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Address: -North Asian International Research Journal Consortium (NAIRJC) 221 Gangoo, Pulwama, Jammu and Kashmir, India -192301, Cell: 09086405302, 09906662570, Ph. No: 01933-212815,
Email: nairjc5@gmail.com, info@nairjc.com **Website:** www.nairjc.com

REVIEW ON SOCIO-ECONOMIC AND ENVIRONMENTAL BENEFITS OF BAMBOO FOR RURAL COMMUNITIES IN ETHIOPIA

KALKIDAN FIKIRIE[1], TEWODROS MULUALEM[2] AND EPHREM TESEMA[3]

[1,2]Jimma Agricultural Research center, P.O. Box 192, Jimma, Ethiopia

[3]International Livestock Research Institute (ILRI), P.O. box 5689, Addis Ababa, Ethiopia

ABSTRACT

Ethiopia had endowed climate with immense natural resources which includes timber and non- timber natural forests. However, little has been done to tap the large potential of bamboos as non-timber forest resources mainly in terms of making them viable to support sustainable rural livelihood, youth employment and as a strategic resources to transform the livelihood outcomes of marginalized communities. This paper attempts to review the potential share of bamboo the country endowed with and the various roles it broadly play as a raw material for construction the food and beverage industries, for pharmaceutical, as a source of income and livelihood for communities and as key natural resource base to protect the ever degrading natural environment. Besides, it provides opportunity to promote green economic development in such era of climate disaster and aridity of knowledge to bring scientific solutions to the problem facing economically transitional and yet developing regions and countries of sub-Saharan Africa.

Keywords: Bamboo, environment, Ethiopia, renewable energy, socio-economic.

1. INTRODUCTION

During the last century, forests were mainly assessed in terms of the commercial value of timber. Rarely was other forest components considered to be of major economic importance (Ogunjinmi *et al.*2009). In the 1900s, an immense area of tropical forests were denuded of timber for local use and exportation, bamboos and other Non-Timber Forest Products (NTFPs) were usually discarded or destroyed during logging operations. In the 21st century, however, there is a growing consensus that NTFPs are not only crucial to ecosystems, but also invaluable to the sustainable foreign exchange and are increasingly being regarded as valuable commodities around the world.

Bamboo is one of the fastest growing NTFPs and therefore, known as "Green Gold" (Ram *et al.*, 2010). It is a green gold which is abundantly available and cheap to meet the growing needs of human populace from the "child cradle to the dead man's bier". That is why sometimes it is known as a "poor man's timber". People who live in Africa, Asia and South America are depending on it for house construction and producing farm tools.

Different species of bamboo have been used by people in imaginative and widely varied ways in different parts of the world. They have long histories of use and play important roles as sources of livelihood for millions of people in the world. Furthermore, as highly renewable natural resource, they are very important mainly in areas where rapid environmental degradation is occurring (Rao *et al*., 1996). Bamboos are an incredibly adaptable to wider environmental niche and useful species of plant. It can be categorized as multipurpose crop varieties, with many usages like raw material for handicrafts and art of basketry (Sarfo, 2008).

Bamboo is indigenous to various countries in Africa and different socio-economic and cultural purposes. In Ethiopia, bamboo has a potential role in providing employment and economic growth opportunities for rural and urban communities. In terms of area coverage, it covered over 1million hectares of land. The country in general is representing 67% of the African bamboo forest which is the largest in the continent and represents about 7% of the world total (Mulugeta, 2013). Despite its socio-economic importance, the production and processing of bamboo for various purposes is low in Ethiopia. The reasons for this, low attention given to the value of the crop, lack of skilled man power and technology problems related to agronomic elements like soil selectivity are a few to mention. In addition, there is no adequate information and awareness with regarding to the importance of bamboo mainly in terms of its contribution for the livelihood of rural households in various agro-ecological contexts in Ethiopia.

However, in many cases, the economic and development potential of bamboo as an alternate "cash crop" can be enhanced through utilization as rich endowment comparing to other natural resource that can provide a platform to stimulate growth and development in the country (Tesfaye, 2007). In this regard, bamboo can be considered as an important NTF resource and can play a crucial role for constructing fences, bridges kraals, houses and water harvesting schemes and also it is useful in cottage industries as raw materials mainly to manufacture matchstick, baskets, tooth-picks, and different other handicrafts (Jessica, 2015). Furthermore, bamboo is important for agricultural activities especially for supporting horticultural crops.

Bamboo is well observed that apart from its cultural and social importance, economically the second useful commodity next to other agricultural crops among communities inhabited in and around bamboo forests (Mulugeta. 2013). In comparison with other natural resource, bamboo is highly profitable and requires resources ranging from modest one to a bigger capital investment. It is a self regenerating crop; new shoots that appear annually ensure future raw material after mature culms are harvested (Kristina and Juan, 2013). It can help reduce deforestation by replacing trees as a source of bio-fuel. In most part of Ethiopia, bamboo charcoal helps meet the energy demands of rural and urban-dwellers (Sarfo, 2008). As it is an area of investment relatively less capital intensiveness, the expected profit margins from the investment tends to be relatively higher (Melaku, 2006). Cognizant of these facts, strategic use of existing bamboo genetic resource in association with its socio-economic and environmental benefits have valuable impacts for sustainable use and to develop conservation strategies. Hence, this review was designed to assess the socio-economic and environmental benefits of bamboo in Ethiopia.

2. AN OVERVIEW: BAMBOO

Bamboo is the common name for member of a particular taxonomic group of a perennial grass with large woody stem or culm belonging to the family *Poaceae*, subfamily *Bambusoideae* (Chaowana, 2013). It is evergreen-monocotyledonous (non-woody) plant which produces primary shoots without later secondary growth. Each shoot has a distal aerial part called the culm, a proximal ground level part called the culm neck and a subterranean part called the rhizome. Culms consist of nodes and internodes the former with meristematic tissue from where culm sheaths and braches rise (Kleinhennz and Midmore, 2001). Naturally bamboo propagates both sexually and asexually from seeds and rhizomes. Artificial propagation by vegetative methods includes planting of offsets, culm cuttings, layering, and grafting of rhizome (Kassahun *et al*., 2002). Globally, more than 1,250 species are encompasses under 75 genera of bamboo, which are unevenly distributed in the various part of the humid tropical, sub-tropical and temperate region of the countries (Subramaniam, 1998; Chaomao *et al*., 2006). Bamboo found to grown practically in the tropical sub-tropical and temperate region where the annual rainfall ranges from 1,200mm to 4,000 mm and the temperature varies between 16^0C and 38^0C. The most suitable conditions for the occurrence of bamboo are found between 770m to 1,080meters above sea level **(**Ram *et al*., 2010**)**. New bamboo shoots are produced every rainy season from rhizome buds that attain full height and diameter in about 3 months in a fully developed rhizome-root system, which occurs in 3 to 7 years after seeding or establishment by seed. They are mature, strong and ready for utilization after 2 to 3 years of planting. Most bamboo plants produced flower once only in their lifetime (14 to 50 years) and deflowered soon after. They emerge again from

germinating seeds if the site is not severely disturbed by detrimental factors like rodents, fire and etc. These phenomena were actually observed in the lowland bamboo forest of Benshangul Gumze region and Southwestern part of Ethiopia. Seedlings were emerged in large quantity in the subsequent years and it is known to be one of the fastest growing plants in the world, with a growth rate ranging from 30 to 100cm per day in growing season (Kassahun, 2000) and also it can grow up to a height of 36 m with diameter of 1-30 cm (Zakikhani *et al.*, 2017). This growth pattern makes it easily accessible in a minimal amount of time, and therefore can be harvested in 3-5 years versus 10-20 years for most soft woods. The Bamboo size ranges from miniatures to towering culms of 60m and adaptable, multifaceted non-timber plants with a considerable potential to the socio-economic development and environmental protection (Sharma *et al*., 1998). However, Bamboo forests are characterized by a complex network of root system making them more efficient than other forest species in holding soil particles together and carbon sequestration (Kassahun, 2000; Kassahun, 2003; Yenesew *et al*., 2013b).

3. BAMBOO DISTRIBUTION IN ETHIOPIA

In Ethiopia, natural bamboo forest coverage about 1million hectares, which is about 7% of the world total and 67% of the African bamboo forest. Ethiopia is biggest bamboo resources country in Africa which is covered over 850,000ha of natural bamboo (Yeshambel *et al.*, 2011). But the distribution is differ across the location, mostly found in Assosa, Injibara, Gimbi, Ambo, Gurage, Bale, Masha, Chencha and Hagere-Selam (Abiy, 2013). Based on the agro-ecology, there are two variety of bamboo in Ethiopia. According to Kassahun (2000) report, there are highland and lowland bamboos.

3.1. Highland bamboo

The highland bamboo *(Yushania alpine)* grows naturally in the south, south-west, central and north-west highlands of Ethiopia with the altitude ranging between 2200m to 4000m a.s.l. and annual rainfall is over 600mm among the rainy season is not less than three months. The average diameter and height of highland bamboo are 8cm and 17m, respectively (Seyoum *et al.*, 2006). It covers about 15% or more than 100,000ha; of which 13,000hectares has been demarcated as reported by Luso consult (1997). Phillips (1995) reported that, the highland bamboo grows in mountain forest, often on volcanic soils and forms extensive pure stands, occurring in *Podocarpus falcatus* rainforest and with *Juniperus procera* in drier forests. Highland bamboo (*Y.alpina*) is found in Awi zone of the Amhara Regional State is used as construction material for houses, fences, furniture and

beehives in the villages. Mulugeta (2013) stated that, the species has different local name in Ethiopia. In Amharic commonly known as "*Kerekeha*" while Afan Oromo "*Lemmana".*

Table 1: Major highland bamboo areas in Ethiopia

No	Bamboo Area	Region	Natural Stand(ha)	Plantation(ha)	Total area(ha)
1	Injibara	Amhara	30	2350	2380
2	Agaro	Oromiya	-	1500	1500
3	Bale Mountains	Oromiya	56,851	-	56,851
4	Shenen/Jibat	Oromiya	1,774	2561	4,335
5	Gera	Oromiya	36,000	1250	37,250
6	Bore/Hagereselam	Oromiya/South	-	2460	2,460
7	Chencha/Arbaminch	South	2,460	3250	5,710
8	Indibir/Jembero	South	-	1850	1,850
9	Jima/Ameya	Oromiya/South	-	900	900
10	MizanTeferi/Kulish	South	-	1850	1,850
11	Debresina/Wofwasha	Amhara	35	-	35
12	Wushwush/Bonga	South	-	1120	1,120
13	Bonga/Ameya	South	7997	-	7,997
14	Masha	South	18652	-	18,652
15	MunesaShashemene	Oromiya/South	4183	-	4,183
Total			127,982	19,091	147,073

Sources: Ensermu *et al*., 2000

3.2. Lowland Bamboo

The botanical name of lowland bamboo is *Oxytenanthera abyssinica* in Ethiopia. It is an indigenous in Ethiopia and endemic in tropical Africa (Kristina and Juan, 2013). This species grows only in the Western part of Ethiopia along the major river valleys and in the lowlands border of Sudan. Lowland bamboo is found between 1100m to 1700 m.a.s.l. Furthermore, this species grows in savannah woodland, mainly in river valleys and often forming extensive stands (Phillips, 1995) and also pure natural bamboo (monotypic genus) in Ethiopia and the largest in Africa. Lowland bamboo covers over 1million hectares of land and 85% of this area is covered by *Oxytenanthera abyssinica.* The average diameter and height of a single bamboo is 5cm and 7m, respectively (Seyoum *et al.*, 2007). The species has enormous importance for the rural society and fill the gaps of construction material in rural areas. It also commonly used as an alternative for timber in house construction, fences and also as fodder for cattle, human food and as energy supply during the dry season (Ensermu *et al*., 2000).

Table 2: Major lowland bamboo areas in Ethiopia

No	Bamboo Area	Region	Natural Stand(ha)	Plantation(ha)	Total area(ha)
1	Hinde/North of Nekemte	Amhara	8,670	-	8,670
2	Asossa	BenshangulGumuz	77,947	-	77,947
3	Bambasi	BenshangulGumuz	64,245	-	64,245
4	Begi	BenshangulGumuz	21,509	-	21,509
5	Nejo	Oromiya	27,612	-	27,612
6	Dibate	BenshangulGumuz	14,200	-	14,200
7	Guba	BenshangulGumuz	7,757	-	7,757
8	Kemashi	BenshangulGumuz	33,723	-	33,723
9	Pawe	BenshangulGumuz	53,830	-	53,830
10	Gimbi	Oromiya	29,125	-	29,125
11	Guten	Oromiya	6,044	-	6,044
12	Metema/Dansha/Humera	Tigray/Amhara	425,000	-	425,000
13	Didessa Valley	Oromiya	135,000	-	135,000
14	Dangur	BenshangulGumuz	27,350	-	27,350
15	Bulen	BenshangulGumuz	16,780	-	16,780
16	Galesa	BenshangulGumuz	10,870	-	10,870
Total			959,662	-	959,662

Sources: Ensermu*et al*., 2000

4.THE SOCIO-ECONOMIC BENEFIT OF BAMBOO

The livelihoods comprise of resources or assets that enable strategies to be employed in order to survive and attain desirable livelihood outcomes such as income, food security, wellbeing and sustainable use of natural resources (Carswell, 1997; Carney, 1998). Bamboo has numerous benefits in day to day uses for the rural livelihoods where the species is growing (Tesfaye, 1998); it also plays important roles in the daily life and wellbeing of both rural and urban communities in Ethiopia (Melaku, 2006). Due to their easy workability, strength, straightness, lightness, combined with extra-ordinary hardness, range of size, abundance, short period in which they attain maturity, they are suitable for several purposes and uses. As a result, there are more than 1,500 uses, ranging from medicine to nutrition and from toys to aircraft (Sharma *et al*., 1998). Worldwide, over 2.5 billion people livelihood depends on bamboo (Cherla, 2008); thus playing important role which is socially acceptable, economically viable and ecologically friendly (Kassahun, 2003). Some socio-economic contributions of bamboo for rural livelihoods are:

4.1. For construction material and household furniture

Bamboo is one of the oldest building materials used by mankind in tropical and subtropical regions (Chaowana, 2013). Due to favorable mechanical properties, the high flexibility, fast growing rate, low weight and the low purchasing costs, bamboo is a building material with many opportunities (Lugt *et al*., 2005). The bamboo culms have been widely used in building applications, such as flooring, ceiling, walls, windows, doors, fences, housing roofs, trusses and rafters; it is also used in construction as structural materials for bridges, water-transportation facilities and skyscraper scaffoldings. In addition to these, it has been also processed into an extended diversity of products ranging from domestic household products such as food containers, skewers, chopsticks, handicrafts, toys, furniture, flooring, boats, charcoal, musical instruments and weapons.

Due to the global shortage of housing materials the importance of bamboo as a construction material has received a greater attention in recent years. Low cost bamboo houses are a cheap and safe alternative to the shelters. Fast rotation period and excellent strength properties make bamboo a sensible alternative construction material (Yuming, 2006). Although bamboo houses are sometimes thought of as only suitable for poor people, new designs and production techniques coupled with shifts in perception mean modern high quality houses that combine safety, durability and aesthetic criteria are being produced, whilst remaining affordable. Similar innovations have produced other bamboo structures such as bridges and housing components equivalent to those of other materials (INBAR, 2009). Bamboo houses are not only economical but these form earthquake proof structures and disaster relief solutions.

4.2. Health and nutritional value of bamboo

Bamboo can help provide food security for both human and livestock. The shoots of many species are edible and nutritious and they are the common ingredient in many dishes, whilst it's leaves are known source of fodder for livestock and feed for fish (INBAR, 2009; Chaowana, 2013). As a result of its rich chemical composition, the shoots of bamboos are edible and nutritious. Many nutritious and active minerals, such as vitamins, amino acids, flavine, phenolic acid, polysaccharide, trace elements, and steroids can be extracted from bamboo culm, shoot, and leaf, all having anti-oxidation, anti-aging, anti-bacterial, and anti-viral functions. These are valuable in health care and can be processed into beverage, medicines, pesticides, or other household items like toothpaste, soaps, etc. The leaf of bamboo contains 2 to 5% flavine and phenolic compound that have the power to remove active oxy-free-radicals, stopping sub-nitrification and abating blood fat. Flavine beverage and beer have been widely

accepted particularly in East Asian countries like China, Korea and Japan mainly because of their value in health care. Some materials extracted from bamboo can be used in fresh flavor preservation or food storage application. Some additives obtained from bamboo are used in food, such as bamboo juice, beverage, bamboo flavored rice, etc. The shoot is one kind of ideal vegetable being free in pollution, low in fat, high in edible fiber and rich in mineral. It is cold in properties, functions well in removing sputum, enhancing digestion, relieving toxicity, improving dieresis, and is often used for healing swollen tissues or edema and abdominal disease in which watery fluid collects in cavities or body tissues, called as cites. The shoot also contains saccharine, which can resist little white mouse tumor and also has anti-aging elements (Ogunjinmi *et al*., 2009; Chaowana, 2013).

Table 3: Nutritional contents of Bamboo

No	**Nutrient found in Bamboo**	**Nutrient content /100gm of Bamboo shoots**
1	Crude protein	10.1
2	Crude fiber	21.7
3	Ether extract	2.5
4	Ash	21.3
5	Phosphorus	86
6	Iron	13.4
7	Vitamin B1	0.1
8	Vitamin B2	2.54
9	Carotene	12.3

Source: (INBAR, 2009; Ogunjinmi *et al*., 2009)

4.3. Renewable energy sources

Unlike most timber, bamboo is a self-regenerating natural resource. New shoots that appear annually ensure future raw material after mature culms are harvested (Kristina and Juan, 2013). It can help reduce deforestation by replacing trees as a source of bio-fuel. In Ethiopia, bamboo charcoal helps meet the energy demands of rural and urban dwellers (Sarfo, 2008). It has the potential to be a sustainable biomass source for renewable heat production. It shares a number of desirable fuel characteristics with certain other bio-energy feedstock. Its heating value can be higher than many woody biomass feedstock and most of agricultural residues, grasses and straws. As a result, the use of bamboo as a domestic heating source is a common practice in some producing countries (Getachew and Wubalem, 2014).

4.4. Bamboo as a source of income and livelihood

Recently, bamboo based small and medium businesses are growing in Ethiopia. In most part of highland areas bamboo grows, it has become the major income generating commodities for local communities (Sertse *et al*., 2011). Smallholders depend on bamboo as major sources of food, medicines, fodder, fiber, household utensils, beehives, hats, mats, baskets, handicrafts, furniture, fences, and other countless products and as constructions materials (Melaku, 2006; INBAR, 2009; Aseri *et al*., 2012). Many landless individuals buy bamboo from farmers and engage in income generating projects such as designing and producing mats, fences and furniture and sell along roadsides (Yenesew *et al*., 2013a). In comparison with other forms of natural resource utilization, bamboo is highly profitable and requires proportionally little to big capital investment. Consequently, the monthly profit margins are relatively high. Besides, the harvesting and processing can form an important economic safety net for youth in situations of economic recession in the country (INBAR, 2009).

4.5.Marketing opportunity

Marketing of bamboo products is very traditional and the market system is not broad based in terms of market connections over geographic locations, distribution and in terms of customers test etc. The quality of the products in urban areas is also low. Taking the country as a whole, the use of bamboo products is much less known outside the bamboo producing areas and their vicinity. There is limited product diversification and value addition along the commodity value chains. The bamboo marketing system is largely informal and less connected. This makes it difficult to analyze the value chains, price formation and marketing channels. The bamboo yards in Addis Ababa are engaged in multiple activities of collecting the raw bamboo from growing areas to produce low quality handicrafts as well as for retailing and wholesaling the raw bamboo (INBAR, 2009).

In recent years, transport cost has become serious and limiting problem for running the business in the bamboo yards. It was reported that during the last few years transport cost has increased by more than 50% which is influencing the price of raw bamboo as well. If the bamboo sector were advanced one and well promoted, the problem would bring multi-sectorial effect by and large. In addition, the skill and technology level of the processing activity is very low as can be seen from the products produced and tools and implements used. Simple hand tools are employed which characterize the sector as a low productivity and less quality producer. There is no standard developed and used for comparing raw materials and products to ensuring the quality standards and regulating the market price. Selection of raw material is largely based on traditional ways. Some of the attributes

used in grading are: internodes length of bamboo culm, thickness of culm and age of culm. There is a traditional preference of highland and lowland bamboo for different products. For instance, the lowland bamboo is preferred for making legs of chairs and sofas as it maintain better strength. Experts have the opinion that following the emergence of a middle class in urban areas like Addis Ababa, microenterprises that are processing bamboo have been emerging. But it needs introduction and a strong promotion of the bamboo products (UNIDO, 2007).

5. ENVIRONMENTAL ROLE OF BAMBOO

5.1. Soil and water conservation

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 and protection of riverbanks (Song *et al*., 2011). According to Kassahun (2003) report, the extensive rhizome system of bamboos lies primarily in the top layers of soil, thus it often play a major role in stabilizing soils on steep slopes and river banks. Most of the time bamboo is characterized by a complex network of rhizome root system which makes them excel other forest types to effectively holding soil particles together, thereby preventing soil erosion and promoting water percolation (UNEP-WCMC/INBAR, 2004). As a result of the widespread root system, uniquely shaped leaves and dense litter floor, the sum of stem flow rate and canopy intercept of bamboo is 25%, which is greatly reduces run off, preventing massive erosion and keeping up twice as much water in the watershed (Pandey and Shyamasundar, 2008), particularly in the areas of prone to high amounts of runoff and degraded lands.

On one hand, this species are evergreen plants, thick canopy and soil cover provided by dead leaves reduces splash erosion and enhances infiltration capacity (INBAR, 2009). So, it makes important in securing the hydrological function of the catchments and rivers. Majority of bamboo species are characteristic in high altitude ecosystems on steep slopes in zones of high seismic activity, hence their role in soil stabilization may be critical. The aboveground part of a bamboo forest helps reduce erosion by rainfall interception and by sheltering the soil from wind erosion and sun drying (Kassahun, 2003; Yenesew *et al*., 2013b). In China, more than 90% of bamboo forests are found in the source regions of major rivers and lakes and also along riverbanks, where they play an important role in regulating water flows, protecting water sources, and reducing water erosion (Xiao, *et al.*, 2007). The litter fall improves soil structure and fertility (Fanshawe, 1972) and planting bamboo can help speed up the

conversion of degraded lands into productive. Furthermore the species is economically viable by raising the water table, helping improve the productivity of different high value crops grown on the site (INBAR, 2009).

Figure 1: Bamboo rhizome holding soil particles (left side) and rehabilitates degraded land (Right side)

5.2.Biodiversity functioning

The stand of the species is essentially monocultures and important for biodiversity conservation. In different part of the country, the species provide habitat, food, shelter, and sites for reproduction to a variety of endangered species (Bystriakova *et al*., 2004). In Africa, the Eastern Mountain Gorilla (*Gorilla beringeiberingei*) inhabits in bamboo forests in Uganda, Rwanda and the Democratic Republic of Congo. These endangered gorillas feed bamboo shoots, which can make up to 90% of their diet, corresponding to approximately 35 kg/day for a male gorilla. Another African animal dependent on bamboo is the endangered Mountain Bongo (*Tragelaphus eurycerosisaaci*) a type of antelope from Kenya that hides in bamboo thickets from predators during the dry season. On other continents, bamboo forests provide a habitat for other endangered species including the emblematic Giant Panda (*Ailuropdamelanoleuca*), different species of Bamboo Rats and Bats in Asia. In Madagsscar, the home of the world rarest and most endangered tortoise Ploughshare Tortoise (*Geocheloneyniphora*), the Madagascan Climbing Poisonous Mantella Frog (*Mantellalaevigata*) and several endemic, critically endangered Lemur species (IUCN, 2009). In South America, the Spectacled Bear (*Tremarctosoranatus*) and the Mountain Tapir (*Tapiruspinchaque*) depend on bamboo for food and 4-5% of Amazonian birds are reported to live exclusively in this thicket (IUCN 2009).

Figure 2: Bamboo habitat for endangered reptiles (left side) and mammals (right side)

5.3.Windbreaks and shelterbelts

Bamboo culms are very elastic, bend in high winds, but usually do not break. As a result, they are used as windbreaks to protect cash crops particularly where high winds are frequently appear (Pandey and Shymasundar, 2008). It used in the pharmaceutical, cosmetics, construction, wood, pulp and paper, textile industries and etc. In these industries, bamboo has largely replaced some of the traditional raw materials (Ogunwusi, 2011a). Therefore, the species have led to savings of several plant species that would have been harvested and processed into various products. In wood and wood products sectors, this species is saving forests by replacing traditional wood species being exploited and converted to plywood, particleboard, block board, floor tiles. In Costa Rica, one thousand houses of bamboo are built annually with materials obtained from 60 hectares of bamboo plantation (Bicol, 2010). If an equivalent project used timber, it would require 500hectares of diminishing tropical forests. Accordingly, using bamboo to replace timber and lead to substantial savings of forest and biodiversity. As diversity makes bamboo adaptable to many environments and can be harvested in 3 to 5 years compared to 10 to 20 years in most softwoods and 30-50 years for hardwoods, bamboo is a very adaptable plant to fight the adverse effects of climate change and poverty (Ogunwusi, 2011b).

5.4. Climate change mitigation

It also considered as one of the most promising plants for incorporation into the Clean Development Mechanism (CDM). The main vehicle promoted by the Kyoto Protocol for reducing greenhouse gases and combating global warming. This is due to the fact that bamboo is one of the most productive and fastest growing plants on the planet. The fastest growing species may grow up to 1.2m in a day. These unique capacities makes bamboo is

invaluable sink for carbon storage, competing easily with the most effective wood species in terms of carbon sequestration capacities and play a bigger role in mitigating the impact of future climate change (Song *et al*., 2011).

Intensive management of bamboo forest offers higher productivity than extensive management of bamboo forest or naturally growing bamboo (INBAR, 2009). The ability to perform annual harvesting without affecting the forests re-growth capacity is an outstanding characteristic of bamboo forests. Adjusting the stand's age structure and its density by means of annual thinning can increase productivity and thereby sequester more carbon (Xiao *et al.,* 2007).

The carbon sequestration potential of the bamboo forest also depends on the lifespan of bamboo products. The carbon stored in these products will be released into the atmosphere when these products are either biologically degraded or burned. Thus, producing more durable bamboo products will be a good way to prolong carbon storage. As the fastest growing canopy, the stands release 35% more oxygen than equivalent stands of trees and sequester up to 12tons of carbon dioxide from the air per hectare per year (EBF, 2001). With increasing consciousness of the need for environmental protection and the need to change unsustainable consumption habits, bamboo products with long lifecycles are becoming increasingly popular, which brings hope for more carbon sequestration. In addition, converting bamboo into charcoal as a substitute for fossil fuels could also provide additional opportunities to mitigate climate change (Song *et al*., 2011). Bamboo charcoal can be used as a water clarifier, shield off electromagnetic waves and absorber of poisonous gases. Pollution indoors caused by poisonous materials would be absorbed if the panels were made of bamboo charcoal instead of the asbestos flake board and plastic boards. About 95% of the nicotine and other poisonous materials would be absorbed if cigarette filters were made of bamboo charcoal. It is discovered that bamboo charcoal loaded with microorganism could purify waste water efficiently and effectively (INBAR, 2009).

5.5.Bioremediation of contaminated systems

Bamboo species are used in the remediation of polluted lands and their roles in filtering animal waste to prevent high nitrogen effluents and water desalination (Kristina and Juan, 2013) and help neutralize acidic soil (INBAR, 1999). Additionally, it plays an important role in pollution management due to its dual function of filtration and purification. It helps mitigate water pollution by absorbing nitrogen, phosphorus and heavy metals and fixing them into its biomass. This attribution makes bamboo a powerful agent for ecological wastewater treatment from

manufacturing, livestock farming and sewage. The use of bamboo in the remediation[1] of oil degraded lands through oil spillage is being investigated (Ogunwusi and Onwualu, 2013).

The bioremediation of polluted surface water by using bio-film on filamentous it is feasible and effective. Polluted surface water with refractory organic pollution, low transparency and high nitrogen pollution can be remediated by using bio-films on filamentous bamboo. The filamentous bamboo is beneficial to forming a rich microbial community. It is recommended that filamentous bamboo be widely used for the bioremediation of polluted river water instead of conventional bio carriers and phyto remediation techniques (Coa *et al*., 2012). Bamboo generates plenty of oxygen, lowers light intensity and protects against U-V irradiations and is an atmospheric and soil purifier (Nath *et al*., 2009).

6. CHALLENGES OF BAMBOO PRODUCTION IN ETHIOPIA

Although Ethiopia has the greatest bamboo resources in Africa, unlike the Asian countries, it has a limited tradition of cultivating bamboo and manufacturing products. The use of this abundant resource is restricted to the household level and the primary use of raw material is for housing, fencing and household utensils. There only exists a very limited local market for bamboo handicrafts, which is not further developed or organized. Lack of a regular raw bamboo supply in the operating centers such as Addis Ababa has become a serious bottleneck to manufacturers. Manufacturers reportedly spend several days searching for suppliers and supply points in rural areas. In addition, bamboo areas are characterized by the absence of bamboo based value added processing technologies and manufacturers to boost income and employment from the sector (Ensermu *et al*., 2000; Kassahun, 2003).There is a general lack of technical knowledge on bamboo management and no harvesting regulations presently exist and cutting is seriously depleting the resource base in the areas where extraction is concentrated (Ensermu *et al*., 2000). Besides, bamboo is neglected by research and development programs in the country and not listed as a priority commodity in the development agenda. The public and privet sector including the government wings have little understanding on the potential of bamboo in meeting rural people's subsistence needs and its immense potential in contributing to the growth and transformation of the rural economy.

Over the last few decades, the federal government seems giving little attention mainly due to existing lower understanding of how rich the bamboo resources are and what could be achieved by the country developing these resources. Coupled with the country's many other socio-economic challenges, it is no surprise that there has been little efforts done by the government in designing and implementing government strategies to improve bamboo management and utilization (Wang, 2006). As an exception, it has been reported that the government had a plan to strengthen the management and use of native bamboo and reed species in 1994. The program focused mainly on assessing the market for bamboo as a raw material for export, manufacturing and marketing of artifacts and use in the paper and pulp industry. But so far little improvement on bamboo development has been done in Ethiopia (Ensermu *et al*., 2000). To this end, Kassahun (2003) concluded that the principal cause that has led to the neglect, underutilization and destruction of the Ethiopian bamboo forests are grouped in to two: insecurity of land tenure right and lack of economic incentive to value them as useful commodities.

Besides, in Ethiopia, natural forest including bamboo belong to the state, yet the government lacks provisioning economic incentive for stakeholders and weak in it's the financial capacity to protect and manage them properly. The attention of the government seems focusing on natural forests from where financial gains are tapped from timber extracted for industrial use (Kassahun, 2003). But on the other hand, when rural people face the shortage of food and raw material for subsistence needs, thousands of hectares of bamboo are either left to decay or degrade for lack of proper management (Wang, 2006). Given the limited market demand and lack of technical knowhow on bamboo management, the percentage of bamboo plantations established by farmers is very small. When farmers realized that there is no large demand for bamboo culms in rural markets, and that transporting them to nearby urban areas was not financially viable (Kassahun, 2003), they chose to focus on other products that can guarantee a stable income though too little.

7. CONCLUSION

Bamboo is one of the oldest building materials used by mankind in tropical and subtropical regions due to their easy workability, strength, straightness, lightness, combined with extra-ordinary hardness, range of size, abundance, they are suitable for several purposes and uses. It can help provide food security for both human and livestock and can help reduce deforestation by replacing trees as a source of bio-fuel. Its extensive rhizome system of bamboos lies primarily in the top layers of soil; hence the species often play a major role in stabilizing soils on steep slopes and river banks. Bamboo is characterized by a complex network of rhizome-root system, which makes them excel other forest types in effectively holding soil particles together, thereby preventing soil

erosion and promoting water percolation and plays a bigger role in mitigating the impact of future climate change by sequester carbon. It releases 35% more oxygen than equivalent stands of trees and sequester up to 12 tons of $C0_2$ from the air per hectare per year.

Bamboos are used in the remediation of polluted lands and their roles in filtering animal waste to prevent high nitrogen effluents and water desalination. Thus, bamboo an adaptable and multifaceted non-timber forest resource with a considerable potential to the socio-economic development, environmental protection and can play an important role in the reduction of timber production, environmental and forest protection, poverty alleviation and sustainable development of rural livelihood wellbeing.

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