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Multiple Uses of Bamboo Species and Its Contribution to Forest Resource Management in Ethiopia

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Acronyms
FAO = Food and Agricultural Organization
FRA = Forest Resource Assessment
NTFPs = Non - timber forest products
UNFCC= United Nations Framework on Climate Change
MOARD= Ministry of Agriculture and Rural Development

Abstract
Deforestation becomes an overwhelming problem of the world in general and in Ethiopia in Specific. High population growth accompanied by high demand for timber forest products is aggravating the problem. For this matter it is worth necessary to use every effort to minimize this high pressure from forest resources. Therefore, reviewing the multiple uses of bamboo and its contribution to forest resource management was an overall objective of this paper. Bamboo, being a substitute to timber, plays an important role in minimizing pressure from the forest. Fast growing nature of bamboo enables it to be a responsible to save the forest. Ethiopia owns about 67% of African bamboo resources. The country possesses about 7% of total global bamboo coverage. Arundinaria alpine (Monopodial bamboo) and lowland bamboo, Oxytenanthera abyssinica (sympodial bamboo) are the two indigenous bamboo for Ethiopia. There are various uses of bamboo as it is reviewed in this paper. It can be used as construction material. As it is estimated in the articles, currently more than 10 million Ethiopians are living in the bamboo houses. Bamboo is feed for animals and food for human beings. It is strong to control erosion and conserve soil water. It also provides a substantial economic benefit, especially for rural community. Bamboo can also contribute to the effort to adapt climate change through carbon sequestration. Bamboo forest has high carbon storage potential due to its high biomass growth rate and high annual regrowth after harvesting. Even though the understanding of multiple use of bamboo plant is increasing from time to time, more researches have to be carried out in the area of bamboo resource development and technological improvements.
Key words: Bamboo; Ethiopia; Forest resources; Deforestation

1. Introduction

Bamboo is widely distributed in Southeast Asia, Africa, and Latin America. As a major non-wood forest product and wood substitute, bamboo is of increasing interest to ecologists owing to its rapid growth and correspondingly high potential for mitigating climate change (Xinzhang et al., 2012). 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 (FAO, 2007).

Bamboo plays a key role in restoring soil fertility through the accumulation of organic matter and nutrients during the fallow period. The slow decomposition of bamboo litter produces a thick organic layer which conserves moisture and minimizes surface runoff and erosion in addition to nutritional contribution (D. Mailly et al., 1997b).

Ethiopia has an estimated one million hectares of natural bamboo forest, the largest in the African continent. Despite the versatile resource base and advanced bamboo utilization at a global scale, its great potential to enhance socio-economic and ecological development remains unrealized in Ethiopia (Zenebe et al., 2014).

In different parts of the world, it is used as a source of raw material for fodder, construction materials, paper production, laminated boards, energy, food, beverage and medicine. However,

In Ethiopia the common use of bamboo resource is limited to fencing, house construction (tukul), waving, household furniture and utensils but there are the experiences of bamboo shoots consumption in the western and south western parts of Ethiopia (Sisaye, 2013).

Deforestation and the resulting environmental degradation is a major problem in the Federal Democratic Republic of Ethiopia and a key factor challenging food security, community livelihood and sustainable development. Between 1955 and 1979, over 77 percent of the country's forested area disappeared and it continues to lose 8 percent of its remaining forests annually (Ellen, 2010).

Developing countries such as Ethiopia, which are experiencing the adverse consequences of

deforestation, cannot afford to see their remaining renewable natural resources decimated, by paying lip-service to their protection, production and wise use. The sensible thing for Ethiopia to do is to foster protection as well as the production and utilization of bamboo through considered management for industrial, household, soil conservation and environmental protection (Embaye, 2003).

1.1 Objective

- To review different uses of Bamboo and its contribution to the forest resource management

2. Multiple Uses of Bamboo Species and Its Contribution to Forest Resource Management

2.1 Bamboo

Bamboo is a perennial grass with over 1200 species in 50 genera of bambuosidaea and grows mainly in the tropics and subtropics. However, 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. (Zhang et al., 2011; FAO, 2007).

Approximately 3.2% of the world's total forest area, or a 37million hectare, is made up of bamboos (*Bambusoideae*), a large subfamily of the grasses. India perhaps has the world's richest resource of bamboo, claiming about 130 species occurring over an area of 9.60 million ha of forest land, where the average productivity of bamboo is less than 1 tonne per ha, against a potential productivity of more than 20 tonnes, if properly managed and harvested (S.K. Pande and S. Pandey, 2008; FAO 2007; P.Shanmughavel, 1997). All the germinated seedlings of bamboo produce rhizomes, which in turn develop in to new rhizome that produce lateral culms, which are the chief causative for the total biomass yield. The number of culms developed from the rhizomes totally constituted to a clump. During the first year, 3 to 4 culms were produced. In the average annual production of culm generally increased year after year. The culms produced during first year in shorter in length and smaller in diameter, but culms from subsequent years will be longer in length and bigger in diameter (P.Shanmughavel, 1997; P. Shanmughavel and R..S. Peddappaiah, 2000b).

Ethiopia is the country in the African Continent with the largest area of natural bamboo stands. It has been estimated that about 67% of African bamboos are found in Ethiopia. Moreover, it has also been estimated that about 7% of all bamboo resources in the world are found in this country. There are only two indigenous species of bamboo in Ethiopia, the highland or African alpine bamboo, *Arundinaria alpine* (Monopodial bamboo) and lowland bamboo, *Oxytenanthera abyssinica* (sympodial bamboo). *Oxytenanthera abyssinica* are found scattered in the south, south-west and central parts of Ethiopia. (Asabeneh et al., 2015; Brias, 2009; FAO, 2005).

2.2 Uses of bamboo

Bamboo includes income from the sale or subsistence use of bamboo products harvested from natural forests or cultivated in plantations on designated forest land. 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 (FAO, 2007). The entire integrated supply chain for bamboo products creates a high percentage of jobs in or near rural communities and employs many women (FAO, 2009).

Bamboo's main use in Kenya is in the fencing and toothpick industries, although flower support, tea-picker baskets and tree seedling support are also heavily in need of bamboo (African Farming, 1993). According to the study conducted in India by (P. Shanmughavel and R..S. Peddappaiah, 2000), bamboo is basically a household species and is the best friend of the Farmers. It can be grown around houses, wells, compounds, on farmlands and other available places in the holdings. It is grown as homestead plantations because every part of it finds one use or onother by users.

Fuel ethanol was successfully produced from bamboo by concentrated sulfuric acid scarification, acid and sugar separation followed by continuous ethanol fermentation as a result of the study conducted in Japan and China by (Zhao-Yong et al., 2011). Bamboo is a multipurpose plant used for everything from food to fuel and irrigation systems to construction. Bamboo supports the livelihood of millions of rural dweller in developing nation, and in particular women and children who do most of the harvesting. Bamboo can be used for making furniture and other innumerable products, for construction of houses, and as food both for human and cattle are among others (Kassa, 2009; MOARD, 2013).

2.2.1 Construction material

Bamboo has been viewed as an inferior good mainly used by poor people as a substitute for higher quality products. It has been frequently labeled as a ''minor forest product''. However, over the last decade bamboo products have gained popularity both in developed countries as an attractive material for house decoration and in developing countries for its potential role in rural development (JinZhong et al., 1999).

Industrially processed bamboo began to compete successfully with wood products for the developed

Western markets. However, because of the novelty of industrial bamboo products and due to a lack of consistent statistical data on their trade and consumption, it is unclear how large the current and potential market for bamboo really is (Pablo and Maxim, 2008).

Bamboos constitute a very important and versatile resource worldwide. A lot of Asian, African and South American people rely on bamboo products for their housing and farming tools (Troya et al., 2014). The bamboo Culms with developed branches either whole or cut into long segments with multiple numbers of nodes can be used as planting material or pole is ideal as an inexpensive source of material for housing and construction, concrete reinforcement, scaffolding, bridges, furniture, plywood, paneling, flooring, roofing, etc. (Bareja, 2010 and Diver, 2001).

It is considered as one of the oldest house building materials used in highland rural areas and villages. Bamboo houses are quite common in many countries including China, India, Bangladesh, Indonesia, Philippines, Costa Rica and Ecuador. Over one billion people live in traditional bamboo houses. These buildings are usually cheaper than wooden houses (bamboos are among the cheapest building materials), light, strong and earthquake resistant, unlike brick or cement constructions (Troya and Xu, 2014).

In Ethiopia, Current use of highland bamboo (Arundinaria alpina) is for furniture (traditional processors and modern workshops), house construction, fencing, water storage/ water pipes, baskets, agricultural tools, beehives, household utensils and various artifacts (FAO, 2005). Currently, it estimated that more than 10 million of Ethiopians are living in bamboo houses. For example, Sidama zone (in Ethiopia) are often made of bamboo spilt, finely woven into a kind of mat which is fastened upon bamboo posts (MOARD, 2013).

Image 1; traditional Sidama houses **Source: (MOARD, 2013)**

Bamboo, as a fast growing renewable material with a simple production process, is expected to be a sustainable alternative for more traditional structural materials, such as concrete, steel and timber (P. vander et al., 2004). Its potential application in the construction industry as an alternative to timber and other scarce building material could have a chain effect in promoting large-scale bamboo farming and processing (Kassa, 2009).

2.2.2 Human consumption and Animal feed

Young shoots of both running and clump-forming bamboos are used for edible purposes. A bamboo shoot is the young bamboo plant that, if not harvested, will grow into a tall bamboo plant within three to four months. It exhibits a great potential as a food resource. For centuries, young edible bamboo shoots have remained one of the highly palatable dishes in delicacies (Poonam et al., 2013).

Bamboo has an immense potential in realizing the food security mechanism of the country Ethiopia. Even though there is no data available to quantify the exact amount used in this regard, there are some people who use bamboo shoots for their diet, particularly, in Benshangul Gumuz region. Therefore, the indigenous knowledge of bamboo shoots consumption which accumulated over centuries can be easily introduced to other bamboo growing and potential areas (FAO, 2005; Sisaye, 2013).

Image 2; edible shoots of Bamboo: adapted from (Troya and Xu, 2014)

Bamboo also has a high nutritional value for the livestock. Bamboo leaves are likely to contain much higher concentrations of nutritionally important components such as non-structural carbohydrates and protein, as well as minerals such as phosphorus and potassium, compared to other plant parts (werger et al., 1998: cited by J.J. Halvorson et al., 2010)

The leaves of bamboo can also have value as a fodder supplement, particularly in the winter time. Worldwide, native stands of bamboo are habitats and forage for a range of wild and domestic animals. Low growing and spreading species of bamboo are an ideal cover crop for game birds and could potentially supplement winter feed for livestock although more research would need to be undertaken to clarify specific suitability (Goodwin, 2011).

2.2.3 Soil improvement

Bamboo plantations improve soil structure by improving its physical and chemical composition and also increase the subterranean water retention capacity by improving the organic content and porosity of top soil and thereby creating a natural water reservoir. Unique root and rhizome structures of bamboo act as binders for soil and erosion control (S.K. Pande and S. Pandey, 2008). Bamboo forests have an extensive rhizome system, a thick litter layer, highly elastic culms, and a dense canopy. These characteristics give bamboo forests a high capacity for erosion control, soil and water conservation, landslide prevention, protection of riverbanks, and windbreak and shelterbelt potential (Xinzhang et al., 2012).

The accumulation and removal of biomass and the inventory of five major nutrients (N, P, K, Ca, and mg) in plants litter fall, forest floor, and in the mineral soil were quantified at various stages of bamboo talun-kebun agroforestry system, the system which consists of a 6-7-year management cycle in which a 4-5-year fallow period of perennial clump bamboo is alternate with two years of food crop production (D. Mailly et al., 1997a and D. Mailly et al., 1997b). As a result, it was concluded that data on nutrient accumulation in the forest floor during the fallow stage show a build-up of soil humus and an increase in site nutrient reserves released after the clearing and hoeing of the mature talun.

Various studies have indicated that bamboo provides interesting advantages over other land uses in terms of maintaining and increasing soil organic carbon, nutrient recycling, conservation and restoration of degraded land, and other ecological services (Proyuth et al., 2012). For instance, the study by (Christanty et al., 1996) in West Java, Indonesia found that bamboo in the rotation cycle of shifting cultivation resulted in an increase of soil organic matter of approximately 7 tons ha−1 to 25 cm depth during the 4-year fallow.

Bamboo forests are characterized by a complex network of rhizome-root system, which make them excel other forest types in effectively holding soil particles together, thereby preventing soil erosion and promoting water percolation. The aboveground part of a bamboo forest helps reduce erosion by rainfall interception and by sheltering the soil from wind erosion and sun drying (Embaye, 2003).

2.2.4 Income generation

The study case (Hogarth and Belcher, 2013) revealed that as an individual source of income, the contribution of bamboo to the total cash component of household income is impressive. At 12.4%, the total cash contribution of bamboo to total income is substantially higher than the 9.1% from all other sources of forest-cash income combined, and also more than 10.5% cash contribution from all crops.

The huge economic benefits derived from bamboo forest management have contributed much to rural development and poverty alleviation in China (Troya et al., 2014). Among other economic activities, the processing and transformation of bamboo products on the spot could simultaneously create local employment and improve the bamboo value chain. However, so far the investor support for the development of new manufacturing plants has not been adequate to strengthen the bamboo supply chain and develop new technologies (Proyuth et al., 2012).

Bamboo is an abundant resource in Ethiopia and has a great potential for commercialization, which can drive rural development (Tefera et al., 2013). According to the (FAO, 2005), the price of bamboo is increasing from time to time since, its importance in the local market is increasing. Even though the low level of its utilization is due to bamboo susceptibility to biological and physical damages, as well as less acceptance by both potential investors and growers as the technology is not developed yet.

The study reveals that bamboo provides various subsistence benefits to households (Zenebe et al., 2014). As a result of the study case (Yenesew et al., 2013), bamboo cultivation in the study area is increasing because bamboo growers understood the multipurpose use of the plant. Out of 5 kebeles in Banja district, Northwestern Ethiopia, where the study was held 4 ranked bamboo plantation first while the furthest one kebele ranked bamboo plantations second. The main reason why they preferred bamboo were those: it is the fastest growing tree, it can give high economic returns and it is multi-purpose.

The major actors in the bamboo supply chain are producers and harvesters, who generally supply culms to local markets or directly to traders although some also make furniture themselves. From local markets, bamboo is bought by local furniture makers and consumers who use it for construction materials. Further afield, traders supply bamboo yards in large towns and cities. These yards primarily sell culms to roadside furniture makers but also often make furniture themselves (Abebe et al., 2009). Rural dwellers living in bamboo growing areas of the country would benefit from revenues generated from farming and processing, whereas the urban poor would benefit from having access to less expensive bamboo based dwellings (Kassa, 2009).

In order to achieve the objective of enhancing bamboo income for rural community of Ethiopia, Value-chain approach has been suggested by (Brias, 2009; Embaye, 2000). Accordingly, Links in the bamboo production, management, processing, manufacturing, end-product distribution, and utilization chain, have to be established. The development of a value-chain approach can lead to greater production efficiency, value-addition at each link of the value-chain, and over-all price/quality competitiveness. This will significantly contribute to uplifting the economic conditions of disadvantaged groups and result in an overall development of the industrial sector.

2.2.5 Bamboo for Carbon sequestration

Besides being a tool for poverty alleviation in rural areas, bamboo plantations are also a significant carbon sink and a key option to mitigate land degradation (Troya and Xu, 2014). While most timber species need decades or centuries to reach maturity, bamboos usually mature in less than a decade. This implies high biomass growth rates, therefore high carbon sequestration capacity (FAO, 2009)

With its fast growth rate and high annual regrowth after harvesting, the bamboo forest has a high carbon storage potential, especially when the harvested culms are transformed into durable products. The increased lifespan of durable bamboo products made possible by modern technology can ensure that the sequestered carbon will not return quickly to the atmosphere, thereby prolonging the carbon storage by bamboo (Zhou and Jiang 2004 cited by Xinzhang et al, 2012).

Not only better soil protection than arable land, bamboo can potentially sequester a substantial amount of carbon in its aboveground biomass and below-ground as soil organic carbon (Proyuth et al., 2012). For this matter, it has been discussed that the marketing of stored carbon under bamboo cropping system would additionally increase farmers' income.

2.4 The Contribution of Bamboo to Forest Resource management

About one half of the forests that covered the Earth are gone. Each year, another 16 million hectares disappear (Uddin, 2008). In 1990 the world had 4128 million ha of forest; by 2015 this area has decreased to 3999 million ha. This is a change from 31.6 percent of global land area in 1990 to 30.6 percent in 2015. Yet deforestation, or forest conversion, is more complicated than that (FAO, 2015). This degradation harmful is also common in Africa. The total forest area of the region which once was 749238ha in 1990, have been fallen to 674419ha in 2010 (FAO, 2010).

Continuous deterioration of the natural resource base has become a serious threat to both ecosystem

functions and economic production in Ethiopia Deforestation is one of the overwhelming problems of the globe today (Balana et al., 2010).

Table 1. trends in extent of forest 1990-2010 for Ethiopia

Year	Forest area (000ha)	Annual change (000ha/yr.)	percentage
1990	15114		
2000	13705	-141	-0.97
2005	13000	-141	-1.05
2010	12296	-141	-1.11

Source: FAO, 2010

Forest degradation is believed to be an important source of emissions by Ethiopia. Understanding drivers of deforestation and degradation is fundamental for the development of policies and measures that aim to alter current trends in forest activities toward a more climate and biodiversity friendly outcome (Hosonuma et al., 2012; UNFCCC, 2016).

Forest resources in Ethiopia have experienced so much pressure due to increasing need for wood products and conversion to agriculture. The trend in Ethiopia today is to protect the remaining natural forests for their various social, economic and environmental values (Yitebitu et al., 2010).

Yield of land is a specific aspect of sustainability, related with the fact that land is becoming scarce, especially when current materials (metals, fossil fuels) will be replaced by renewable materials like wood and non-wood forest products like bamboo (Vogtländer et al., 2010).

Bamboo is a major non-wood forest product and wood substitute. It 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 (FAO, 2007; M.Ruiz et al., 2004).

Bamboo can contribute to the sustainable forest resource management if it is successfully managed and used on scientific basis, merely traditional way of production (P.Shanmughavel, 1997). Forest department can play an important role in the supply of bamboo seedlings and to provide technical assistance necessary for bamboo plantation establishment. Also take initiative to rehabilitate and afforest degraded land with the objective of supplying raw materials that can minimize pressure on the natural forest (Tapan et al., 2000).

Environmentally, bamboo is arguably a superior land use to annual crops (assuming lower soil erosion rates, no use of agrochemicals and fertilizers, etc.) and could be a benign substitute for wood (Troya et al., 2014; Proyuth et al., 2012).

Bamboo is a favored species in the national afforestation programs as being a marvelous substitute of timber towards meeting the industrial and rural requirement. Rehabilitation of degraded forest area is afforestation of degraded area with the view to meeting the requirement of fuel wood and fodder of the local population. Here the management usually remains with the forest department (P. Shanmughavel and R..S. Peddappaiah, 2000b).

(FAO, 2007) has elaborated the rationale for the importance of bamboo saying: 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. Bamboo is often cultivated outside the forest on farms, where it is more easily managed. (MOARD, 2013) document has also stated the fast growing nature of bamboo plant. Compared with other timber or hardwood Production, bamboo can be shown to have yields seven to ten times those of wood (Jim et al., 2014).

3. Conclusion and Recommendation

3.1 Conclusion

Bamboo is a marvelous resource that provides a myriad of benefits for billions of people. It has significant socio-economic impact. It is useful plant for one purpose or the other, for income generation, house construction, fuel wood, animal fodder, fences and furniture, food for human, soil improvement and erosion control and significant carbon sequestration. Development of bamboo resources is economically assisting impoverished people while at the same time stabilizing erodible slopes and flood prone watersheds.

Global forest resource has shown a decreasing trend. Deforestation due to increased population size that is characterized by increased demand for forest product has put the world's as well as Ethiopia's forest under the danger of degradation.

Bamboo, which can substitute timber, is believed to be an alternative option to the sustainable management of the remaining forest resource. As it is well reviewed throughout this paper, Bamboo can give multi-directional solution for forest related problems and even the problems of biodiversity at ecosystem level at large. In short, bamboo has a substantial contribution to the sustainable forest resource management.

3.2 Recommendation

- Broad policy and development intervention measures are needed to address the various challenges and constraints undermining the socio-economic and ecological importance of bamboo resources and to tap opportunities attached to the resources
- Research, which currently do not seem to exist has to come up with various innovative bamboo uses and management technologies
- Specific bamboo propagation and stand management techniques should be developed and communicated to the farmers
- Bamboo is still considered as a perishable material, which has led to its neglect as a useful renewable resource. Its potential for industrial use has yet to be popularized, and accepted by both potential investors and growers. Practical demonstrations are the most effective ways of convincing people

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