap and effective) techniques and methods of propagation by seed and vegetative means must be identified and verified through well-defined bamboo research. There is no information about culm-damaging pests and protection mechanisms. It is necessary to study the processing of composite materials and other industrial products made from bamboo with high added value. In addition, biologic characteristics of bamboo forest and study on cultivation technology, ecological value of bamboo forest and others, are some of the areas that need to be scaled-up and investigated further.

Accordingly, major and generalised research gaps for bamboo resource can be outlined as follows:

1) lack of database on types, local uses, traditional methods of harvesting, processing, storage and properties of bamboo resource,
2) improved technologies on harvesting, processing, packing, storage, and grading are not thoroughly looked into,
3) comparative economic analysis, market information and feasible production options are limited,
4) information on seasons of harvesting, optimum harvesting rates, locations of high potential, and valuation techniques of the resources unavailable,
5) technologies for efficient utilisation are not practically applied by the people where the resources exist. Introduction and utilisation of modern processing technologies are at their infant stage (i.e. apart from machineries introduced for training purposes, up to now only one modern bamboo processing industry is introduced in Ethiopia)
6) technologies for large-scale regeneration/propagation (silviculture) and management of bamboo are lacking,

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7) conclusive management concepts/ knowledge on suitable bamboo forest management are still lacking, and
8) pre-extension services for the generated technologies and dissemination of information to the intended users are absent.

Policy frameworks and institutional issues

In view of the present and potential industrial, socio-economic and environmental significance of bamboo resources, sustainable utilisation deserves special attention. Hence, as one big commodity, it needs to be either thoroughly mainstreamed into the existing institutions (more preferable option) or some other responsible organisation/institute that could take the lead and exert a big effort to its development should come into being. Formulation of bamboo development and industrial policies and strengthening international collaboration are important points to be thoroughly considered.

Currently, there is no organised marketing system even for unprocessed bamboo and customary bamboo products. Much bamboo remains unused, especially in areas where transportation is a constraint. When thinking about industrial products of bamboo, marketing is a big concern to be looked into.

More reently, raining centres on bamboo processing have been started. The start-up includes the establishment of nurseries of introduced bamboo species This action was the collaborative effort of the Ministry of Agriculture and Rural Development (MoARD) and the Ministry of Trade and Industry (MoTI). Such effort needs to be scaled-up and the number of trainees in both management and processing increased considerably. It was at the beginning of the Ethiopian Millennium (2007 and 2008) that bamboo was declared to be "the Millennium grass". Such initiatives are crucial. So, policies that bring such efforts into effect are important.

Most possibly, entrepreneurs are financially weak and find it difficult to be involved in big commercial production and marketing. Accordingly, there is a need to develop a mechanism that supports them as well. Support is required from government and non-governmental organizations.

Depletion of bamboo resource

It is often emphasised that Ethiopia is endowed with large bamboo resources. However, these resources are under serious threats. 1) Bamboo stands are being replaced by agricultural (especially in highly populated areas) and grazing land, 2) the natural bamboo stand is mostly exposed to fire, 3) areas for bamboo production are getting marginalised, 4) there is more focus on using the natural

stand than developing bamboo. Hence, unless reversing mechanisms are designed, it would be a big challenge to exploit its potential.

Opportunities

Though there are different constraints that need to be addressed by concerned stakeholders, there are also encouraging opportunities that enable bamboo development to go further.

1) Recently, there has been more interest in in national and international circles in bamboo resource for its utilisation and sustainable development. International organisations like the International Network for Bamboo and Rattan (INBAR), International Center for Bamboo and Rattan (ICBR), Food and Agriculture Organization of the United Nations (FAO) are focusing on world bamboo resources. A link is already established between East Africa, including Ethiopia, and INBAR on market-oriented bamboo development. Research findings and information from these organisations can also be adopted.
2) both federal and regional research centres/institutes are giving special attention to undertake research to fill the research gaps,
3) there are also some research outputs regarding bamboo suitability for laminated bamboo lumber and vegetative propagation methods, which can be widely demonstrated to end users,
4) the country has about 1 million ha of bamboo (67% of African bamboo resources and more than 7% of the world total), hence applying concerted effort can be rewarding in the short term.

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