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The Challenge of Optimizing Use of Wood in Tackling Climate Change in Nigeria

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Abstract
The effects of climate change are fast becoming a reality globally. The greenhouse effect caused by increasing atmospheric CO_2 is expected to lead to increase in mean temperature at a rate of 0.1 to 0.4°C per decade during the half of the century. Forests are part of the global efforts being deployed to address climate change in terms of mitigation through reforestation, afforestation and by reduction in the rate of deforestation and forest degradation. The global forests currently store approximately 286GT of carbon. Wood is a major product of atmospheric carbon harnessed by the tree through photosynthesis. A growing tree on an average absorbs an equivalent of 1, ton of CO_2 for every m^3 of its growth while producing an equivalent of 0,7 ton of O_2. After the trees are harvested, they provide wood products which continue to store the carbon in service. In addition, wood provides a very good alternative to other building raw materials as a result of its low embodied energy. When wood is used to produce energy through combustion, the energy produced is effectively stored solar energy and the amount of energy emitted is not more than those previously stored, making the process carbon neutral. Despite the very important role of forests and wood in climate change mitigation, the process is not very effective in Nigeria in view of high rate of deforestation and low capacity utilization in the nation's forest industry. For the Nigerian forest industry to be able to contribute effectively to climate change mitigation, there is need for massive reforestation, afforestation, plantation establishment and retooling in the industry.
Keywords: climate change, Afforestation, embodied energy, carbon, mitigation

1.0 Introduction

The need to put in motion every possible mitigating factor to halt the problems of climate change globally has become imperative in view of the expanding influence of climate change on the sustainability of global economic, environment, industrial and agricultural production patterns. There is no longer any doubt that the climate is changing. According to the Intergovernmental Panel on Climate Change (IPCC), the 20^{th} Century was the warmest since record taking began, with the 1990's the warmest decade and 1998, the warmest year (CEI bois, 2006).

Since the beginning of the industrial revolution, there has been sharp increase in green house gas (GHG) emission into the atmosphere mainly due to CO_2 from the burning of fossil fuels and deforestation. As a result, mean temperatures are expected to rise at a rate of 0.1 to 0.4°C per decade during half of the century (Rakonczay, 2003). The greenhouse effect is caused by CO_2 which is growing at 0,5% per year and will double in 2100 (IPCC, 2000). At least 60% of climate change can be attributed to human activities. Burning of fossil fuel alone contribute 6 billion tones of carbon emissions annually (IPCC, 2000). To maintain CO_2 concentration in the atmosphere at current level would require a reduction in global emissions of more than 40%. This will necessitate about 85% cut in fossil fuel utilization. As a result, it is imperative to ensure reduction in CO_2 emission in activities occurring in all industrial sectors. In the forestry sector, available statistics indicated that this can be achieved through sustainable management of forests and optimal processing and utilization of wood products.

Wood is a renewable material. It offers simple ways of reducing the CO_2 emissions through carbon sink effect of forests, carbon storage effect of wood products and substitution of carbon intensive materials with wood which is the fifth most important product traded globally (CEI BOIS, 2006). Vast quantities of wood are logged to provide fuel, fibers (for pulp, paper products, and boards) and sawn timber (for house building and furniture). The complex chemical makeup of wood (cellulose, hemicelluloses, lignin, and pectin) also makes it an ideal raw material for ligno-chemical industry that could replace the petrochemical industry in providing plastic, several types of chemical products, food and textile materials. In addition, wood is the most important natural and renewable source of energy and therefore has a major future role as an environmentally cost-effective alternative to burning of fossils fuels. Apart from energy generation, wood also endures as an energy efficiency material for use in buildings and many other products. In countries where forests are managed by adopting sustainable management principles such as in Europe, Canada and the United States, etc, forests constitute major sinks for carbon dioxide, thereby, playing greats role in mitigating climate change (CEI bois, 2006). This study outline the role of forests in carbon sequestration, the environmental benefits of optimal wood processing into durable products and the challenges facing the forests and forest products industry in Nigeria. It also highlights the prospects for developing forest industry in Nigeria to align with global best practices.

2.0 The role of forests in climate change mitigation

Forests are vital parts of global efforts to address climate change. Forests have been mostly considered in terms of mitigation through reforestation, afforestation and more recently, by avoiding deforestation and forest degradation (Muhammad et al, 2013). Forests store enormous quantities of carbon. FAO (2006) estimated that global forests store 286 gigatonnes (GT) of carbon in their biomass. If this is complemented with carbon stored in the deadwoods, litter and soil, it will be up to 762 GT, which is more than the carbon stored in the atmosphere. According to IPCC (2000), the total annual turnover of carbon between global forests and atmosphere (as characterized by gross primary production) ranged from 55 to 85 GT per year. The amount of atmospheric carbon transformed into forest biomass through primary production has been estimated at 25 to 30 GT per year (Field, 1998; Mohammad et al, 2013). Trees also act as net sinks for SO_2, NO_2 and other particulate matters (ATS, 1998). In 2002, the National Greenhouse Inventory estimated that Australian Forests locked up 21.8 million tones of CO_2 more than were released through harvesting (AGO, 2004).

Forests cover more than a quarter of the total land area of the world. Forests store enormous quantities of carbon per hectare than other biomes (Gorte and Sheik, 2010). Carbon sequestration and release vary by forest types which can be divided three general biomes. These are boreal, temperate and tropical forests. Table 1 shows the global average carbon levels in the vegetation and soils of major terrestrial biomes. While the boreal forests store approximately 236 metric tones of carbon per hectare as plant carbon and 1,260 metric tones of per hectare carbon as soil carbon in an area totaling 1.37 billion hectares, the deserts and semi deserts with a total of 4.55 billion hectares store only 6 metric tones of carbon per hectare as plant carbon and 154 metric tones of carbon per hectare as soil carbon (Gorte and Sheik (2010). This underscores the need to maintain vegetation cover on biomes in order to increase their carbon sequestration potentials. Although, boreal forests which are occur North of about 50^0 north latitude are dominated by relatively few trees such as spruce, fir, larch and pines with relatively small sizes as a result of broad scale destructive agents such as wild fires, they are very important for carbon sequestration because of the enormous quantities of carbon stored in the forest soils (Gorte and Sheik, 2010). The carbon in the vegetation is slightly greater than for temperate forests which occur in the mid latitudes from Tropic of Cancer ($23^{1/}{}_2$ North latitude) to about 50^0 north latitude and South of Tropic of Capricorn ($23^{1/}{}_2$ South latitude). The carbon in boreal forests is about half of the level of those present in tropical forests which occurs between the Tropic of Cancer and the Tropic of Capricorn, $23^1/_2{}^0$ north and south of the equator respectively.

The temperate forests account for a quarter of global forests, the most extensive of which occurs in the United States, South of Canada, Europe China and Australia. They contain a wide variety of trees such as pine, marble and oak with lower species diversity than in tropical forests. Although the forests have lesser species, the trees have moderate growth rate and desirable characteristics for a variety of other wood products. They are mostly sustainably managed for commercial wood production (Gorte and Sheik, 2010).

Tropical forests accounts for about 42% of global forests (Gorte and Sheik, 2010). They are mostly found in Brazil, Nigeria, Democratic Republic of Congo, Indonesia, etc,. They have enormous diversity of plant species and have been generally free from frequent broad scale destructive events such as fire which occur frequently in boreal forests. As a result, the trees usually respond to minor localized climatic differences that have led to diversification of species over thousands of years. As a result, tropical forests are generally not well suited for intensive management or plantations (Gorte and Sheik, 2010). Many desirable species have narrow habitat requirements. Further they contain only modest soil carbon levels as a result of rapid decomposition which effectively prevent sustained intensive management over extensive periods without substantial application of fertilizers (Gorte and Sheik, 2010). However, tropical forests are important for carbon sequestration. The carbon content doubles the level in other forests. Nevertheless in contrast to the carbon in the vegetation tropical forest soils contain only average levels of carbon as the carbon depletes quickly when vegetation, is cut as a result of the warm, humid conditions which causes decomposition while high rainfalls leaches minerals from the soils.

In general, young, vigorously growing trees have a higher rate of carbon dioxide absorption than mature as trees. Trees follow the sigmoid curve in its growth rate. The growth rate is higher in the early to middle years and drop off as they mature. In the tropical forests in Nigeria, this drop happen between 50 to 80 years, depending on tree species. When a tree is harvested, about half of the carbon stays in the forests and the rest is removed in logs which are then converted into forest products. Some carbon is released when the forest soil is disturbed during harvesting and the roots, leaves and branches left behind release carbon as they decompose. However, when the area is regenerated, either naturally, or by planting seedlings, the forest once again begins to absorb and store carbon. In the case of unmanaged forests, old trees will eventually stop capturing carbon. However, they continue to store the carbon already absorbed until they start to decay and release carbon in form of CO_2. In addition to natural forests, a plantation is likely to sequester between one and ten times carbon per hectare per year over a 30 years period (AGO, 2001). Thus, enrichment planting, plantation establishment and agroforestry practices ensures continuity of growing trees that absorbs CO_2 (Ogunwusi, 2013a).

3.0 Deforestation, forest fires and climate change

The major factors that limit the potentials of forests from mitigating climate change are deforestation, forest fires and application of unsustainable management methods. Deforestation is the loss of tree cover, usually as a result of forest clearance for other land uses. Deforestation affects carbon fluxes in the soil, vegetation and atmosphere. The major causes of deforestation differ from one forest type to another. According to Hobson *et. al.* (2002), the primary driver of boreal deforestation has historically been land clearing for agriculture, although, recent statistics are inconclusive on continuity of this practice. However, Jarden (1994) contended that logging is a significant factor in boreal deforestation. Other major causes are wild fires, insect and disease infestations (Jarden 1994). Historically, forest clearance for agriculture has been observed to be the major cause of temperate deforestation. According to CEI bois (2006), Europe's temperate forests are increasing in volume. However, in developing temperate countries, deforestation is still ongoing for conversion of forest land to non agricultural uses such as such as residential, commercial development and development of infrastructure. Timber harvesting and natural disaster are also major causes of temperate deforestation. While most of the lands are reforested, reforestation is not always successful as a result of drought, invasion by competing species and long number of years required for natural sucession (Gorte and Sheik, 2010).

Tropical deforestation is the most potent as a result of its tendency to release higher quantity of CO_2 at very fast rates. Despite this, tropical deforestation has been going on at a very high rate. In the tropics, the drivers of deforestation vary among regions. Williams (2003) categorized direct drivers of deforestsion as agriculture, most especially, shifting cultivation farming practices which is predominant in rural Nigeria, timber extraction, fuelwood harvests, road construction and urbanization. The drivers also differ between rainforests and tropical dry forests. FAO (2010) estimated that Nigeria loses about 3.7% of its forests per year and this has resulted in the highest net loss of forests from 2000 to 2010. According to FAO Forest Resources Assessment (2000), about 14.6 million hectares of natural forests are lost annually to deforestation. Of this, 1.5 million hectares was converted into plantations aimed at increasing wood supply (Ogunwusi, 2011). FAO (2005) also reported that Nigeria has the highest rate of deforestation in the world. Between 1990 and 2005, Nigeria lost 35.7% of its forest cover or 6, 145,000 hectares of forests FAO (2005). As a result, a lot of damage has been done to Nigeria's landscape. One of this is the advancing desertification in the northern part of the country (Omofonmwan and Osa-Edoh, 2008).

4.0 Deforestation and forest products industry in Nigeria

The present public forest estate which was acquired between 1900 and 1970 embraces 100,000 km or 11% of the total land of the country. Only about 26% of this is in the high forest area while an additional 90,000km^2 of forest is available outside the forest reserves. The forests have served as engine of growth and propelled economic activities as far back as 1792 when pit sawing operation commenced in Nigeria, followed by the establishment of a power sawmill in Delta area 1902 (Aribisala, 1993). These developments led to substantial increase in wood exploitation for use by the domestic industries and for export. Wood export peaked in 1950's with log and sawn wood and subsequently, veneer and plywood. This trend was maintained and sustained in the 1960's and early 1970's. However, by mid 1970's, the toll of intensive exploitation has started showing and volume of wood export which peaked at 700,000m^3 , in 1964, decreased steadily to 290,000m^3, in 1970 (Aribisala, 1993). Also, as far back as 1899, the perspective planning for economic development hinged on the exploitation of forest resources (Adeyoju, 1975). The export revenue from forestry grows at 4.1%, 8.0% and 28.8% between 1950-60, 1960-70 and 1970-80 respectively (Aribisala, 1993). The period witnessed the development of a virile forest products industry which was made up of well structured saw mills, wood panel industries, furniture industries, match factories and pulp and paper industries. This promoted the vast growth of the economy by making positive contribution to raw materials production and supply for construction, furniture and packaging.

More recently however, there have been changes in the structure of the forestry sector. The forest resources survey, 1996-1998, revealed that the forest cover has decreased by 20% over the preceding 18 years. According to Adeyoju (2001), the total forest estate is now less that 6%. World Wildlife Fund estimated that over 90% of the natural vegetation had been cleared and over 350,000 ha of forest and natural vegetations are lost annually (WWF, 1989), These developments have significant impact on the operations of the forest industries. Studies by RMRDC (2009) indicated that the total volume of usable wood down to 30cm cutting diameter in the forest reserves is as low as 239,775,500m^3 which is not significantly different from 437,507,205.9m^3 reported by Akindele *et al* (2001), considering the difference in the reporting periods.

As a result of the above, capacity utilization in most of the wood processing companies within the industry have been on decline. The capacity utilization in the sawmill industry has been on decline since 1988. Table 2 shows the installed capacity and capacity utilization in the sawmill industry in Nigeria. The decline in capacity utilization occurs as a result of changes in the raw material characteristics. Among these are reduction in the volume of economic wood species, decrease in log diameter in Nigerian forests and increasing scarcity of economic timber resources (Olorunisola, 2000; Ogunwusi, 2012; RMRDC, 2003; RMRDC, 2009; Larinde, 2010).

Furniture production in Nigeria dates back to 1872 when commercial logging commenced. This industry is strategic in the use of planks from sawmills and plymills. Capacity utilization is generally low as economic wood species are dwindling in availability and the industry is relying more and more on lesser used wood species. Although, the domestic market for furniture is growing rapidly the subsector has not contributed significantly to foreign exchange earnings as it is dominated by small scale operators of about 3-5 workmen (RMRDC 2009; GWV. Consultants, 1994). In Nigeria, the furniture industry uses simple technologies; they have low technical knowhow and low capital input. They are mostly made up of outfits with crude hand tools and equipment (RMRDC, 1991; 2003 and 2009), resulting in poor quality products (GWV Consultants, 1994). The small scale furniture producers are technically inefficient as they fall below efficiency level of 60% (Ako and Kuye, 2010).

Plywood production in Nigeria has reduced drastically in the country as a result of high reduction in the volume of economic wood species (Olorunisola, 2007; RMRDC, 1991; Arowosoge, 2010). Face veneer is in short supply as one of the major producers; the government owned African Timber and Plywood has closed operations. Currently a considerable volume of face veneer is being imported from Ghana and various parts of Europe (GWV Consultants, 1994). Other problems of face veneer producers are old equipment and lack of spare parts.

The major factors limiting optimal production of particleboard in Nigeria are uncertain investment climate and low exchange rate of local currency required for importation of new equipment, spare parts and glue (GWV Consultants, 1994). Also, production is hampered by high cost of imported resins. The low cost of imported matches in juxtaposition with the high cost of those produced in Nigeria make local production an unprofitable enterprise. To protect this subsector it may be necessary to increase tariff on imported matches. In addition, while the need for preservative treatment of wood is becoming germane locally as a result of decrease in ages and diameter of remaining wood species in the nation's forests, the treatment plants in the country are closing down by the day as a result of old age of equipment. Thus, there is increasing utilization of hand brushed wood in the wood and wood products sector.

In general, the Nigerian wood industry is gradually declining in performance, efficiency and productivity due to the reasons already highlighted. High quality saw and veneer logs are limited with 97% of log production factoring into the lesser used wood species (Arowosoge, 2010). The shortage of domestic supply of round wood is a constraint to producing high quality final products that are competitive in international markets. As a result of this, a number of lesser used wood species are now widely available in plank markets in various parts of the country.

4.0 The role of wood in climate change mitigation

Wood has significant roles to play in climate change mitigation. Some of these are subsequently discussed.

Wood and Carbon Storage

Timber and other forest products are largely made from atmospheric carbon. Wood is one of the major products of atmospheric carbon harnessed through photosynthesis and converted from starch and other food products to wood through the activities of the cambial xylem. A growing tree on an average absorbs through photosynthesis, the equivalent of I ton of carbon dioxide for every m^3 growth while producing equivalent of 0,7ton of O_2 (CEI bois, 2006). To produce 1 kg of wood, a tree takes in 1.47kg of CO_2 and returns 1,07 kg of O_2 to the atmosphere (AGO, 2004). After trees are harvested, they provide wood products which continue to store carbon in service.

As wood products are renewable and recyclable and as their manufacture releases less GHG emissions than steel or concrete, the use of wood provides wood an opportunity to tackle climate change. The production and processing of wood is highly energy efficient, giving wood products an ultra low carbon footprint. In addition, wood can be used to substitute materials such as steel, aluminum, concrete or plastics which requires large amounts of energy to produce. Every cubic meter of wood used as a substitute for other building materials reduce carbon dioxide emission in the atmosphere by an average of 1,1 t CO_2. If this is added to 0,9t of CO_2 stored in the wood, each cubic meter of wood saves a total of 2 t CO_2. Based on this calculation, a 10% increase in the percentage of timber houses in Europe alone would produce sufficient CO_2 savings to account for about 25% of the reduction prescribed by Kyoto Protocol (CEI bois, 2006). Timber in buildings and other wood products sequester carbon from the atmosphere for as long as they are in service. In Nigeria, although, the volume of wood available in the forest resources are dwindling, greater use of wood and wood products will provide impetus for expansion of forest areas. The reduction of carbon dioxide in the atmosphere can be achieved through storage, substitution, recovery and renewal. Of all materials available for construction, only wood can perform these four functions. An annual increase in wood consumption for a period of two years would sequester an additional 150 million tones CO_2 per year. The market value of this environmental service of tree is put at 1.8 million euro per year (CEI bois, 2006).

5.1 Wood as substitute to other building materials and fossil fuels

When wood is used to produce energy through combustion, the energy produced is effectively stored solar energy. As the amount of CO_2 emitted from combustion is not more than those previously stored, the process is carbon neutral. Wood products store an amount of carbon which is equivalent to 2.5% of the emission released by fossil fuels (Werner and Nebel, 2007). Wood is clean energy as it contains little sulfur or nitrogen that contribute to acid rain. Most of the energy used in the production of building materials is derived from fossil fuels (gasoline, diesel, coal) and their impact is measurable by their embodied energy (EE). The embodied energy measures the total energy used to transform raw materials into ready to use building products. It is expressed in gigajoules per ton (GJ/t) or megajoules per kilogramme (MJ/kg). The embodied energy of materials in buildings forms a component of total life cycle energy consumption. Specifically, it includes energy required to either mine or harvest and process raw materials into tertiary raw materials, energy used in transportation of the materials at all stages and the energy used in construction.

The embodied energy of various building materials have been calculated and an example for building materials in Australia is given in Table 3, while, the amount of carbon released and carbon stored in the materials are shown in Table 4. Both tables indicated that wood is the most environmentally friendly material. It has the lowest EE and carbon release (CR), thereby making it the most potent material for mitigating climate change. Wood production in the forests requires little energy (only about 1% of the energy content of wood). Manufacturing of both semi and finished wood products also require little energy. Table 5 shows the fossil fuel required to produce major building materials. The table indicated that the manufacture of rough sawn timber require less fossil fuel energy per unit volume, compared with steel, concrete and aluminum. The fossil fuel required to manufacture rough sawn timber is 1.5 MJ/kg, while aluminum manufacture required 435MJ/kg. Cement production is a significant source of GHG emission. Concrete contains 10-15% cement. As much as 1.25 tones of CO_2 is produced for every ton of cement produced while about 1,600kg of raw material is needed to produce 1000kg of cement. The manufacture of Portland cement is one of the most energy intensive of all industrial manufacturing processes and is responsible for 10% of manmade CO_2 emissions worldwide.

AGO (2004) prepared a green house accounting methods for forest products. The accounting method calculates decomposition of forest products service life pools. The four pools of forest products are shown in Table 6. From the table, it will take 3 years for carbon locked in paper to return to the atmosphere while it will take 50 years for carbon locked in poles and construction materials to return to the atmosphere. While this model takes into account the varying initial service life of wood products, it does not allow for products to move from one pool to the other or to be permanently in service throughout its lifetime. The consequence of this is that the amounts of carbon in solid products quickly plateau unless their use is continually increasing (Gadner, et al, 2000).

Another method by Gardner et al (2000), focuses on life cycle approach to green house accounting. The model allocated different service life classes to wood products while at the same time gave adequate consideration to factors such as retention in land fill and recycling, thereby, considering lifetime storage of CO_2. The method establishes five life style pools of 3, 10,30,50 and 90 years with three age groups demarcated into Young, Mid and Old within each pool. This approach however shows that life cycle approach including consideration of the use of residues, storage in service, recycling and disposal to landfills has the potential to significantly reduce the contribution of wood products to green house gas emissions. Another important advantage of wood over other building materials is low production of externalities in form of wastes when wood is being converted to building materials compared to other products. Also air and water pollution and solid wastes generation are far lower when wood is being converted to building materials compared to other products. In terms of thermal efficiency, wood provides efficient thermal insulation and helps to save energy over the life of a building. The cellular structure of wood provides insulation 15 times better than concrete, 400 times better than steel and 1770 times better than aluminum (CEI bois, 2006). A 2.5 cm timber board has better thermal resistance than 11.4cm brick wall (TRADA, 2006).

5.2 Role of wood in supporting forests

Increasing use of wood usually results in better management of forests. Wood use is not a contributory factor to deforestation as it creates a market value for the forests. This provide an inventive to preserve them. In Nigeria, the future of the forest industry is linked to a multiplicity of factors among which is available productive forests, quality and quantity of wood resources there in, management patterns and goals of management. Forest management pattern to be adopted in Nigeria must be sustainable and should take into consideration, the challenges currently facing the industry. Currently, the capacity underutilization in all sectors of the forest industry in Nigeria is mostly a product of unmitigated deforestation. Although, Nigeria now imports lumber and plywood (FAO, 2006), this is not a sustainable option in view of instability in prices, the need to develop the local industry and generate employment coupled with demands skills acquisition for the industry. Thus, there is need for stringent regulations on deforestation and initiation of a policy on reforestation that will engender private sector participation and sustainable forest management. Also development of forest certification schemes is needed to give stability for forests to continue to thrive.

Developing markets for wood will help owners and governments to see forests in a different way. It will enable people to recognize forests contribution to local and national economies. As soon as posterity of a local community is seen to be associated with the presence of a forest, the principles of sustainable management will be respected (CEI (CEI bois, 2006).

6.0 The challenges of climate change mitigation by forest industry in Nigeria.

As already highlighted, the Nigerian forest industry is already performing at suboptimal levels (Ogunsanwo, 2010; Ogunwusi, 2012a, 2012b; 2013; Ogunwusi et al, 2013; Olorunisola, 2000; RMRDC, 2009; Larinde, 2010). Capacity utilization is low (Ogunwusi, 2012a; RMRDC, 2005) and the facilities for conversion of wood into various products in most cases are outdated (GVW Consultants, 1993). The industry is mostly made up of cottage and small scale manufacturers (GWV Consultants, 1993) with low technical efficiency (Ako and Kuye, 2010), synergy and access to investible funds (Bamikole, 2007; Ogunwusi, 2009) and innovations. The outputs are inefficient as producers are more interested in profits than in products development (NACETEM, 2010). More recently, FAO (2005) reported that Nigeria has turned into a wood importer as most of the high quality wood have been harvested. For the Nigerian forest industry to contribute in any significant manner to climate change mitigation, it is important that the following are gregariously embarked on:

1. Establishment of plantations of indigenous economic wood species combined with exotic species of high industrial potentials and with proven ability to maintain their inherent characteristics in the Nigerian environment.
2. Enrichment planting in log over forest areas has become imperative. Out of more than 600 species found in Nigerian forests, less than 15 are considered as economic. As tropical wood species hardly occur in more that 2 to 3 trees stands per hectare, most of the forests have been logged over and lesser used species abandoned. Consequently, it important than enrichment planting be embarked on to protect the future of the industry and its contribution to climatic change mitigation.
3. Investment in modern wood processing techniques and equipment is necessary to complement or replace the old and inefficient facilities currently predominantly available in the industry in Nigeria.
4. The small scale investors in the industry require government intervention to make them perform more efficiently and effectively. This can be done through the establishment of clusters by the government and other relevant organizations and development agencies. This is necessary as clusters have the advantage of promoting acquisition of skills, synergy and exchange of knowledge and experience amongst others.
5. Research into the utilization potentials of the lesser used wood species is important. This is to elucidate information on the properties and utilization potentials of the species, thus, aiding their conversion into appropriate wood products. This approach will reduce deforestation while at the same time promoting establishment and sustainable management of more forests.
6. The eradication or reduction in shifting cultivation farming practices has become germane. The practice of agroforestry has been advocated by a number of authorities in view of its potentials in fostering carbon sequestration.
7. Since early 1990’s forest certification practice has grown rapidly globally as an option for controlling illegal logging and trade in wood products. By mid 2008, certified forests accounted for more than 307

million ha worldwide (or 23% of the world's 1360 million ha of forest actively managed for wood and non wood products). Originally designed to halt tropical deforestation, forest certification has spread widely globally, making the issues of illegal logging and trading in illegally harvested wood global phenomenon. In sub-Saharan Africa, the issue of illegal logging needs to be properly addressed to obviate the problems surrounding deforestation. Illegal logging has become a major impediment to successful development of the forest industry in most parts of the tropics. Unless this is assiduously addressed, the movement of illegally logged wood from sub Saharan Africa to Europe and Asia will continue to militate against the development of forest industry in Africa, thereby, reducing their propensity and potentials to contribute in any reasonable measure to the problems of poverty alleviation, improvement of livelihood systems and the fight against climate change.

7.0 Conclusion

The increasing importance of wood in climate change mitigation cannot be contested. Optimal utilization of wood for production of highly required products with long shelf live will continue to be a major way of climate change mitigation globally. It will also continue to provide impetus for the establishment of forests. In Nigeria and in most parts of the countries in sub Saharan Africa, this may be difficult to achieve in view of stressed resources and extensive poverty which are encouraging unmitigated deforestation. There is therefore the need for global consensus and enforcement of agreement on the percentage of forests that should be maintained by each country in sub Saharan Africa. Also, the principles of sustainable management have to be introduced and enforced. Forest certification practices must be initiated, maintained and sustained as a way of curtailing Africa's contribution to the global climate change problems. However, while deforestation causes climate change, climate change is also a contributor to deforestation. Change in rainfall, temperatures and extreme weather increases biological stress on forests in various geographical areas. This contributes to global poverty and creates climate refugees.

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Table 1: Average carbon stocks for various biomes (Area in billion hectares: carbon in metric tones of CO2 per hectare

Biome	Area	Plant Carbon	Soil Carbon	Total Carbon
Tropical forests	1.76	442	450	892
Temperate forests	1.04	208	352	561
Boreal forests	1.37	236	1,260	1,496
Tundra	0.95	23	467	490
Croplands	1.60	7	293	300
Tropical savannas	2.25	108	430	538
Temperate grasslands	1.25	26	865	892
Desert/semi desert lands	4.55	6	154	160
Wetlands	0.35	157	2,357	2,514
Weighted average across total areas	15.12	113	488	601

Source: Gorte and Sheikh (2010)

Table 2: Installed capacity and utilization (round log equivalent) in the Sawmill industry

Year	No of sawmills	Total installed capacity M^3/year	Utilization capacity M^3/year	Capacity utilization %
1988	N/A	8,831,750	6,994,660	79
1992	910	15,793,188	6,031,922	38
1996	1252	10,900,000	4,200,000	39
2002	1259	14,684,000	5,177,700	35
2010	1325	11,734,000	3,800,000	32

Source: Ogunwusi (2012a)

Table 3: Embodied energy of various building materials from Australia.

Materials	Embodied Energy (MJ/M^2)
FLOORS	
Timber suspended, timber subfloor enclosure	740
Timber suspended, brick subfloor wall	1050
Concrete slab on ground	1235
WALL	
Weatherboard, timber frame	410
Brick veneer timber frame	1060
Double trick	1975
WINDOWS	
Timber frame	880
Aluminum frame	1595
ROOFS	
Concrete tile, timber frame	755
Concrete tile steel frame	870
Metal cladding, timber frame	1080
Clay tile, timber frame	1465

Source: Adapted from Townsend and Wagner (undated) as sourced from National Timber Development Council, 2001

Table 4: Carbon released and stored by various building materials

Building material	Proportion of carbon stored to carbon released (%)	Carbon released (Kg/m^2)	Carbon stored (Kg/m^2)
Sawn timber	16667	15	250
Steel	0	5320	0
Concrete	0	120	0
Aluminum	0	22000	0

CEI bois (2006)

Table 5: Green House accounting method for forest products

POOL	SERVICE LIFE	WOOD PRODUCT
1	3	Paper
2	10	Pallets
3	30	Kitchen furniture
4	50	Poles, Construction materials

Source; Australian Government (2008). Timber as a sustainable building raw material

Table 6: Fossil fuels required for producing building materials

Material	Fossil fuel energy (MJ/kg)	Fossil fuel energy (MJ/m^3)
Rough sawn timber	1.5	750
Steel	35	266000
Concrete	2	4800
Aluminum	435	1100000

Source; Australian Government (2008). Timber as a sustainable building raw material