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Socio Economic Aspects of Lowland Bamboo (Oxytenanthera abyssinica)

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Abstract
Bamboo Plays a vital role in environmental amelioration, biodiversity preservation, and soil conservation and protects other plants from frost, wind and water erosion and itself from freely moving speedy winds and frost. It also contributes to flood management, wastage disposal, waste purification and ecological sanitation as well as recharging groundwater. Bamboo sequesters up to 12 tons of carbon dioxide from the air per hectare and it release 35% more oxygen than equivalent stands of trees. Despite the large area coverage, economic, social and conservation significance of bamboo in Ethiopia, information about production, utilization and its use as forage for livestock is limited. Therefore, the present review was conducted with the objectives of generating holistic information socio-economic aspects of the indigenous low land bamboo species. The primary use of raw bamboo material is for housing, fencing, household equipment's and amenities. The majority of rural families are entirely dependent on raw bamboo for household furniture and as a source of domestic energy and Bamboo is the main material for the construction of house, animal sheds fences, fuel wood and beehives in Asossa Zone, Benshangul-Gumuz Region. In addition, for Jeblawi people of Mandura district in this Region, the shoots of bamboo are very important for their delicious nutritional food sources.
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1 INTRODUCTION

1.1. Background and Justification

Bamboo is the strongest and fastest growing perennial grass species that belongs taxonomically to the subfamily of *Bambusoideae* under the family of *Gramineae* (FAO, 2007). More than 1,500 species and 90 genera of bamboo are found in the world, covering 36 million ha of land which is distributed in the tropical and sub-tropical belt between 46^0 north and 47^0 south latitude at elevations as high as 4000 m above sea level (FAO, 2007). Regarding their abundances 65%, 28% and 7% of the world bamboo are found in Asia, America and Africa, respectively (FAO, 2007).Forty-three species and eleven genera of bamboo are found in Africa, with area coverage of 2.7 million ha. About 93% of Africa bamboo species are found only in Madagascar (FAO, 2007; Tesfaye Hunde, 2007; Seyoum Kelemwork, 2008). In terms of area coverage, 67 % of the African and more than 7% of the world bamboo resource is found in Ethiopia (Ensermu *et al*., 2000; Kassahun Embaye, 2003; Seyoum Kelemwork, 2008). Ethiopia has two bamboo species namely, the high land bamboo,*Yushaina alpina* and the low land bamboo *Oxytenanthera abyssinica*). Out of which the high land bamboo comprises about 130,000 ha and low land bamboo covers over 850,000 ha (Ensermu *et al*., 2000; Kassahun Embaye, 2003).

Bamboo is a versatile and multifaceted non-timber plant with a considerable potential to the socio-economic development and environmental protection (Kumar and sastry, 1999). It has numerous benefits in day to day uses for the local community where the species is growing (Tesfaye Hunde, 1998). Due to their easy workability, strength, straightness, lightness, combined with extra-ordinary hardness, range of size, abundance, short period in which they attain maturity, make them suitable for a various of purpose and use (Nath *et al*., 2009 and kasahun Embaye, 2000). As result, there are more than 1,500 uses, ranging from medicine to nutrition and from toys to aircraft (Nath *et al*., 2009).

2. Bamboo Resources

2.1 World bamboo resources

Bamboo is the fastest growing perennial grass species belong taxonomically to the subfamily of *Bambusoideae* under the family of *Gramineae* (EABP, 2007). According to FAO (2007), bamboo is known as poor man's timber, giant woody grass and a single bamboo clump can produce up to 15km of usable pole in its lifetime. There are more than 1,500 species and 90 genera of bamboo in the world, covering 36 million ha of land where are distributed in the tropical and subtropical belt between 46^0 north and 47^0 south latitude (FAO, 2007; Kasahun Embaye *et, .al.* 2004*)*. Bamboo is an extremely diverse plant which easily adapts to different climatic and soil conditions (FAO, 2007). Dwarf bamboo species grow to only a few centimeters while medium-sized bamboo species may reach a few meters and massive bamboo species grow to about 30 m, with a diameter of up to 30 cm. Bamboo stems are generally hard and vigorous plant can survive and recover after severe calamities, catastrophes and damage. For example, young bamboo shoots were the first sign of new plant life after the nuclear bombing of Hiroshima and

Nagasaki at Japan Districts (FAO, 2007). Bamboo has received increasing attention over the last two decades for its economic and environmental values (Kumar; Sastry, 1999). In Africa, Asia and Latin America, it is closely associated with indigenous culture and knowledge 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 utilization (Bereket Haile, 2008, INBAR, 2011 and Maxim Lobovikov et.al. 2005).

2.2. Bamboo resources in Africa

About 43 species and 11 genera are originated in Africa, with area coverage of 1.5 million of ha(FAO, 2007). In Africa 93% of bamboo species are only found in Madagascar (Tesfaye hunde, 2007; FOA, 2007; Seyoum Kelemwork, 2008) while the remaining are found in mainland Africa (Ensermu *et al*. 2000). These species are found in some other African countries, but no elsewhere outside the African continent (Ensermu *et al.*, 2000). Contrary, the total areas of bamboo reported by the six African countries (Ethiopia, Kenya, Nigeria, Uganda, the United Republic of Tanzania and Zimbabwe) make up over 2.7 million hectares. This equals 4.1% of their total forest area. Ethiopia reported 6.5 % and Nigeria over 14 % of bamboo in the forest cover.

2.3 Bamboo resources Ethiopia

The existing information about the distribution and coverage of bamboo in Ethiopia is rather limited (Arsema Andargachew, 2008). Ethiopia contributes the larger fraction in Africa accounting for about 67 % of the African and more than 7% of the world bamboo resource (LUSO Consult, 1997; Ensermu *et al*., 2000; Kassahun Embaye, 2003). Ethiopia has two bamboo species namely the high land bamboo *(Yushaina alpine)* and the low land bamboo (*Oxytenanthera abyssinica)*. As indicated in Table 2.1, the area Coverage is about one million ha, out of which the high land bamboo comprises about 130,000 ha and low land bamboo covers 850,000 ha (LUSO Consult, 1997; Ensermu *et al*., 2000; Kassahun Embaye, 2003; Demissew Sertse *et al*., 2011).

Table 1. Major lowland bamboo growing area in Ethiopia

Bamboo area stand(H)	Region	Natural stand(Ha)	Plantation(ha)	Total
Hinde	ONRS	8,670	-	8,670
Asossa	BGNRS	77,947	-	77,947
Bambasi	"	64,245	-	64,245
Begi	"	21,509	-	21,509
Dibate	"	14,200	-	14,200
Guba	"	7,757	-	7,757
Kemashi	"	33,723	-	33,723
Pawe	"	53,830	-	53,830
Dangur	"	27,350	-	27,350
Bulen	"	16,780	-	16,780
Galesa	"	10,870	-	10,870
Nejo	ONRS	27,612	-	27,612
Gimbi	"	29,125	-	29,125
Guten	"	6,044	-	6,044
Didessa	"	135,000	-	135,000
Metema	ANRS/TNRS	425,000	-	425,000
Total		**959,662**	**-**	**959,662**

Sources: Bereket Haile, (2008) and Ensermu *et al.,* (2000)

2.4 Current status bamboo resource in Benishangul gumuzu National Regional State

More than 85 % of the lowland bamboo in Ethiopia is found the three zones of Benishangul Gumz Regional States (Demissew Sertse *et al*., 2011). Ethiopia has 959,662 ha of lowland bamboo forest area in 2000. Lowland bamboo grows in Amahara, Bebshangul Gumuzu, Oromiya and Tigray Regional States in Ethiopia. In Benshangul Gumuzu Regiona States bamboo grows in nine districts (table 1.1).

3. Characteristics of low Land Bamboo

The lowland bamboo species is botanically known as *Oxytenanthera abyssinica*. It is a clump forming and solid stemmed bamboo that is widely distributed in the dry regions in the western part of Ethiopia. It has traditionally been used as a raw material for building and it has also been used for making numerous household utensils, basketry, and handicrafts. It is also a plant with nutritional value: young bamboo shoots can be cooked and eaten as a vegetable, and the foliage can be used as animal fodder. In Ethiopia, the species grows on dry rocky hillsides where the mean annual temperature is above 30°C and where an annual rainfall of about 700-1000 mm is

concentrated over a period of three to four months (Table 1.2). The species occurs mainly in the western part of the country towards the savanna woodlands of Sudan boarder at elevations between 1200-1800 m. Stands of *Oxytenanthera abyssinica* thrive on poor soils and provide a buffer zone for desert areas (EABP, 2009).

Table 2. General characteristics of the Ethiopian natural lowland bamboo forests

Mean altitude	1000 – 1800 m
Mean rainfall	1150 mm
Total area	850000 ha
Stand density(tree/ha)	8000
Percentage of dead tree	34
Aboveground biomass(t/ha)	20
Culm	semi solid to solid
Seeds	viable

Source: Anonymous(1997) and Kassahun Embaye(2003)

Bamboo is a highly versatile resource that is used in many ways and in many parts of the country. Bamboo culms are currently used as construction material for housing especially in roofing and fencing, for beehive construction, production of mats, furniture, and baskets. Bamboo is used as fuel wood and also provides most of the fodder for livestock in the Southern areas of Ethiopia (Teshamulwa, 2006). Bamboo also possesses desirable characteristics required for biological wastewater treatment. It has high nitrogen and phosphorus consumption and a dense root system that traps oxygen required for the microbial action. Bamboo collects these nutrients and takes them up in abundance. In addition, bamboo is also effective in reducing non-organic pollutants and is known to absorb heavy metals (Melaku Tadesse 2006).

3.1. The growth habit of bamboo

The bamboo plant is made up of an underground axis and above ground axis. The under-ground axis is comprised of rhizomes, roots, and buds and the above ground axis is comprised of stems, branches, and foliage. Buds on the rhizomes may develop into shoots that emerge from the ground (Figure1.1). The new shoot elongates vertically into a main stem or culm until it attains its full height. The growth of a culm is completed in one growing season. In large bamboo species, new culms may grow to a height of more than 20 meters within 3 months (Bereket Haile, 2008 ; KEFRI, 2007; Tessfaye Hunde, 2007).

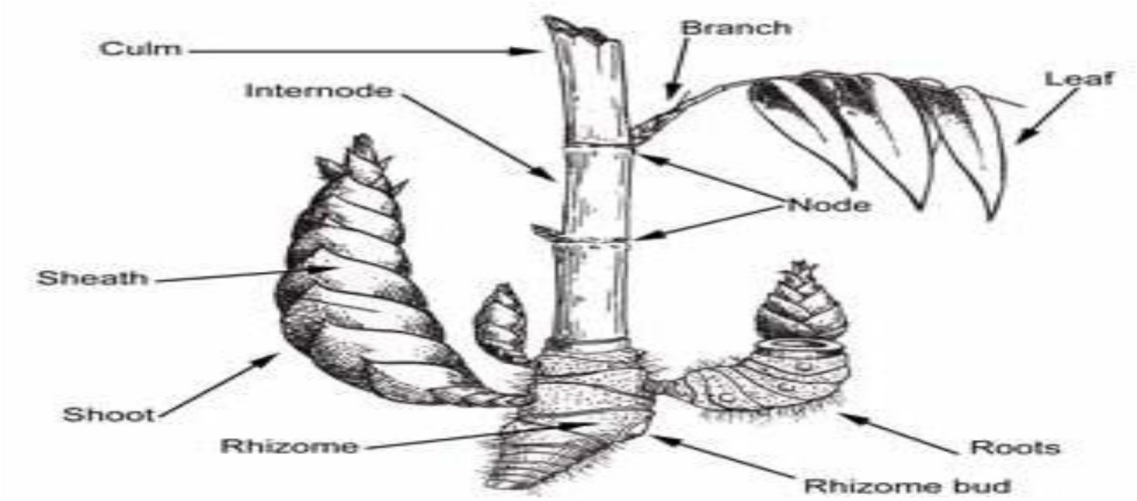

Figure 1. Parts of bamboo culm

The bamboo culm is cylindrical and is divided into sections by diaphragms or nodes. The section between two nodes is called internodes. Internodes are hollow in most bamboos, but solid in some species. The new culm is protected by sheaths that are attached to each node. The Culm gradually develops branches and leaves. As the culm matures, it lignifies and becomes harder and stronger. The bamboo culm does not get thicker each year. Unlike trees, bamboos do not have any secondary growth. Rather, as the rhizome system develops and matures, new and larger shoots emerge annually until the maximum size of the species has been reached. The life of a culm varies from species to species. Usually, a culm is fully mature after 3 or 4 years. As mature culms grow older, they deteriorate and eventually die and rot. The life of the bamboo plant is however sustained by the new shoots and culms (Bereket Haile, 2008, KEFRI, 2007). Silvicultural management of bamboo is heavily based on its growth habit, particularly the way the underground rhizome develops leading to the formation of culms. Effective management involves systematic but selective cutting of mature culms, there by harvesting a crop that is valuable

and useful. The removal of mature culms also maintains the vigour of the plant and allows for the continuous generation of new shoots (Bereket Haile, 2008). There are two main systems of rhizome formation are predominant in bamboos, namely clump forming rhizomes and running or creeping rhizomes. Clump forming bamboos have rhizomes that exhibit a sympodial branching pattern. Running bamboos, on the other hand, have rhizomes with a monopodial branching pattern (Bereket Haile, 2008). In sympodial branching, each branch or axis becomes dominant. In the case of bamboos with sympodial rhizomes, each new rhizome turns upward and develops into a culm. On the other hand, bamboos with monopodial rhizomes have a single, dominant subterranean stem, or axis that develops secondary stems that either extend laterally or turn upward to become culms. The lateral extension of the monopodial bamboos may exceed hundreds of meters (Bereket Haile, 2008).

3.2. Raising of planting materials

Growing bamboo starts with obtaining the materials for planting. Such materials may come in the form of seeds, wildings, offsets or cuttings that may be gathered from forests. Tissue-cultured plantlets provide other forms of planting materials. Such planting materials can be obtained and raised in the nursery as described below (Bereket Haile, 2008; Junthan and kigomo, 2008).

3.2.1. Propagation by seed

Bamboos generate seeds when they flower. For many tropical bamboos, flowering intervals range from 40 to 80 years. There are two types of flowering in bamboos, gregarious flowering and sporadic flowering. When gregarious flowering occurs, the clumps of an entire species flower, produce seed, and then die. Although large quantities of seed are produced during gregarious flowering, they are viable only for a short period, sometimes only for a few days or months. Sporadic flowering occurs in many species, in this type of flowering, seeds are produced but the clumps generally survive. The flowering of bamboo is not yet scientifically understood and the onset of flowering is therefore not predictable (Bereket Haile, 2008; FAO, 2007; Demissew Sertse *et al,.*). Because of the long flowering intervals of bamboo, seeds are very seldom available and is not always a viable method for large scale propagation. If seeds of a certain bamboo species become available, it is highly advisable to buy only from reputable vendors or specialized organizations that can guarantee the provenance and viability of the seeds(Bereket Haile, 2008; FAO, 2007).

3.2.2. Vegetative Propagation

When seeds or wildings are not available, bamboos can be propagated by vegetative and this offers a better source of planting material. Offsets (rhizome with attached section of stem) are commonly used but their extraction is laborious and time consuming, and it is difficult to collect large quantities of planting materials. During extraction, damage may also occur to the roots, buds and rhizomes of mother clumps. Offsets are bulky and also difficult to transport. Only small annual planting program may therefore be possible when using offset materials (Bereket Haile, 2008).

3.2.3. Use of wildings

Apart from raised seedlings, wildings of bamboo from indigenous forest stands can be collected and used for raising a bamboo plantation. Young clusters of bamboo wildings can be scooped using a spade and taken to the nursery for individual transplanting into polyethylene tubes. Care should be taken to avoid disturbing intact small wildings which resemble a mass of grass in the field. Small wildings of bamboo that are pricked into tubes and kept under shade generally establish well. This method can raise many seedlings (Bereket Haile, 2008; Kigomo, 2007).

3.2.4. Using Culm Cuttings

Use of culm cuttings is a viable alternative and has several advantages. Multiplication of several clumping species is possible by this method. When out planted, vegetative materials raised from cuttings develop to clumps much faster than offsets and even seedlings. The local species of bamboo, Yushania alpina and Oxytenanthera abyssinica, have however proved difficult to propagate in this manner (Bereket Haile, 2008 and Kigomo, 2007). Good cuttings are obtained from 2 to 3 years old culms of healthy clumps. Double node or triple node cuttings are then prepared from the cut culms. The cuttings should be made leaving a space of 5-7 cm away from the nodes. A sharp cutting knife is necessary. For bamboos with thin walls the use of a saw is recommended to avoid splitting of the cut ends. The best culm cuttings are generally those that are obtained from the lower and thicker part of the culm, which has the vigor to generate roots and shoots. Successful rooting and shooting is generally harder to achieve with cuttings from the upper and thinner part of the culm (Bereket Haile, 2008 ; Kigomo, 2007).

3.3. Bamboo plantations

The term ‘plantation’ can mean different things and it is useful to explain the various senses of the term in relation to different bamboo plantation systems. This can at the same time help to illustrate various applications for bamboo in relation to forestry and farming. It is useful to distinguish, for instance, between homestead, commercial plantations, agroforestry, and forestry programs (Bereket Haile, 2008).

3.3.1. Bamboos in homestead farms

Bamboo in a homestead farm is a small property with a dwelling house where a family resides and adjoining land where cash crops and trees are planted. Planting bamboo clumps in a homestead can foster self-sufficiency of woody materials as well as fiber for producing domestic implements such as baskets and mats. It is common to see this kind of plantation in Amhara region. In Awi-zone it is considered as alternative income source in addition to agriculture (Bereket Haile, 2008; Kigomo, 2007).

3.3.2. Bamboo as commercial plantations

Bamboo can be planted as a commercial crop in areas of farms of just a few hectares to large estates of thousands of hectares. Plantations have a well defined structure and a selection of crops that are cultivated mainly for generating economic gain. A bamboo plantation not necessarily needs a monoculture plantation (Bereket Haile, 2008; Kigomo, 2007).

3.3.3. Bamboo as Agroforestry planting material

The term 'agroforestry' broadly refers to land use systems and agrarian practices that involve the cultivation of woody species in combination or rotation with agricultural crops and/or animals on the same land management unit. Agroforestry systems are driven by economic and ecological goals. The aim is to generate a sustainable use of land for the benefit of livelihood and the environment. The use of bamboo in agroforestry systems involves intercropping of cash crops and the planting of hardwood trees. In this way, cash crops can generate income in the short term, bamboo can generate income in the medium term, while the trees can generate high value in the long term. The use of numerous species with different rotations has a beneficial impact on the soil. Knowledge, careful selection and good management of species are needed to maximize the production and positive environmental effects while avoiding the shortcomings of monoculture plantations (Bereket Haile, 2008; Kigomo, 2007).

3.4. Socio- Economic Importance of low Land Bamboo

3.4.1. Use of bamboo for making traditional materials

Traditionally, bamboos seen as the "poor man's tree," in recent years bamboo has risen to a high-technology, industrial raw material and substitute for wood (FAO, 2009). Although the commercialization of planted bamboo has been slow, bamboo is becoming an increasingly important economic asset in poverty eradication and economic and environmental development (FAO, 2005 and EABP, 2009). Bamboo: "The Gift of the Gods" was used in Latin America since ancient times, mainly for vessels, constructions, tools for farming, music, weapons, among others (INBAR, 2006). Bamboo is used for building and construction such as bamboo house, shade house, construction frame, door-window frames, fencing, beehives and furniture (Ensermu Kelbassa *et al.,* 2000; EABP,2009; INBAR, 2011), sofa sets , tools, bamboo sticks, umbrella sticks, mats, cotton swab, ice-cream sticks, bed spread, table wares, cattle sensor, musical flutes, wind chimes, pan pipes, xylophones (Nath *et al.*, 2009) .

3.4.2. Bamboo as Food and Food preservative

About 200 species of bamboo can provide edible and palatable bamboo shoots (Bereket, 2008). Its leaves contain flavones, amino acid and microelements, these elements are of excellent biological efficacies in anti-oxidation, anti-consenescence, and strengthening human immunity. These functions have attracted attentions in the fields of food, nutrition and medicine researches (KEFRI, 2007). Bamboo shoots are rich in fiber, protein and minerals and processed product developed from bamboo shoots can provide food and nutritional security. Every year, over 2 million edible bamboo shoots- rich in vitamins and low in carbohydrates, fats and proteins are consumed around the world (EABP, 2009). Production of edible bamboo shoots is more common in different countries especially China, Japan, Taiwan and Thailand. Shoots of *Yushania alpina* are consumed by communities around Mount Elgon in Uganda and, to a lesser extent, in Kenya. In other countries in Africa there are niche markets for bamboo shoots. Many hotels and Asian restaurants around Africa serve bamboo shoots as vegetable dishes. Some bamboo species recently introduced in East Africa produce good quality shoots. Jeblawi people of Mandura district in this Region, the shoots of bamboo are very important for their delicious nutritional food sources (LUSO Consult, 1997; Ensermu *et al*., 2000; Yeshambel Mekuriaw *et al*., 2011).

3.4.3. Bamboo as Medicine

Extracts of bamboo leaves can be used for lowering concentration of blood triglyceride and cholesterol and acting as a positive control of high blood-lipid (EABP, 2007). The powdered hardened secretion from bamboo is used internally to treat asthma, coughs and can be used an aphrodisiac. In China and in some parts of Ethiopia, ingredients from the root of the black bamboo help treat kidney disease, roots and leaves have also been used to treat venereal disease and cancer, sap is said to reduce fever and ash will cure prickly heat. Current research points to bamboo's potential in a number of medicinal uses. (EABP, 2009).

3.4.4. Bamboo as art and culture

Bamboo is integrally connected with culture and arts. It is spiritual plant known for its symbol of strength, flexibility, tenacity, endurance, luck and comprises (Nath *et al.*, 2008). In Asia and ancient African Countries like Ethiopia, bamboo has for centuries been an integral element to religions ceremonies, art, music and daily life. It is the paper, the brush and the inspiration of poems and paintings. Among the earliest historical records, 2nd century

B.C. was written on green bamboo strips strung together in a bundle with silk thread. Instruments made of bamboo create unique resonance and melody (EABP, 2009 and Nath *et al*., 2009).

3.4.5. Bamboo as Energy sources

Bamboo bio-mass is a potential alternative source for bio-energy and opportunity to pioneer another industrial usage through gasification to produce electricity, as it has very favorable characteristics for gasification and the synthesis of gasoline and diesel. Bamboo has a number of desirable fuel characteristics such as low ash content. Its heating value is higher than most agricultural residues, grasses and straw. Besides, bamboos have high biomass productivity, self-regeneration, sustainable basis and environmental friendly functions. This means countries like Ethiopia can exploit their untapped bio-fuel potential from bamboo fully and effectively to propel their economy (FAO, 2005; EABP, 2009).

3.4.6. Bamboo as charcoal and its multiuse

Bamboo charcoal and active carbon is an item of a new product developed in recent years. According to FAO (2005), small sized and old tops and roots of bamboo which are not fit for making other bamboo products and residues from bamboo processing industry can be used in the production of charcoal. Bamboo charcoal can be used as an air purifier and for other antipollution purposes. It also can be used for absorbing unpleasant odors; as a deodorant in refrigerators, bathrooms and pools; for refining wines of high grade and edible oil; for purifying water due to its micro-porous structure. It can also be used to treat drinking water in eliminating organic impurities and offensive smell; for purifying air and to absorb harmful chemicals such as phosphorous dioxide, carbon monoxide and hydrogen sulfide released to the atmosphere (EABP, 2007). The calorific value of bamboo charcoal per unit weight is about half that of oil (FAO, 2007). Its absorption capacity is 6 times that of wood charcoal (FAO, 2007; Bereket, 2008). To get maximum yield in charcoal production, moisture content of bamboo should be around 20-25%, accordingly freshly cut bamboo should be stored for 15-20 days to lower down the moisture content (Suneel, 2008). According to INBAR (2003), bamboo charcoal contains many microelements like calcium, magnesium, aluminum and calcium*, etc.* Therefore; it can be utilized in producing anti-static products. In Asia it is known as "Black Diamond". Bamboo charcoal products are well received in Japan, Korea and Taiwan (Suneel, 2008).

3.4.7. Bamboo in Industrial Engineering

Bamboo board possesses physical and mechanical properties similar to that of water proof plywood and has excellent internal bond strengths, a high plane rigidity and hence high racking strength (Nath *et al*., 2008). It is as durable as phenolic-bonded plywood and is resistant to boiling water, weather and biological agencies (KEFRI, 2007). It has better scratch and stain resistance properties than plywood. It resists fire with the same degree as fire-retardant treated plywood. It has a rich natural appearance and bamboo board can be used for making bottom boards of trucks and buses (ply bamboo and laminated bamboo strips), bottom boards of railway wagons, bottom boards of railway flatcar, furniture, prefab houses, flooring, partitioning for commercial and industrial buildings, and ceiling for residential and commercial buildings. Some other industrial products of bamboo are pulp and paper, ply bamboo, bamboo medium density fiber boards, laminated bamboo flooring, bamboo particle boards, corrugated bamboo roofing boards, bamboo strand boards, bamboo cement particle boards, bamboo curtains, incense sticks, tooth picks, tool handles, umbrella, broom handles, wine storage barrels, sport and musical instruments, canes, brushes and buttons. Bamboo is also used in a brewery plant to produce beer through fortification of extracts of bamboo leaves (KEFRI, 2007).

3.4.8. Bamboo as source of income

Bamboo is a potential economic resource capable of generating employment for rural poor and skilled and semi-skilled farmers and entrepreneurs in plantation and in semi industrial and industrial ventures. Bamboo and its related industries provide income; food and housing to over 2.2 billion people worldwide (Cherla, 2008; Walter, 2002). The investment return for a new bamboo plantation is 3-5 years thereby signifying that it is a critical element of an economy (FAO, 2005). Today, the overall world market over 10 billion US $ trade as many substantial uses of bamboo exist (FAO, 2007). Bamboo is the most widely used plant in Ethiopia, especially by the economically disadvantaged, local poor groups/communities. Therefore, in the bamboo production villages, bamboo has economic, social and cultural importance, ranking second only after agriculture in village production systems. In comparison with other forms of natural resources utilization, the bamboo sector is highly profitable and it requires from little to big capital investment. Therefore, the monthly profit margins are relatively high. Moreover, bamboo harvesting and processing is an important economic safety net for young men in situations of economic recession (Melaku Tadess, 2006; Ensermu *et al*., 2000).

3.5. Environmental Contribution of Bamboo

Bamboo is playing an important role in the protection of ecological systems. Broadly speaking, bamboo belongs to green plant and it can purify air and help regulate climate. Because of its growth habit, it can also reduce water and soil erosion, conserve water resources while also protecting against wind and sand erosion and sand drift. In many ways, bamboo is superior to other trees and plants in the protection of ecological systems. Compared with

the other trees and plants, bamboo production cycle is shorter, germination is quicker and ecological adaptation is better. It can renew forest vegetation rapidly, fix top-soil and reduce erosion of the water and soil and Bamboo can maintain the water and soil effectively due to its huge rhizome-culm system. Bamboo stand community structure is steady and can protect ecology sustainability even if it is harvested for several decades (INBAR, 2006).

3.5.1. Bamboo for Soil conservation and degraded land rehabilitation

Bamboo forests have an extensive rhizome system, a thick litter layer, highly elastic culms, and a dense canopy (Song *et al*., 2011). These characteristics give bamboo forests a high capacity for erosion control, soil and water conservation, landslide prevention, protection of riverbanks, windbreak and shelterbelt potential. In China, more than 90% of bamboo forests are found in the source regions of major rivers and lakes and along riverbanks, where they play an important role in regulating water flows, protecting water sources, and reducing water erosion (Song *et al*., 2011). According to study on a new bamboo plantation programs by INBAR project studies with 106 ha of land in India, its 5th year after planting, the annual soil erosion has significantly decreased from 4,235 tons/km^2 to 436 tons/km^2 (Lou , 2009). Bamboo is an ideal plant to help prevent erosion as it grows and spreads quickly and forms a network of rhizomes and roots to control or stop damage from flowing water (bamboophil, 2011). Bamboo forests are characterized by a complex network of root system making promoting water percolation, and in sheltering the soil from wind erosion and sun drying (Kassahun, 2003; KEFRI, 2007) making them more efficient than other forest species in holding soil particles together (Kassahun, 2003). Its networks of rhizomes it protects soil erosion, and conserves water hence reduces downstream and very good to rehabilitate the degraded lands (UNEP, 2008; Ogunjinmi *et al*., 2009; ECOMAR Consult, 2011). Bamboo trees maintain permanent canopy over the soil and are excellent at reducing soil erosion, while providing a source of wood for income-generating activities. Three years old plantation reduced soil erosion by 75% at an INBAR project site in China, even before canopy closure. Bamboos are also often used to stabilize riverbanks. They can also be used to absorb excess nutrient and fertilizer runoff such as around piggeries/chicken sheds, septic tanks, and sugarcane fields (Nath *et al*., 2009; Andrew *et al*., 2012). It regulates water flows, reduces water erosion on slopes and along riverbanks, can be used to treat wastewater and can act as windbreak in shelterbelts, offering protection against storms (Andrew *et al*., 2012).

3.5.2. Bamboo as maintenance of soil fertility

Bamboo helps maintain soil fertility by adding organic matter to the soil, increases oxygen levels in the air, can be used as windbreaks and privacy screens and for enhancing the beauty of landscapes, and provides shade as well (Bamboophil, 2011). A study by Nath and Krishnamurthy, (2008), indicated that a site planted with bamboo for 15 years showed that Soil organic matter content increased greatly from 31.0 to 79.2 g kg^{-1}; total N increased from 2.02 to 4.61 g kg^{-1} total phosphorus content increased significantly from 7.14 mg kg^{-1} to 475.6 mg kg $^{-1}$ and amount K increase even with high fertilizer input. However, soil pH value lowered significantly on the contrary. Bamboo grows on elevated grounds and riverbanks (Nath *et al.,* 2008) and can cope with temporal floods (Kaushik *et al*., 2005). This explains why bamboo has been reported as a successful measure in different areas. In the midlands of Nepal bamboo was planted in gullies were it was effective in trapping collapsed soil (Kaushik *et al*., 2005). The deposition of soft soil and the increased retention of soil moisture resulted in favorable growth conditions. Bamboo was planted in a plantation but a combination of bamboo and a check dam was also installed probably similar have been taken on another location.

3.5.3. Bamboo for Carbon Sequestration and climate change mitigation

Global attention to the potential role of afforestation and reforestation in the fight against climate change has been increasing. However, the majority of traditional reforestation schemes utilize slow growing species. With regards to the sequestration properties of trees, bamboo differs in two major ways: its fast growth enables it to sequester significant quantities of carbon dioxide (CO_2) in a relatively short time period, and the harvesting of selective culms does not kill the tree but rather stimulates further growth. Bamboo even sequesters up to 12 tons of carbon dioxide from the air per hectare and it release 35% more oxygen than equivalent stands of trees (ECOMAR Consult, 2011). Bamboo forest ecosystem is an important part of forest ecosystem and an important carbon source and carbon sink on the earth (Song *et al*., 2011). Bamboo is one of the fastest growing plants in the world. Studies showed that appropriately managed and regularly harvested bamboo stands can sequester more carbon than if left in their natural state, and moreover, it can sequester more carbon than fast-growing tropical and sub-tropical trees in comparable conditions (INBAR, 2012). Due to its renewability, bamboo can take pressure of other forest resources and contribute to avoided deforestation (INBAR, 2012). Thus bamboo has a high potential to use in mitigation measures to alleviate threats imposed by local changes in climate on vulnerable populations (INBAR, 2011). Modeling by INBAR indicates that managed bamboo holds higher levels of carbon than equivalent tree plantations, and bamboos sequester carbon more rapidly in the early years of plantation establishment (INBAR, 2011). Over 90% of bamboo carbon can be sequester in durable products such as boards, panels, floors, furniture, buildings, cloth, paper, and activated charcoal. Bamboo also has potential as a source of bamboo biochar, a carbon product produced from plant matter under conditions of low oxygen, which releases gasses that can be used to produce fuels and for power generation (Andrew *et al*., 2012). According to Intergovernmental Panel on Climate

Change (FAO, 2009), bamboo is useful in climate change mitigation and poverty alleviation. Significant climatic changes are expected for the regions where bamboo species is plentiful as natural or introduced species. Beneficial environmental effects of bamboo that range from reclamation of severely degraded sites to providing shelter during floods and earthquakes may foster project developments (FAO, 2009). However, not considering bamboo stands as forests in a plans of (reducing emissions) from deforestation in developing countries (REDD), would neglect significant carbon stores, highly effective carbon sinks, and proven pillars of rural livelihoods.

4. Conclusion

Bamboo can play a crucial role in rural economy and environmental protection to sustain the livelihoods of many rural households. It uses as a vital role in environmental amelioration, biodiversity preservation, and soil conservation and protects other plants from frost, wind and water erosion and it from freely moving speedy winds and frost. Bamboo is useful in climate change mitigation and poverty alleviation. Significant climatic changes are expected for the regions where bamboo species is plentiful as natural or introduced species. It helps maintain soil fertility by adding organic matter. It also used as a potential economic resource capable of generating employment for rural poor and skilled and semi-skilled farmers.

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