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ECONOMIC, SOCIAL AND ENVIRONMENTAL ASSESSMENT OF BAMBOO FOR INFRASTRUCTURE DEVELOPMENT

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Abstract

The economic, social and environmental assessment of bamboo was necessary in this study, because there is a shift by world's industries to its cultivation and usage. The increasing demand for wood and its products, coupled with the high depletion of the forest has contributed to the world global warming and as a result of this problem, most industries are now advocating for the use of natural materials for infrastructure works. Bamboo being a multifunctional, fast growing and a renewable plant was considered as an alternative to timber from the forest. Its wide range of uses as wood and wood product has add greatly to the agricultural economy as this has created an employment and income generation to the rural poor who goes into its cultivation and it has contributed to community development and revenues to governments. The social assessment also looked at how bamboos investment in a geographical area affects the livelihood of the people looking at the benefits, risks and threats related to the industry for the local people whilst the environmental assessment explores the plantation's impacts on local forests, non-timber forest products, water resources and biodiversity, paying attention to the interlinkages between social and environmental assessment. The fast diminishing of the forest cover, degradation of environment and fast deteriorating ecology threatens the very existence of man and animals. The development of the bamboo resources globally will greatly add to the environment and the ecological balance of oxygen and carbon dioxide in the atmosphere and the impact of the industry on the social life of people, as we consider the threats related to the industry in the locality. The study shows that a planned, scientific and holistic approach to the cultivation, processing and management of bamboo on a sustained basis will make bamboo a sustainable alternative material for infrastructure development and can play a significant role in the restoration and rejuvenation of rural and national economies by those who goes into its cultivation. By adoption and implementation of an appropriate technology on bamboo and its products, the infrastructure needs in most African countries will be attained.

Keywords: Appropriate Technology, Cultivation, Deteriorating Ecology, Global Warming, Management, Renewable Plant, Sustainable Material.

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1. INTRODUCTION

Bamboo, the fastest growing and highest yielding renewable resource is found extensively in Africa, Asia, South and Latin America with numerous advantages over

soft and hardwoods. Its current economic and social benefits to its growers has impacted positively in revenue returns on the livelihood of the people as well of serve as employment to the youth in the geographical areas where they are setup and brings massive development to the communities where their cultivation is commercially and industries to process them. Bamboo's maturity for harvesting is between 3-5 years from the time of plantation as compare to that of softwood or hardwood which takes 50-100 years ABS (2002). Bamboo could grow from sea level to as high as 300 meters whilst it attains its full height within 2-4 months Adekoya (2003). The culm/stem of bamboo has been used as a building material for construction by mankind for centuries Londoño (2002). In recent years, the bamboo culm has been made into an extended diversity of products ranging from domestic household products to industrial applications. The advancement of science and technology in recent years has contributed enormously to bamboo growth commercially by farmers, new methods of processing and preservation techniques by industries which rely on its produce as their raw material supply for their manufacturing. Some of the industrial products from bamboo are chopsticks, handicrafts, musical instruments, pulp and paper, toys, food containers, skewers, weapons, bridges, furniture, flooring, boats and charcoal Kusters, *et.al.*, (2001).

The current high dependency on forest cover, degradation of environment and fast deteriorating ecology threatens the very existence of man and animal because of its adverse impact on climate and ground water resources. Accelerated overuse and mismanagement of our natural forest resources and galloping rise in human and livestock population is leading to fast dwindling of our natural resources with adverse consequences leading to impoverishment of watershed, disruption of ecological balance and consequently having an adverse impact on the quality of life of man globally. With a sustainable bamboo investment combine's managed forestry with the potential for short-term profitability, delivering returns which take just 3-5 years after planting, makes it a stable and reliable source of annual income to its users as well as the government. A planned, scientific and holistic approach to the cultivation and management of bamboos on sustained basis can be an inexhaustible source of goods and services which can play a significant role in the restoration and rejuvenation of rural economies and the overall economic development of countries which goes into its cultivation. A 20m bamboo culm can replace itself within 50 days as opposed to a 20m hardwood tree which can take decades to grow. A single bamboo clump can produce up to 15 kilometres of usable pole over a 15-year period. Bamboo sequesters around 4 times more CO_2 than average timber and produces 35% more Oxygen. Bamboo possesses an excellent tensile strength property of 52 pounds per square inch, stronger than most steel. Bamboo is a major component in the construction industry and infrastructural developments across South America and Asia. In the past 10-20 years, bamboo and its products has been developed as an exceptionally-valuable and often superior substitute for soft and hardwood which has contributed to infrastructure development of most countries in Asia and South America especially. Considering the increasing demand of timber and wood, which is scarce due to deforestation in the world today of which Africa in not exception, bamboos can serve as an alternative to survive the forest and its products. Due to its multiple uses, bamboo's cultivation is contributing greatly to the social needs of those who goes into its growth as well as the

community and the nation at large. It creates employment to farmers, small and medium scale enterprises within the geographical areas of it plantation which add greatly to the rural agricultural economy in general and alleviates poverty from the rural poor. In spite of the positive attributes, their cultivation has brought some adverse threats and risks to the local dwellers, animals, plants, water source, natural inhabitants which depends on others to survive, non-timber forest products, the natural forest as well as the environmental effects due to the various activities that goes on with the processes in the industries. This paper seeks to assess bamboo's economic, social and environmental development on infrastructure as a drive for economic and integration in Africa.

2. Methods

There was an assessment on cultivating, harvesting, preservation and management techniques for bamboo was examine and how it promotion could be improve the socio-economic livelihood of those who goes into it propagation as well as help in reducing the environmental threats that the world is facing now of which Africa is inclusive. A detailed study was conducted on the applications of bamboo to the infrastructure development of Africa. The Strengths, weaknesses, opportunities and threats analysis (SWOT) of bamboo was taken into account to determine the way forward.

3. RESULTS AND DISCUSSION

3.1 Economic, Social and Environmental Assessment of Bamboo

In the sections above, the status of natural resources and socio-economic development of bamboo was assessed along with background information on its plantations. The economic, social and environmental impacts of bamboo plantations in this case was examined as stated below.

3.1.1 *Economic benefits of bamboo*

The economic assessment revealed that bamboo plantation, harvesting and processing have both positive and negative economic effects in the geographical areas of growth. Bamboo cultivation creates an opportunity for income generation activities for rural people and serves as job creation to those who engages in its activities as well as employment to small and medium scale enterprises. The most important economic benefits that most rural dwellers get is when they engage in commercial transaction in their bamboo produce. Commercial bamboo farmers employ worker from the locality to work on their farms. Findings shows that most communities that bamboo is grown commercially benefit from infrastructures such as houses, roads, electricity, schools, hospitals as well as good pipe borne water. The local community and the people has benefited from community development projects from these industries as their livelihood has improved through these benefits. However, most farmlands and production forest areas have been negatively being affected as bamboo farming has

become lucrative and most farmers are now turning their crop growing farmlands into bamboo farms though they do intercrop between the bamboos when they are young. These have cause the migration and destruction of some species of birds, animals, flies, insects and plants that help in provision of food and medicine to the local people within the community. The spillage of chemicals herbicides from the plantation has contaminated the land which causes the land to become infertile. Most people have to travel long distance to search for limited lands for crops cultivation and if care in not taken food security will become tenuous in the future. In all, the economic benefits outweigh the negative effects as from the assessment made so far in the communities where they are propagated. Rural communities and people have experienced great impact in their economic lives, infrastructure and in their livelihood. Income generated from farm produces was seen to have declined in areas where commercial bamboo farming is increasing while other income generating activities, such as trade and wage labour has increased in the bamboo enterprises.

3.1.2 Social benefits of bamboo

The social assessment of bamboo has revealed that bamboo plantation, harvesting and processing has brought much social benefits to rural dwellers, communities and nations which commercialized its plantation. 'Bamboo' mostly considered as "poor man's timber" because it is readily available for poor classes at often very low costs in some years past, mostly in many developing countries where it is available. Social development, investment management system and agriculture production were assessed. From the assessment made from this study shows that, the social conditions of the people in the areas where bamboos are grown commercially has transform positively, because they have made huge amount of returns from their proceeds. They get foreign exchanges in the form of capitals, machinery and other facilities to boost their socio-economic lives as they engage in its trade. This has brought a new development to the wood processing industries as bamboo's investment has come to stay. This was particularly demonstrated in the republic of China's in the Linan County, where bamboo was capable of moving the entire communities from the poorer to the richer social class, based on their engagement in its cultivation and trade commercially. Bamboo groves can be managed by individual farmers, who need only basic tools for harvesting. And with processing plants for shoots, culm for flooring, paneling and many more products for domestic and export markets, bamboo has provided much needed revenues and enhanced most of the social developmental amenities to the people, communities and nations which engages in its cultivation and processing commercially and this has been demonstrated in most Asian and South American countries.

3.1.3 *Environmental benefits of bamboo*

The environmental and ecological benefits of bamboo explore the plantation's impacts on local forests, non-timber forest products, water resources and biodiversity. The current environmental problems being experienced globally in recent years indicated

that the current patterns of development are not sustainable. These indications highlight the need for injection of environment friendly developmental patterns and processes through industrial development needs to be sustained. In recent times, our environment has suffered many disasters resulting from climate changes causing floods in many countries leading to loss in human lives and properties Soyinka (2012) and Folaranmi (2012). In view of the above, the effect of climate change is fast becoming global reality. As climate change is fast becoming a global phenomenon, it is already influencing patterns of production and consumption activities, including international trade. Among the major causes of climate change is deforestation which accounts for almost 20% of all anthropogenic emissions ITTO (2005). As a result of this, development initiatives globally tends to support activities that downplays the role of forest resources as industrial inputs, most especially, the utilization of slow growing soft and hard wood plant species, as efforts are been directed towards production and utilization of fast growing high yielding alternatives such as bamboo in industrial production processes.

Currently, more governments appreciate bamboo's quality in protecting soils and regulating water levels. In Mali, Savannah bamboo (Bindura bamboo as it is known there) is officially protected and in Colombia, Guadua bamboo harvesting is strictly regulated by the environmental authorities. Bamboo groves also support important biodiversity, which can be retained as long as sustainable, selective harvesting systems are applied. Bamboo management requires few inputs of biocides, as few problems with pests and diseases have been reported. Globally, deforestation has led to significant reduction in the forest cover as a result of high dependence on wood species for domestic processing and exportation. Though, bamboo has contributed immensely to the social needs of its growers and traders, as it enhances the development of their communities' amenities, there are some negative effects on the environment as natural forests are being destroyed to pave way for the cultivation of bamboos. Most chemicals such as pesticides and weedicides used in the plantations drains into the soil and water bodies causing the death of livestock and other aquatic species in the area of its cultivation as well as the human beings living in the communities of growing.

3.1.3.1 *Environmental degradation*

The environmental degradation is assuming a serious dimension globally, more especially in most African countries, where it is affecting security of nations. Environmental security deals with environmental issues which threatens national security of a nation in any matter. Environmental degradation is not the case that all environmental events can be said to be threatening national security, issues such as deforestation, destroying of water resources, natural forest produce and biodiversity losses which have assumed serious dimensions and are capable of threatening a nation's security Fagboun (2011). The urgency of addressing issues of environmental degradation is also recognized by United Nations which has identified environmental

degradation as one of the six classified threats with which the world must be concerned now and in the decades ahead UN (2004).

Environmental degradation is the deterioration in environmental quality from ambient concentration of pollutants and other activities and processes such as improper land use and natural disasters. The erosion of the quality of natural environment are caused directly or indirectly by human activities. Environmental degradation is of two broad types: when natural habitats are destroyed or rendered unusable through pollution or contamination; or natural resources are misused, overused, and made scarce and eventually depleted FAO (1994). The major causes of environmental degradation across the globe are the misuse of natural resources. Cook *et al.,* (1999) reported land degradation to be caused primarily by activities relating to increase in human populations, in-appropriate agricultural and human settlement policies. Land degradation can be a slow process or extremely rapid, depending, on environmental or social conditions, leading to reduced carrying capacity of the land due to loss of ecosystem formations Cooke *et al.,* (1999). Some major environmental problems being faced globally today include:

a. Climatic change and ozone depletion;
b. Industrial pollution and waste generation;
c. Uncontrolled logging with inherent problems of the destruction of bio-diversity;
d. Oil pollution from spillage and gas flaring related problems;
e. Inappropriate agricultural practices;
f. Destruction of watersheds;
g. Soil-crust formation caused by loss of water;
h. Population pressure and the continuous exploitation of marginal lands and desertification;
i. Coastal and marine erosion; and
j. Destruction of vast agricultural lands.

Environmental degradation from the perspectives of physical and cultural landscapes, the physical or natural environment globally has been seriously destroyed. The cultural landscape which denotes interaction between man and environment has seriously been destroyed too by activities such as inappropriate agricultural practices, mining operations, tree felling and construction of bridges, houses, road networks and railway among others. According to Jimoh *et al.,* (2012), land degradation has assumed a definite pattern globally. The major causes of climate change, environment and land degradation are subsequently discussed.

3.1.4 *Deforestation, climate change and land degradation.*

The over exploitation of the forest resources in most countries across the globe have contributed to the climate changes. The high rate of deforestation of reserved forest by nations has placed serious limitation on forest cover in most countries Adeyoju (2001).

Other causes of deforestation are population increase, poverty, poor farming systems, extensive grazing and uncontrolled forest fires, urbanization, land tenure system, inadequate forest policy and law by nations across the globe, especially most African countries.

3.1.5 *Bamboo, contribution to climate change mitigation and land degradation*

The challenge presented by climate change has been described as a MAD challenge by INBAR (2009). According to Schellenhuber (2009), this challenge requires simultaneous action on Mitigation, Adaptation and Development (MAD). In Africa, the resort to this approach will assist in ameliorating the problems of land degradation, erosion, flooding and deforestation. As a result of its nature, industrial properties and growth characteristics, bamboo contribute to the MAD challenge INBAR (2009). The roles of bamboo in mitigating climate change and land degradation problems, deforestation, soil erosion, biodiversity loss, conservation, industrialization and in food security are subsequently discussed.

Bamboo may be important in helping reduce global climate change effects. Bamboo may be more efficient than some other crops in sequestration of carbon dioxide. Sequestration of carbon dioxide by bamboo may be partially neutralized by a shorter life cycle of bamboo products. Bamboo products often last shorter periods of time in their applications compared to other materials, before decay sets in and greenhouse gas emissions are returned to the atmosphere.

In achieving the United Nations agenda on industrial development pattern on climate friendly and sustainable paths, it has become imperative that new concepts, ideas and actions be put in place. The positive contribution of bamboo to the development of the Asian economy and its deployment as a major agent to fight climate change in other parts of the world including Kenya, the Philippines, India, etc. through reduction in the rate of deforestation and biodiversity loss makes it an appropriate agent for infrastructure development across the globe. Hence promotion of awareness and understanding of bamboo as “Green Gold” among farmers, traders, industry, and to other people globally with a view to utilizing its full potential and to galvanize the rural and industrial economy.

3.1.6 *Carbon sequestration*

The rate of carbon sequestration by bamboo is one of the highest in the world. Bamboo grows very fast and establishes rapidly RMRDC (2004). It grows both in the forest and plantations INBAR (2009). In plantations where selective annual harvesting of mature culms takes place, bamboo can sequester more carbon, especially if the harvested carbons are turned into durable products Karmakur *et al.*, (2008). Bamboo produces more carbons when managed intensively according to a report by INBAR (2009) and EBF (2001). Consequently, development of bamboo plantations is one of the major ways of reducing environmental effects of the climate change. According to

Environmental Bamboo Foundation EBF (2001), bamboo growth habits allow high rate of production of oxygen than equivalent stand of trees. Bamboo growth holds significant implication for reduction of atmospheric carbon dioxide being the fastest growing canopy that releases 35% more oxygen than equivalent stands of trees and sequester up to 12 tonnes of carbon dioxide from the air per hectare per year in a report by EBF (2001). The storage sequestration potentials of managed forest ecosystem also depend on the use of harvested materials. As long as the volume of the bamboo production keep increasing, then the bamboo system is a sink, as the rate of extraction is higher than the rate of carbon release INBAR (2009) and ABS (2002).

3.1.7 *Reduction in the rate of deforestation*

Reduction in Forest Degradation and Destruction (REDD+) is one of the building blocks of the United Nations Framework on Climate Change Convention (UNFCCC) to fight climate change. As deforestation is a major cause of greenhouse gas emissions, curbing deforestation is an important way of reducing greenhouse gas emissions and reducing concentrations of CO_2 in the atmosphere quickly INBAR (2009). Bamboo also covers light intensity and protects against ultraviolet rays Pandey and Shyamasundar (2008). The basic idea of REDD+ is to create positive incentive for developing countries with tropical forests to reduce deforestation rates by rewarding them financially Bells *et al.,* (2007). The strong potential of bamboo for poverty alleviation in rural areas, the establishment of bamboo plantations, coupled with production and development of a broad range of durable bamboo products could address mitigation without compromising development objectives Williams and Pao (1994) and Stevens (1995). These make the case for establishment of bamboo forests very important and eligible under REDD and Land use, Land Use Change and Forestry (LULUCF) in UNFCCC negotiations INBAR (2009). Bamboo accumulates considerable quantity of biomass in a short time, having a low rotation period of 2-5 years. Biomass production depends on species, site quality and climate. The figure varies from 50 to 100 tons per hectare, comprising culm biomass of 60 to 70%; branches, 10 to 15% and 15 to 20% foliage EBF (2001). Thus the establishment of bamboo plantations and industrial utilization of the plant instead of wood will substantially lead to reduction in the rate of deforestation globally (Ogunwusi, 2011a) and (Ogunwusi, 2011b).

3.2 BAMBOO RESILIENCE

Bamboo provides resilience for a high number of people on global basis. About 1 billion people rely on bamboo in one form or the other Sanjay (2008). Throughout the sub tropics and tropics, rural populations live in bamboo houses, build their agricultural infrastructures and tools from bamboo and sleep on bamboo mats Hoogendoorn *et al.,* (2008). Nearly all areas of livelihood such as transportation, storage, medicine and food depend on bamboo Ogunwusi (2012). Described as wood of the poor in India and friend of the people in China, bamboo has become so much a part of the culture in a number of societies that the existence of a bamboo age has not been ruled out (World Custom Organization (2007). Bamboo is currently providing resilience for the millions of

people exposed to violent climate events. In typhoon-battered parts of the Philippines, traditional bamboo houses have been designed to include features that will make the structures resistant to high winds and floods and to provide maximum strength EBF (2001). For those who derive their livelihoods from bamboo cultivation, bamboo offers a number of benefits and has relatively high levels of growth and income security. Bamboo grows very fast with speeds of up to 1 meter in 24 hours. Productive grooves can be established from scratch in ten (10) years and individual culms harvested after 3 to 5 years (depending on species) Alfonso (1987). The benefits of this short rotation include lower levels of exposure to outside risks such as fire, and flexibility to change management and harvesting practices relatively quickly when facing climatic changes. The fast growth and early maturation of bamboo culms means that a bamboo stand can be selectively harvested by extracting older culms and leaving younger ones to grow without decreasing total stand biomass INBAR (2009). Annual harvesting of bamboo generates regular income stream that gives bamboo farmers a quick return on investment and an important annual safety net INBAR (2009). Another major advantage of bamboo is that it grows on marginal lands, such as degraded land and steep slopes, leaving better lands for more demanding crops ABS (2002b). Consequently, bamboo can be planted in nearly all degraded lands, especially where gully and sheet erosion are ravaging Ogunwusi (2012) and in soil damaged by overgrazing and poor agricultural techniques Pandey and Shyamasundar (2008).

3.3 EROSION AND WIND CONTROL

Bamboo offers important ecosystem services, making it an important plant for agro forestry. The most important of these services are shown in Table 1 below. Bamboo is very good as it holds the soil together which help reduce erosion due to its extensive rhizome system, particularly in areas prone to high amounts of run off like steep slopes, river banks or degraded lands. As a result, the root system creates an effective mechanism for watershed protection, stitching the soil together along fragile river banks, deforested areas and in places prone to earthquakes and mud slides. Unlike in most trees, proper harvesting does not kill bamboo plants, so the top soil is held in place. 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 means that bamboo greatly reduces run off, preventing massive erosion and keeping up twice as much water in the watershed Pandey and Shyamasundar (2008) and BF (2010). In Philippines, Kenya and Andes region bamboo is well known for its capacity to control erosion. In Punjab, India, about 62,000 clumps were stubbed in 1980 in order to stabilize 311ha of embankments Chandarshekara (1996) and Andeam (1995). These clumps started production with 5 culms per clump in year 5 and were expected to attained full development of twelve (12) bamboo culms per clump after ten (10) years onwards – yielding an annual profit of as much as U$70,000 Environment (2003). Bamboos are evergreen plants and the thick canopy and soil cover provided by dead leaves reduces splash erosion and enhances infiltration Alfonso (1987). Bamboo culms are very elastic. They bend in high winds, but usually do not break as they are used as

windbreaks to protect cash crops, particularly, in coastal areas where high winds are frequent Pandey and Shymasundar (2008). Planting bamboo can help speed up conversion of degraded lands into productive and economically viable systems, reducing erosion and raising water table after mining of minerals. This will help to improve productivity of other commercial and food crops. Bamboo can be grown as a pioneering plant in soil damaged by overgrazing and poor agricultural techniques Pandey and Shymasundar (2008).

3.4 PROVISION OF SHELTER

Bamboo does provide reliable shelter Jalan (2008) when properly managed. Bamboos have been a popular and common housing material for centuries as a poor man material for rural dwellers who depends on it for the building of their houses, bridges, etc. In recent years, new designs and production technologies coupled with shifts in perception have made the construction of modern high quality houses that combine safety, durability and aesthetics from bamboo products possible and affordable Jalan (2008) and Pandey (2008). Similar innovations have produced other structures such as bridges and housing components, equivalent to those of other materials. Bamboo's excellent growth characteristics, mechanical and engineering properties make it a fine alternative to tropical timber for infrastructure development (Jalan, 2008; Pandey, 2008; INBAR, 2009; Ogunwusi, 2011a, 2011b).

3.5 BIO FUEL AND ENERGY PRODUCTION

Bamboo can help reduce deforestation by replacing trees as a source of bio fuel EBF (2001). In Ethiopia, bamboo charcoal has helped them meet the energy demands for rural and urban dwellers, as in Manipur, India, household operated drum kilns provide reliable sources of bamboo charcoal that provide both household energy and employment for local communities EBF (2001). In Africa, most households and some industries depend on wood for domestic energy generation. This has been a major reason for advancement of the Sahara downwards because most forests are being over depleted for wood to provide energy for household use. The use of bamboo in place of timber will reduce deforestation and consequently stem the rate of land degradation in most African countries to meet the energy infrastructure needs.

Table 1: Services Provided by Bamboo

S/N	Category of services	Types of services provided by bamboo
1	Support service	Nutrient cycling, primary production
2	Provisioning services	food, Fuel wood, fibres, biochemical, generic resources
3	Regulating services	Climate, water regulation and water purification
4	Cultural services	Recreation, aesthetics, inspirational, educational, sense of place, cultural heritage.

3.6 FOOD SECURITY

Bamboo can help provide food security for both human and livestock. The shoots of many species are edible and nutritious and they are a common ingredient in many dishes, whilst bamboo leaves are common source of fodder for livestock and feed for fish INBAR (2009). As a result of its rich chemical composition, the shoots of bamboos are edible. Taiwan alone consumes 80,000 tonnes of bamboo shoots annually, constituting about U$50 million industry INBAR (2009). They are used in numerous Asian dishes and broths. They are available in supermarkets in various sliced forms. The sap of young stalks tapped during raining season may be fermented to make a sweet wine (Ulanzi) or simply made into a soft drink. In Japan, the antioxidant property of pulverized bamboo skin which prevents bacterial growth is used as a natural food preservative. Bamboo leaves are normally used as fodder during scarcity. Young bamboo leaves and twigs are favorite meals of Panda and elephant. In addition, bamboo is used in Ayurvedic and Chinese herbal medicine INBAR (2009).

3.7 ROLE OF BAMBOO IN BIODIVERSITY CONSERVATION

Bamboo is used as industrial raw material in a variety of sectors. Bamboo is used in the pharmaceutical, cosmetics, construction, wood, pulp and paper, textile industries, etc. In these industries, bamboo has largely replaced some of the traditional raw materials Ogunwusi (2011a). These have led to savings of several plant species that would have been harvested and processed into various products. For instance, in wood and wood products sectors, bamboo is saving forests by replacing over exploitation of traditional wood species being converted to plywood, particleboard, block board, floor tiles, etc. In Costa Rica, one thousand (1,000) houses of bamboo are built annually with materials obtained from (sixty) 60-hectare bamboo plantation BF (2001). If an equivalent project used timber, it would require five hundred (500) hectares of diminishing tropical forests. Consequently, using bamboo to replace timber saves the rainforests. With a 10 to 30% annual increase in biomass, compared to 2 to 5% for trees, bamboo creates greater yield of raw material for use. Apart from this, the application of bamboo as an industrial raw material for production of ply bamboo, bamboo pulp, briquettes for fuel, construction of houses and rebar for reinforced concrete beams annually 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 ten to twenty (10-20) years in most softwoods and thirty to fifty (30-50) years for hardwoods. Bamboo is a very versatile plant to fight the adverse effects of climate change and poverty alleviation EBF (2001). Bamboo can be harvested and replenished without any adverse effect on environment and can grow in many environments hostile to other plant species. Its sustainable production and utilization offers a very important opportunity for biodiversity conservation in tropical forests.

3.9 BAMBOO AND SUSTAINABLE INDUSTRIAL DEVELOPMENT

According to Ogunwusi (2011a), bamboo is used for many industrial works as a raw material for pulp and paper, construction and engineering, wood industry, chemical, textile, food and pharmaceutical industries. Most countries in Africa currently depend mostly on importation of wood products from the European market in view of the absence of adequate sized economic wood species in the national forests. Thus, deployment of bamboo to service will substantially lead to reduction in foreign exchange expenditure locally Kaminski (2013). In addition, many nutritious and active minerals, such as vitamins, amino acids, flavine, phenolic acids, polysaccharide, trace elements and steroids can be extracted from bamboo culm, shoot and leaf. Many of these have anti-oxidation, anti-aging, anti-bacterial, and antiviral infection properties Naxium (2001). Consequently, bamboo is valuable in health care delivery and can be processed into beverage, medicines, pesticides and other household items such as toothpaste, soaps, etc. Naxium (2001) Bamboo leaf contains 2% to 5% flavine and phonelic compound that have the power to remove active oxy – free – radicals, stopping nitrification and abating blood fat. Figures of nutrient contents of *Bambusa vulgaris* shows it contain crude protein (10.1g), crude fibre (21.7g), ether extract (2.5g), ash (21.3g), phosphorous (86mg), iron (13.4mg), vitamin B.1 (0.1mg), vitamins B2 (2.54mg), and carotene (12.3mg)/100g), respectively Paglione (2003). Flavine beverage and beer have been widely accepted particularly in Asian countries such as China, Korea, and Japan mainly because of their value in healthcare. Some materials extracted from bamboo are used in fresh flavour and preservation of food. Bamboo shoot is one kind of vegetable that is free in pollution, low in fat, high in edible fibre and rich in mineral. It is cold in properties, function well in removing sputum, enhancing digestion, relieving toxicity, improving dieresis and it is often used for healing swollen tissues or edema and abdominal disease in which watery fluids collects in cavities or body tissues Naxium (2001). The shoot also contain saccharine, which can resist little mouse tumor and also has anti – aging elements. Of late, research has shown bamboo charcoal as one of the base materials for human health, from water treatment to its uses as shield from electro-magnetic radiation. The high growth rate, the wide range of applications coupled with the high renewing ability, makes bamboo resource occupy a significant position in the 21st century as a versatile and important raw material Salam (2008). More recently, bamboo had been reported to have more than 1,500 documented applications, ranging from medicine to nutrition and from toys to aircraft Salam (2008). The most recent incursion of bamboo into the industrial arena as a raw material is due to its environmental friendliness BF (2010).

4. CONCLUSION AND RECOMMENDATIONS

4.1 Strengths, Weaknesses, Opportunities and Threats Analysis of Bamboo

There is no such thing as a perfect biomass crop. Each crop, including bamboo, has its specific properties that make it suitable for specific circumstances. Hereafter, bamboo is analyzed for its strengths, weaknesses, opportunities and risks to be taken into account by (future) biomass project developers.

4.1.1 *General SWOT analysis*

(a). Strengths

Bamboo is a rapidly growing biomass source, with a wide range of species, it grows most in temperate and tropical climate conditions. Current global trade in bamboo and bamboo products amounts to over 100 million € as it is environmentally friendly. Bamboo is a perennial crop that can be managed through short-cycled harvesting systems, with only basic tools, making it ideal for community based development. Bamboo groves and forests can provide steady revenues as well as important ecological services, including carbon sequestration. It serves as an alternative to soft and hardwood in the wood and timber industries.

(b). Weaknesses

Bamboo is difficult to propagate, for lack of seeds and dependence on laborious cloning techniques. Bamboo management and harvesting requires hard labour and much knowledge regarding culm selection and quality control. Bamboo is a very heterogeneous material even within the same clump, with properties varying among species, growing sites and seasons. Bamboo is very perishable after harvest, requiring preservation methods and short supply chains.

(c). Opportunities

Bamboo can replace fossil oil based products, chemicals and fuels in a diversity of market products and thus hold a key for realizing the biobased economy. Bamboo can replace wood in almost all uses and thus help reduce pressure on the world's forests. Bamboo can be grown on steep slopes and rehabilitate degraded lands, whilst not competing with agriculture. For the production of bamboo and bamboo products, diversified employment, in cultivation, processing and manufacturing is required.

(d). Threats

Demand for bamboo products may lead to mass conversion of natural forests into bamboo monocultures, possibly leading to biodiversity loss and pests and diseases. Bamboo may compete with food production when grown on fertile land. Transport of bamboo biomass, particularly intact (hollow) culms, may be too costly for bulk processing. The problem of environmental degradation requires urgent solution. Natural occurrence, issues pertaining to soil erosion, loss of topsoil, desertification, etc. are mostly man made. Being a non-man made occurrence, flooding often times defile scientific approach. While upgrading environmental infrastructure is important in flood control, the use of bamboo to complement other solutions is imperative. Establishment of bamboo plantations in most African countries will help to arrest gully erosion which

is a significant step in curbing this menace. A multidisciplinary approach by environment engineers, urban planners, foresters, industrialists and policy makers, especially, the political will. It is however imperative to state that while bamboo may not solve all social, economic and environmental problems in Africa in terms of infrastructure needs, a bamboo based industrial development pattern, most especially in the chemical and pharmaceutical, wood and pulp and paper sectors will lead to substantial savings in foreign exchange, a cleaner environment and reduction in the current rate of infrastructure development in Africa.

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