African Forest Forum

A platform for stakeholders in African forestry

Policies and other related issues to the food-fuel-fibre nexus production in the context of climate change in West Africa and the Sahel

2017

 African Forest Forum, United Nations Avenue, Gigiri P.O. Box 30677 00100 Nairobi GPO KENYA Tel: +254 20 7224203 Fax: +254 20 722 4001
E-mail:exec.sec@afforum.org Website: www.afforum.org. Twitter @ africanff. Facebook / African Forest Forum. LinkedIn / African Forest Forum (AFF).

Correct citation: Ajewole, O. I. (2017). Policies and other related issues to the food-fuel-fibre nexus production in the context of climate change in West Africa and the Sahel. AFF Report. African Forest Forum, Nairobi.

Cover photos (L-R): Dry forest in the Sahelian Parklands; Secondary forest in the southern part of Nigeria © Larwanou Mahamane / AFF 2008; Harvesting timber in the Vipya forest plantations in Malawi ©Björn Lundgren/AFF

Policies and other related issues to the food-fuel fibre nexus production in the context of climate change in West Africa and the Sahel

Ajewole, Opeyemi Isaac

Table of Contents

List of Tables

List of Figures

Acronyms and abbreviations

3Fs	Food, fuel, fibre
ADB	African Development Bank
AFF	African Forest Forum
AMADER	Agence Malienne pour le Développement de l'Energie Domestique et l'Electrification Rurale
ANADEB	Agence Nationale de Developpement des Biocarburants
CDM	Clean Development Mechanism
CIA	Central Intelligence Agency
CILSS	Comité Permanent Inter-Etats de Lutte Contre la Sécheresse dans le Sahel
CO_2	Carbon dioxide
CNDD	Counseil National de l'Environment pour un Development Durable
DERED	Directorate of Renewable Energy and Domestic Energy
EASE	Energizing Access to Sustainable Energy
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Regional Centre for Renewable Energy and Energy Efficiency
EU	European Union
ha	hectare
GHG	Greenhouse gas
FLEGT	Forest Law Enforcement, Governance and Trade
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IEA	International Energy Agency
IIED	International Institute for Environment and Development
LECB	Low Emission Capacity Building
LPG	Liquefied Petroleum Gas
MCSSRS	Mali Ministry of Secondary and Higher Education and Scientific Research
MDAs	Ministries, Departments and Agencies
MMEE	Ministry of Mines, Energy and Water
NGO	Non-Governmental Organization
NL	Netherlands
NSBD	National Strategy for Biofuels Development
PEC	Politique Energétique Commune
PRBE	Programme Régional Biomasse Énergie
PREDAS	Programme Régional de Promotion des Énergies Domestiques et Alternatives au Sahel,
REDD	Reducing Emission from Deforestation and Forest Degradation
RFM	Rural Firewood Market
SDR	Stratégie du Développement Rural
SE4ALL	Sustainable Energy for All
SMEs	Small and Medium scale industries
SNED	Stratégie Nationale des Energies Domestiques
SNEP	Strategic National Energy Plan
SNER	Stratégie Nationale sur les Énergies Renouvelables

SSA	Sub Saharan Africa
UEMOA	Union Economique et Monétaire Ouest Africaine
UNDP	United Nations Development Programme
WACCA	West Africa Clean Cooking Alliance

Acknowledgements

First and foremost, my appreciation goes to the Governing Council and the Executive Secretary of the AFF Prof. Godwin Kowero for availing me the opportunity to carry out this study. The contribution of the duo of Prof. Lawanou Muhamane and Dr. Vincent Oeba of the AFF is acknowledged for coordinating and reading through the draft reports. The contributions of the following people are also acknowledged: Mr. Bankole Philips, the Director of Forestry, Ministry of Environment, Abuja, Nigeria who gave valuable information and publications; Mr. Joseph Osiakwon of the Ministry of Land and Natural Resources, Accra, Ghana for providing publications and links to contacts in other relevant MDAs in Ghana; Mr. Abdou Maisharou , Directeur General, Agence Nationale de la Grande Muraille Verte, Niamey, Niger Republic for providing publications, logistics and links to contacts in relevant MDAs in Niamey and also Dr. Kouloutan Coulibaly, Point Focal National, GMV, Mali for providing logistics and links to contacts in relevant MDAs in Bamako, Mali.

Executive Summary

The estimates by the International Energy Agency (IEA) in 2013 indicated that in 2011 about 2.64 billion people relied on biomass, mostly fuel wood for cooking. Sub-Saharan African (SSA) countries which have about 79% of their population relying on traditional biomass energy, account for 26% of global population which still rely on traditional biomass energy for cooking and heating. Biomass energy accounts for almost 15% of the World's total energy supply and as much as 35% in developing countries mostly for cooking and heating.

Biomass has considerable potential to become more important in total energy consumption, and this growth could have significant impacts, both positive and negative on agriculture and the poor. Therefore, concerns have been raised about the economic viability as well as the environmental and social sustainability of bioenergy systems.

Furthermore, an expansion of bioenergy production from agricultural and forestry sources also generate concerns over land use management and governance within the context of growing demands for food, resulting from increasing global population and wealth.

As energy production competes with food and land, the production of food declines and the price of food goes up. There are concerns that this competition could affect food security, as food crops may be used as fuel and agricultural land may be used for feedstock production. Biofuel feedstock production may compete with food, fiber and timber for land, water and fertilizers. The use of trees as a feedstock to produce biomass energy on a large scale can also lead to widespread deforestation, degradation, desertification and loss of biodiversity since large amount of wood and other waste products have to be burnt in order to produce considerable amount of bioenergy.

There exist also a growing concern on bioenergy about global climate change and the need to reduce greenhouse gas (GHG) emissions. Although bioenergy is in principle a carbon-neutral source of energy that could do much to reduce carbon emissions, it also requires fossil fuels for growing, transporting, and processing the feedstock and for refining and distributing the biofuel. Depending on the type of feedstock, and on where and how it is grown and used, the net carbon balance can vary widely.

A clear understanding of the linkages between bioenergy production and food security, land security, biodiversity, forestry and climate change is therefore needed in order to inform the development and implementation of bioenergy policies that will contribute to food, fuel and fibre production in a sustainable manner.

This study, commissioned by the African Forest Forum (AFF) sought to address these issues using four West African countries, namely: Ghana and Nigeria representing the humid or the forest zone; and Niger and Mali representing the dry zone or the Sahel as case studies.
Data used for this study were secondary in nature and they were gathered through visits to relevant governmental Ministries, Departments and Agencies (MDAs), institutions and private libraries as well as consultation of documents, publications, and internet as well as with senior officials of the MDAs in the studied countries.

Ghana is the only country among the four which recorded net forest gain of 0.3% between 1990 and 2015 even though the deforestation and forest degradation are evident and remain a serious concern. The other sampled countries, Mali, Niger and Nigeria suffered net loss in their forest cover within this period of time. Nigeria is reported to have the highest rate of deforestation in Africa with forest loss of 3.5%, followed by Niger (2.1%) and Mali (1.4%).

In Nigeria, logging, timber export, subsistence agriculture and collection of wood for fuel are the chief causes of deforestation, while deforestation is a result of forest clearance for cocoa and food crop farms as well as logging in Ghana. Similarly, the causes of deforestation in Mali comprise land clearance for agriculture as well as meeting the country's demand for fuel and timber. Deforestation, the second largest anthropogenic source of carbon dioxide (CO_2) to the atmosphere, currently accounts for between 6% and 12% of CO_2emission and releases nearly about 1.5 billion tons of carbon into the atmosphere per year through combustion of forest biomass and decomposition of remaining plant material and soil carbon. Deforestation has decreased global vapour flows from land by 4% and this slight change in vapour flows can disrupt natural weather patterns and change current climate models.

In Nigeria, the consequences of resource extraction such as deforestation, forest degradation and crop land contamination have given rise to continuous restiveness and community agitation. In Ghana, deforestation, substantial loss of farmland within mining concessions, loss of livelihood for women subsistence farmers and widespread spill-over effects as relocated farmers expand farmland into forests have been the major consequences of resource extraction. Pollution of land and water resources with radioactive waste and toxins, irreversible damages to the sandstone aquifers in near and mid-term future, land dispossession, especially the appropriation of pastoral livestock corridors and grazing territories without compensation are some of the impacts of uranium exploitation in Niger Republic, while land expropriation, environmental degradation and social tensions are parts of the effects of mining in the Republic of Mali.

Logging in Nigeria is enshrouded in controversy, corruption and illegality. C*orruption by local officials and sharp practices by Chinese businessmen drive a thriving illegal trade in timber from Nigeria and a large part of West Africa with grave consequences for the economy, ecosystem and the environment.* Similar to Nigeria, corruption and illegal logging are widespread and thus serious issues of concern in the Ghanaian forestry sector. Illegal logging has contributed in no small way to: reduction in the forest covers of Ghana over the years, undermining the resource base of the timber industry, causing distress to the formal timber sector, loss of revenue to land owners and government and degradation of the environment. Despite significant progress in tackling illegal logging in the country, inconsistency, lack of transparency, and large amounts of illegal logging still remain. Weak law enforcement, poor domestic production standards, and a large export market have continued to drive illegal chainsaw milling in Ghana.

Nigeria, Ghana, Niger and Mali account for 42.4%, 17.9%, 6.5% and 1.7 % of charcoal production in West Africa, respectively. In the same comparison, Nigeria accounts for 13.5% of charcoal production in Africa whereas Ghana accounts for 5.7%. Niger and Mali account for 2.1% and 0.6% of charcoal production in Africa, respectively. This demonstrates that charcoal production has a potential to contribute to deforestation and forest degradation, depending on forest management approach.

Moreover, the concentrated exploitation of a few species with a high density for charcoal production can adversely affect biodiversity. In addition, some dense tree species which have a high economic value such as a source of timber, are unrecognized by the charcoal producers and are thus used for charcoal production leading to great economic loss.

The study also revealed that the cultivation of Jatropha as source of biomass energy impacts positively and negatively on the food production, land security and biodiversity. Specifically in Ghana, the cultivation of Jatropha plantations reduced vulnerabilities in household food security, created employment and increased income. However, it led to decreases in household landholdings which further precipitated negative impacts on household socio-economic status, food security, fallow periods, and fodder availability. The cultivation of Jatropha in Mali provided extra income and opportunity for diversification of the farmers' livelihood strategies, used to demarcate field boundaries and avoid land tenure conflicts and mitigate soil erosion, contributed to increased biodiversity while the seed cake was used for fertilizing food crops. However, the conversion of fallow, savannah and high-biodiverse forest and woodland to Jatropha plantations calls for concern.

Bionergy development in most of the Economic Community of West Africa (ECOWAS) member states follow an ad-hoc and unsustainable path. However, the institutional frameworks for development of bioenergy have been put in place, namely: the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) (2010); the ECOWAS Bioenergy Strategy Framework (2012), West Africa Clean Cooking Alliance (WACCA) 2012), reducing emissions from deforestation and forest degradation (REDD+)(2013); and the ECOWAS Bioenergy Policy (2015). The other two sub-regional noteworthy initiatives in the Sahel of West Africa include the Programme Régional de Promotion des Énergies Domestiques et Alternatives au Sahel (PREDAS), implemented by the Permanent Interstate Committee for Drought Control in the Sahel (CILSS) and the state members of ECOWAS, and the Programme Régional Biomasse Énergie (PRBE) implemented by the ECOWAS/UEMOA.

Bioenergy development somewhat constitutes greater part of strategies for development of renewable and domestic energies in Niger Republic, since the energy sector is dominated by the high consumption of the residential sub-sector, which is mainly based on wood resources (wood and biomass remnants). The Directorate of Renewable Energy and Domestic Energy (DERED) in the Ministry of Energy and Petroleum is responsible for promoting and coordinating the use of renewable energies as part of the national strategy to enhance access of bioenergy resources so as to achieve an efficient management of wood and other sources of domestic energy. The other two major strategies formulated for the development of biomass energy in Niger Republic are National Renewable Energies Strategy (La Stratégie Nationale sur les Énergies Renouvelables (SNER) and the National Strategy for Domestic Energies (La Stratégie Nationale des Energies Domestiques (SNED).

Biomass energy accounts for 78% of the national energy supply in Mali making bioenergy development in the country to take frontline position in all the action plans for energy development. Mali is one of the few SSA countries with policies that encourage Jatropha cultivation.

The Ministry of Environment and Sanitation (Le Ministre de l'Environnement et de l'Assainissement du Mali) is responsible for the promotion of renewable energy while the Ministry of Mines, Energy and Water (MMEE) through its specialized agencies which include, National Biofuel Development Agency (ANADEB); Agency for the Development of Domestic

Energy and Rural Electrification (AMADER) and National Centre for Solar and Renewable Energies is responsible for the production and use of Jatropha in the country. Essential support to the MMEE is provided by other major ministerial departments, including the Ministry of Agriculture, Ministry of Secondary and Higher Education and Scientific Research and Ministry of Industry, Investments and Trade, while the Malian National Strategy for Biofuels Development (NSBD) aims to increase local energy production by developing biofuels to meet the country's socio-economic needs and substitute imported oil.

The 2015 United Nations Development Programme (UNDP) Low Emission Capacity Building report presented the relevant national and sector strategies and policies for biomass energy development in Ghana. This include the Bioenergy Policy for Ghana **(**2010), the National Energy Policy (2010) and the Ghana Sustainable Energy for All Action Plan (SE4ALL, 2012).

The institutional arrangement specifically meant for bioenergy development in Nigeria is virtually non-existent. There are neither institutions nor strategies that focus on sustainable development of charcoal and firewood. Moreover, none of the Nigerian National Biofuels Programme and Policy of 2005 addressed the development of bioenergy particularly charcoal and firewood.

However, some initiatives such as Energising Access to Sustainable Energy (EASE) addresses the massive deforestation and cutting of trees for fuel wood. This initiative encourages planting of more trees; and aims at improving the enabling framework conditions for renewable energy and energy efficiency in Nigeria and, in particular, with a focus on the use of renewable energies by Small and Medium Enterprises (SMEs) and households.

The rural firewood markets in the Republic of Niger and Mali was an epoch making and laudable strategy for development of viable bioenergy business in these countries. The establishment of a rural market gave village people exclusive control over their own woodlands. At the end of 1995, a year before termination of the scheduled funding period, a total of 85 markets were in operation and total turnover through the markets was estimated to be FCFA 100 million (about US$ 200,000). Collection rates for firewood taxes increased from an average of 15% in 1988 before the rural firewood market (RFM) project, to an average of 47% during the years 1989-93. RFM preserves biodiversity, brings income to the villagers and increases tax revenues of the state. The promising progress made in developing and implementing the RFM concept in Niger during the late 1980s and early 1990s led to its rapid replication in Mali and elsewhere. The RFM in Mali was an improvement over that of the Niger, because the actors of the programme used the Niger model as a template for an improved RFM. The RFM is a somewhat microcosmic model of forest certification and public private participation and therefore can serve as a template for the African indigenous forest certification and participatory forest development.

Lack of coherent policies and strategies for sustainable development of biomass energy particularly in Nigeria and Ghana made its production, transportation, and distribution informal and unregulated with consequent inefficient and risky production methods. Organizations such as AFF should therefore in collaboration with other forestry key stakeholders across the globe work towards the formalization of the bioenergy sector through formulation of appropriate intervention policy and strategies for sustainable development of this sector particularly in Ghana and Nigeria.

Furthermore, in order to reduce charcoal production induced deforestation and forest degradation, it will be imperative to promote and support the use of energy efficient stoves and conversion of agricultural and wood wastes to high calories bioenergy such as briquette, green charcoal etc; and encourage the use of wood harvested from purposely-established plantations for charcoal production.

To this effect, international forestry development institutions will have to partner with national governments in Africa and development agencies to put in place interventions that will encourage the use of energy efficient stoves as well as encourage communities, groups and individuals to establish agroforestry plots, woodlots and forest plantations planted with fast growing multipurpose energy trees on marginal, degraded or fallow lands using the business model approach. Moreover, regional and sub regional as well as other international and national key forestry stakeholders, organizations and institutions have to put efforts together to increase the area of forest under certification in in West Africa and Sahel sub region.

The use of solar energy is also expected to reduce the demand for biomass energy and consequently reduce pressure on the land, and eventually make more land available for food and fibre production. For example, the ECOWAS SOL train West Africa, a thermal capacity building and demonstration programme designed to run from 2015 to 2018 aims at removing existing awareness, political, technological, and capacity related barriers that has restricted solar thermal energy deployment in ECOWAS countries. Overall, the programme is expected to contribute to the switch from a fossil fuel based energy supply to a sustainable energy supply system based on renewable energies in general but based on the advancement and use of solar thermal technologies in the ECOWAS region.

Finally, the effects of bioenergy development on food security, land security, biodiversity and fibre production can be net positive if bioenergy development is properly planned and the community is carried along and involved in it right from the onset.

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

The estimates by International Energy Agency (IEA) (in 2013) indicated that in 2011 about 2.64 billion people which is about 38% of the global total relied on biomass, mostly fuel wood, for cooking. Sub-Saharan African (SSA) countries accounts for 26% of the global population and have about 79% of their population relying on traditional biomass energy for cooking and heating (Mirzabaew *et al*, 2014; IAASTD, 2008). Unlike oil, biomass can be produced in just about every country. It's easily available to many of the world's poor. Biomass has become one of the most commonly used renewable sources of energy in the last two decades, second only to hydropower in the generation of electricity. It is such a widely utilized source of energy probably due to its low cost and indigenous nature that it accounts for almost 15% of the world's total energy supply and as much as 35% in developing countries (Alternative Energy, 2016).The share of biomass energy in total energy consumption varies across developing countries, but generally the poorer the country, the greater its reliance on traditional biomass resources. Thus, biomass accounts for more than 60% of final energy use in Africa, 34% in Asia, and 25%t in Latin America (Hazel and Pachauri, 2006).

Bioenergy potentially offers many advantages if properly managed as compared to other renewable energy sources. Some of the merits include but not limited to: renewed investment in the agriculture sector; rural development opportunities; job creation; and increased energy security and access (FAO, 2014). Other advantages of bioenergy include reduction in carbon footprint and greenhouse gases (GHG) such as methane, sulphur dioxide, etc; prevention of forest fires; improvement of air quality; reliability; recyclability; renewability; reduction in emissions and levels; cleaner environment; abundance; carbon neutrality; cost effectiveness; less harmful emissions; cleanliness; reduced dependency on fossil fuels; reduced landfills; obtainable from diverse sources; versatility and reduction in waste (Conserve Energy Future, 2016; Maehium, 2012; Our Energy, 2016; ReEnergy , 2011).

Although widespread use of traditional and inefficient biomass energy in poor countries has been linked to indoor air pollution as well as to land degradation and attendant soil erosion, biomass-based industries are a significant source of jobs and income in poor rural areas with few other opportunities. Biomass has considerable potential to become more important in total energy consumption, and this growth could have significant impacts both positive and negative on agriculture and the poor (Karekezi and Kithyoma, 2006). Therefore, concerns have been raised about the economic viability as well as the environmental and social sustainability of bioenergy systems. Moreover, an expansion of bioenergy production from agricultural and forestry sources also generates concerns over land use management and governance within the context of growing demands for food, resulting from increasing global population and wealth. A clear understanding of the linkages between bioenergy production and use, sustainability and food security is therefore needed in order to inform the development and implementation of bioenergy policies that will contribute to both energy and food security in a sustainable manner (FAO, 2014).

1.2 STATEMENT OF PROBLEM

Despite the exciting prospects for bioenergy, there are issues that call for serious concern because of the implications of bioenergy production and use on the poor, the environment, and food security. First, as energy production competes for land with food production, the production of food declines and the price of food goes up. There are therefore concerns that this competition could affect food security, as food crops may be used as fuel and agricultural land may be used for feedstock production. Biofuel feedstock production competes with food, fiber and timber for land, water and fertilizers. Moreover, the increasing demand for biofuels is likely to increase the cost of land, labour, and agricultural inputs. The traditional use of solid biofuel for cooking is time consuming; causes unsustainable logging; and increases exposure to hazardous indoor air pollution.

The contamination of air by smoke from incomplete biomass combustion leads to asthma and other respiratory problems, causing premature deaths. The use of trees as a feedstock to produce biomass energy on a large scale can lead to widespread deforestation, degradation, desertification and loss of biodiversity since large amount of wood and other waste products have to be burned in order to produce considerable amount of bioenergy. For example, trees which are not very suitable for charcoal production might be felled to produce charcoal whenever there is scarcity of suitable tree species. This is particularly of great concern, as the need for forests and their important role in carbon sequestration in a world of climate change cannot be understated (Greentumble, 2016; Energypedia, 2016b).

Furthermore, the production of some biomass energy crops requires arable land that could otherwise be used for food production. In a world with increasing natural resource scarcities of food, water, and other basic human necessities, the use of our world's suitable arable land and other natural resources may need to be dedicated to producing sufficient food to feed a hungry human population (Greentumble, 2016). Equally, many easily grown grains like corn, wheat are being used to make ethanol. This can have bad consequences if too much of food crop is diverted for use to produce biomass energy. Adding to the interest in bioenergy is a growing concern about global climate change and the need to reduce GHG emissions.

Although bioenergy is in principle a carbon-neutral source of energy that could do much to reduce carbon emissions, it also requires fossil fuels for growing, transporting, and processing the feedstock and for refining and distributing the biofuel. Depending on the type of feedstock, and on where and how it is grown and used, the net carbon balance can vary widely. Net carbon and energy savings are thus not assured. Beyond issues related to carbon balances, bioenergy crops and plantations present their own local environmental challenges for soil, water, and biodiversity management (IAASTD, 2008).

Friends of the Earth Europe (2010), observed that a third of the land sold or acquired in Africa is intended for fuel crops estimated at about 5 million hectares (ha). Agro-fuels are competing with food crops for farmland where agro-fuel development companies are competing with farmers for access to land. This has resulted to communities losing their traditional land leading to growing food insecurity and hunger that is threatening human rights to food.

Pressure on farmland has led to forest being cleared to make way for agro-fuel plantations, destroying valuable natural resources and increasing GHG emissions. In Ethiopia, land inside an elephant sanctuary was cleared to make way for agro-fuels. Farmers have found that the much vaunted wonder crop Jatropha, rather than bringing a guaranteed income, it takes valuable water resources and needs expensive pesticides. In some cases, food crops have been cleared to plant Jatropha, leaving farmers with no income and no source of food.

1.3 JUSTIFICATION

In due consideration of the foregoing advantages and challenges of production and utilization of biomass energy coupled with the fact that biomass energy remains the major source of cooking and heating in SSA where in some countries it accounts for about 90% of energy use (IAASTD, 2008), it becomes very pertinent to investigate if: agricultural sector could meet the bioenergy demand without compromising food security; biomass energy production could effectively mitigate climate change; increase in bioenergy demand could result in increase in land use competition between food and fuel crops causing tenure insecurity among smallholder farmers; and how bioenergy development can affect food security, energy needs and employment opportunities for the poor rural people.

This study seeks to address these issues using four West African countries, namely: Ghana and Nigeria representing the humid or the forest zone; and Niger and Mali representing the dry zone or the Sahel.

1.4 OBJECTIVES

The study specifically sought to:

(i) assess trends in forest cover change in selected hotspot areas of respective sub regions;

(ii) assess and document impact of extractive industries (logging, mining, charcoal making, petroleum exploration, fuelwood exploitation etc.) on the 3Fs in the context of climate change;

(iii) examine how the competition on bioenergy (charcoal, fuelwood, tree biomass and *Jatropha*) production impact on food production, land security and biodiversity habitat;

(iv) analyse the mechanisms supporting/incentivizing the production and commercialization of biofuels and their specific socioeconomic contributions (employment, income, gender, etc.) in the selected countries;

(v) evaluate policies, legislations and other factors influencing land shifts between food, fuel, fibre (3Fs) and blending of liquid biofuels and fossil fuels and implications on carbon in the context of climate change;

(vi) assess fuel-wood and charcoal policies and other practices that will make fuel wood and charcoal industry a viable business at national and sub-regional levels; and

(vii) analyse strategies that will help tracking changes in the levels of production and consumption of fuel wood and charcoal.

CHAPTER 2: METHODOLOGY

2.1 POLITICAL AND ENVIRONMENTAL SETTING OF THE SUB-REGION

West Africa, also called Western Africa and the West of Africa, is the western most subcontinent of Africa with most of it being in the SSA(Answers Africa, 2016). It lies between latitudes 4°N and 28°N and longitudes 15°E and 16°W (FAO, 1983). According to FAO (2003), the West Africa sub-region occupies 505 million ha and constitutes about 17% of the total land area of Africa. West Africa is divided into two broad ecological zones, the dry zone (Sahel) and the humid (forest) zone. The dry zone includes part of the Sahara and covers approximately 22% of the area of the sub-region.

West Africa has wet and dry seasons resulting from the interaction of two migrating air masses. The first, is the hot, dry tropical continental air mass of the northern high pressure system which gives rise to the dry, dusty, Harmattan winds which blow from the Sahara over most of West Africa from November to February. The second, is the moisture-laden tropical maritime or equatorial air mass which produces southwest winds.

West African countries have limited forest resources because of the climate countries of the Sahelo-Sudanese zone, large populations in Nigeria, Benin, and Togo; agricultural clearing or long-term export of wood products such in the case of Côte d'Ivoire. Therefore, the forests of this sub region represent only 13% of the total forest cover of the continent and 2% of the world forest area (FAO, 2000). The total forest cover in the West Africa sub region is estimated at 72 million ha accounting for about 14% of the land area. There is considerable variation between countries in the extent of forest cover.

2.1.1 Nigeria

The Federal Republic of Nigeria, commonly referred to as Nigeria is a federal constitutional republic in West Africa. It lies between latitudes 4° and 14°N,andlongitudes 2° and 15°E. It has a total area of 923,768 km^2, making it the world's 32nd-largest country. Most of Nigeria has a tropical climate with warm temperatures throughout the year. The North is generally hotter and drier than the South. The average annual temperature in the north is about 29^{o}C, where daily temperatures may rise above 38^{o}C. The average annual temperature in the South is about 27^{o}C. Nigeria supports a wide range of vegetation, which is determined by

Photo: Secondary forest in the southern part of Nigeria© Larwanou Mahamane / AFF 2008 climate, in particular by the rainfall, and the severity of the dry season. Farming, fires and soil also profoundly affect it.

2.1.2 Ghana

Ghana, officially called the Republic of Ghana, is sovereign unitary presidential constitutional democracy, located along the Gulf of Guinea and Atlantic Ocean, in the sub region of West Africa.

Ghana lies between latitudes 4° and 12°N,and longitudes 4°W and 2°E. It has a total area of 238,533 km^2 out of which land accounts for 227,533 km2 and water occupies the remaining 11,000 km2. Ghana has 69.1% of its land area under agriculture, 21.2% for forestry while other land uses share the remaining 9.7% (CIA, 2014). Ghana has a population of approximately 27 million, spanning a variety of ethnic, linguistic and religious groups. Its diverse geography and ecology ranges from coastal savannahs to tropical jungles. Ghana's economy is one of the strongest and most diversified in Africa, following a quarter century of relative stability and good governance (Wikipedia, 2016b).

Panorama and landscape view of Lake Volta in Volta Basin and Eastern Region of Ghana. Photo credits: SandisterTei via Wikimedia Commons at https://upload.wikimedia.org/wikipedia/commons/e/e7/Volta_lake_from_the_Saint_Barbara_Church.JPG

2.1.3 Republic of Niger

The fertile south of Niger near the Niger River. Photo via Wikimedia Commons at https://commons.wikimedia.org/wiki/File:Niger_Safari.jpg

The Republic of Niger which is named after the Niger River, is a landlocked nation in West Africa, located along the border between the Sahara and SSAs. The country lies between latitudes 11° and 24°N, and longitudes 0° and 16°E. Niger's area is 1,267,000 km^2, of which 447,820 km^2 are used for agriculture and 11,668 km^2 (FAO, 2016). Niger which has over 80% of its land area covered by the Sahara desert is the largest country in West Africa (Wikipedia, 2016c) though only half of this is habitable due to adverse climatic or soil conditions.

Niger can be roughly divided into three zones: the north, center, and the south. The northern zone, covering about two thirds of the surface area, is located within the Sahara. It is an elevated region formed by plateaus and mountains, and with the exception of some isolated oasis, vegetation is rare. The center is part of the Sahel (the Ténéré region). It is a semi-arid region with few trees. The south is the only fertile and wooded region and where it rains enough for food crop farming without irrigation. The southwest is characterized by periodic floods of the River Niger (Ciesin Columbia University, 2016).

Niger is situated in one of the sunniest regions of the world, and has a mainly dry climate with considerable temperature variations. Potential evaporation is 2 to 4 m per annum, while rainfall nowhere exceeds 800 mm and even falls to below 100 mm over almost half the country. Annual temperature differences vary from around 16°C in the northeast to around 9°C in the southwest (Geesing and Djibo, 2001). Less than 4% of the country is arable, 9% has permanent pastures and only 2% has forests and woodlands. Burning wood and other traditional fuels account for 80% of the country's energy consumption. Also about 7.7% of the Niger's land is officially protected. Niger covers two geobotanical zones: the Saharo-Sindian in the very north and the major part and the Sudano-Zambezian zone. Biogeographically, Niger covers three areas: the Saharan, the Sahelian and the Sudanese.

2.1.4 Republic of Mali

Mali is a landlocked country in West Africa, located southwest of Algeria. It lies between latitudes 10° and 25°N, and longitudes 13°W and 5°E. Mali which lies in the southern Sahara Desert, and which produces an extremely hot, dust-laden Sudanian savanna zone has an area of 1,242,248 km^2.

Mali lies in the Torrid Zone and is among the hottest countries in the world (Wikipedia, 2016d). Most of Mali receives negligible rainfall and droughts are very frequent. Its intertropical continental climate is characterized by the alternation of a long dry season and a rainy season lasting from 2 months in the north to 5-6 months in the south, with a highly irregular pluviometry ranging from less than 100 mm in the north to over 1200 mm in the south (Kanouté, 2010).

View of Bamako. In the background the Niger with the Pont du roi Fahd. Photo credits: Arensond via Wikimedia Commons at https://commons.wikimedia.org/wiki/File:Bamako_037.jpg

The total area of arable land is estimated at some 1,486,300 ha. (Kanouté, 2010). Agriculture and forestry account for 34.1% and 10.2% respectively of the country’s land area (CIA, 2016).

Mali is sub-divided into four large eco-climatic areas comprising 49 agro-ecological areas. (Coulibaly, 2003). The vegetation in Mali is divided into two zones, Sahel and

Sudan which correspond to the climatic regions of the Sudan and the Sahel (Encyclopaedia Britannica, 2016).

2.2 DATA COLLECTION AND ANALYTICAL APPROACH

Data used for this study were secondary in nature and they were gathered through visits to relevant government ministries, Departments and Agencies (MDAs), institutions and private libraries as well as consultation of documents and publications from the MDAs and the internet. Some of the MDAs visited to solicit for information include the Federal Department of Forestry, Ministry of Environment, Abuja in Nigeria; Ministry of Lands and Natural Resources, Accra, Ghana; Ministry of Food and Agriculture, Accra and Ghana; Energy Commission, Accra, Ghana; Ministere de l'Environment, de la Salubrite Urbaine et du Development Durable, Niamey, Niger; Comite National du Code Rural, Niamey, Niger; and Cabinet du Premier Ministre; Counseil National de l'Environment pour un Development Durable (CNDD); Secretariat Executif, Niamey in Niger Republic; Ministere del'Energie et l'Eau, Direction Nationale de l'Energie Bamako, Mali; Agence Malienne pour le Développement de l'Energie Domestique et l'ElectrificationRurale (AMADER); Bamako and Project de Promotion de l'Utilisation de l'Huile de Jatropha comme Biocarburant au Mali, Bamako in Mali. Data collected were subjected to content analysis and descriptive statistics.

CHAPTER 3: RESULTS AND DISCUSSION

3.1 TRENDS IN FOREST COVER CHANGE

The world's forests are changing, in quantity and quality, and in both positive and negative ways. This process is associated with social, economic and environmental factors (FAO, 1999). Forests can undergo changes in various ways such as deforestation, degradation or by natural disasters - volcanic eruptions or severe mud slides, which can result in the forest being unable to naturally regenerate. Conversely, forest areas can be increased through afforestation, reforestation or by natural expansion of forests. While natural disasters are relatively rare, clearance of forests has been practiced throughout documented human history. Prior to the industrial era, such clearances were generally part of a relatively slow and steady process but in recent times, the rate of deforestation around the globe has increased dramatically. On the other hand, planting of trees has resulted in new forests being established while in other areas, forests have expanded on to abandoned agricultural land through natural regeneration, thus reducing the net loss of total forest area (UNEP, 2006).

It can be observed from Table 1 and Figure 1 that apart from Ghana which recorded net forest gain of 0.3% between 1990 and 2015, all the other three countries suffered net loss in their forest cover within this period of time. Nigeria which according Worldatlas (2016) has the highest rate of deforestation in Africa, recorded the highest rate of forest loss of 3.5% out of the four countries under study, followed by Niger (2.1%) and Mali with 1.4% rate of forest loss (FAO, 2015).

Table 1: Forest Cover Change in the Selected Countries between 1990 and 2015

Country	Forest area (1000Ha)				
	1990	2000	2005	2010	2015
Ghana	8627	8909	9053	9195	9337
Nigeria	17234	13137	11089	9041	699
Mali	6690	5900	5505	5110	4715
Niger	1945	1328	1266	1204	1142

Source: Adapted from FAO (2015)

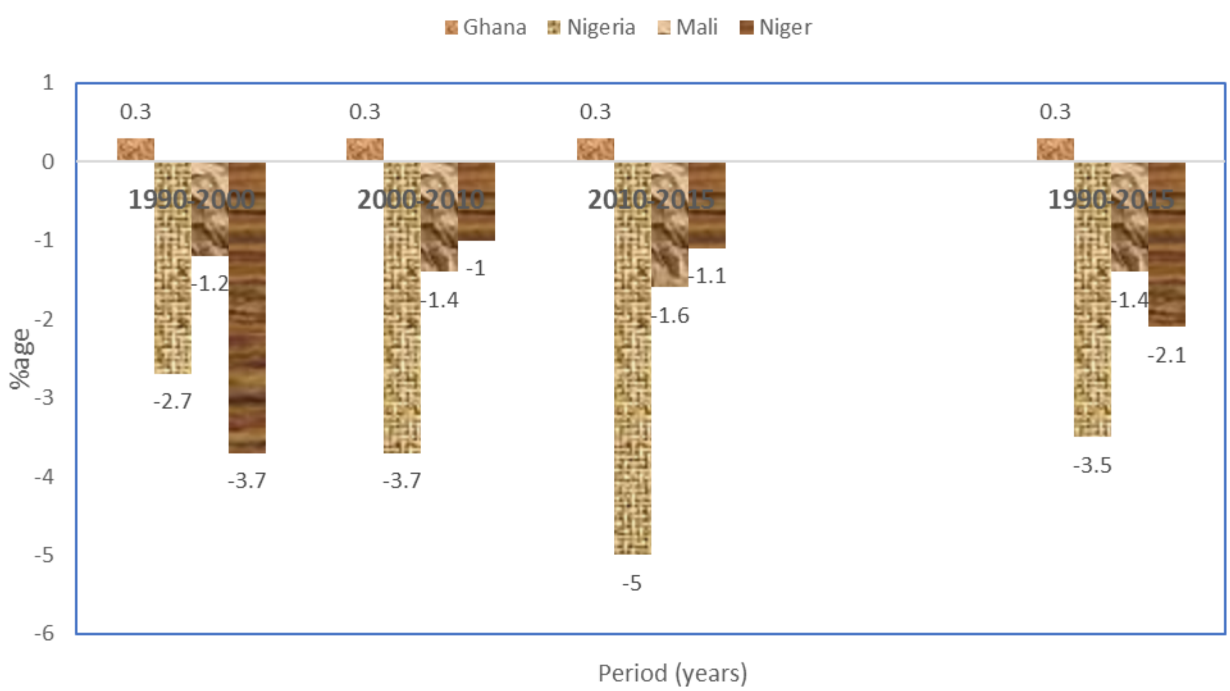

Figure 1: Percentage change in forest cover in the selected countries between 1990 and 2015

3.1.1 Deforestation and forest degradation in West Africa

Deforestation is one of the major factors contributing to the greenhouse effect and desertification. According to FAO (2000), only 22.8% of West Africa's moist forests remain and most are degraded. West Africa has a high annual negative rate of forest area change (-1.5 % on average) compared to the whole of Africa (-0.78 %). One factor contributing to the continent's high rates of deforestation is the dependence of 90% of its population on wood as fuel for heating and cooking (Wikipedia, 2016e).

The direct causes of deforestation generally include commercial agriculture for cropland, pasture and cash crop plantations for both international and domestic markets; subsistence agriculture (shifting cultivation), mining (industrial or artisanal), infrastructural development, urban expansion, wars and conflicts (Hosonuma et al., 2012). The indirect causes include: poverty, ignorance, corrupt practices of governments, security and forestry officials, weak institutions, inappropriate policies, lack of law enforcement, lack of concern by local communities, land tenure issues among others (News Ghana, 2016).

In Nigeria, logging, timber export, subsistence agriculture and collection of wood for fuel are the chief causes of deforestation (Wikipedia, 2016f), while deforestation is a result of forest clearance for cocoa and food crop farms as well as legal and illegal logging in

Ghana. Similarly, the causes of deforestation in Mali comprise land clearance for agriculture as well as meeting the country's demand for fuel and timber. This high rate of deforestation incidentally has effects on agriculture and serves as catalyst to desertification, as soil fertility declines and erosion accelerates (TREE AID, 2015).

3.1.2 Deforestation and forest degradation in the context of climate change

Deforestation is considered to be one of the contributing factors to global climate change. Deforestation not only lessens the amount of carbon stored, it also releases carbon dioxide into the air. This is because when trees die, they release the stored carbon. According to Wikipedia (2016f) deforestation used to account for more than 20% of CO_2 emissions, however, Bradford (2015) put the current rate between 6% and 12%. Deforestation, the second largest anthropogenic source of $CO_2$to the atmosphere, releases nearly about 1.5 billion tons of carbon into the atmosphere per year through combustion of forest biomass and decomposition of remaining plant material and soil carbon (Climate and Weather, 2014; Earth Eclipse, 2016; Wikipedia, 2016f). Deforestation has also decreased global vapour flows from land by 4% and even this slight change in vapour flows can disrupt natural weather patterns and change current climate models (Bradford, 2015).

3.2 IMPACT OF EXTRACTIVE INDUSTRIES ON THE 3Fs IN THE CONTEXT OF CLIMATE CHANGE

3.2.1. Mining

Resource extraction – whether artisanal or industrial in scale causes great adverse effects on the environment. Impact of resource extraction can include the introduction of invasive alien species through transport operations, expanded agriculture into natural forests, expanded illegal logging (UNEP, 2016), and high levels of atmospheric pollution, which damages crops and causes severe health problems (Friends of the Earth Europe, 2016). Large-scale mining operations, especially those using open-pit mining techniques, can result in significant deforestation through forest clearing and the construction of roads which open remote forest areas to transient settlers, land speculators, and small-scale miners.

On the other hand, strip mining eliminates existing vegetation, destroys the genetic soil profile, displaces or destroys wildlife and habitat, alters current land uses, and to some extent permanently changes the general topography of the area mined. Furthermore, artisanal miners use the forest and its resources for food, construction materials and energy. During rush situations', large numbers of miners suddenly descend on a previously untouched area to extract its minerals and cause significant damage to the forests. Also the construction of transport infrastructure may open up remote forests to other activities, such as logging, hunting and agriculture.

In Nigeria, deforestation, forest degradation and crop land contamination resulting from extractive activities have given rise to continuous restiveness and community agitation (militancy). According to Schueler et al (2011), deforestation, substantial loss of farmland within mining concessions, loss of livelihood for women subsistence farmers and widespread spill-over effects as relocated farmers expand farmland into forests have been the major consequences of resource extraction in Ghana.

Besides, illegal miners sneaked into forest reserves at night to exploit land for mineral wealth in protected forest areas. These inappropriate practices by the illegal miners are causing loss of timber resources, land degradation and cyanide pollution of soil and water bodies. Larsen and Mamoso (2013) observed that pollution of land and water resources with radioactive waste and toxins, irreversible damages to the sandstone aquifers in near and mid-term future, land dispossession, especially the appropriation of pastoral livestock corridors and grazing territories without compensation are some of the impacts of uranium exploitation in the Republic of Niger. In the Republic of Mali, land expropriation, environmental degradation and social tensions are parts of the effects of mining.

3.2.2. Logging

Logging, both legal and illegal, remains a lucrative business that has contributed to the rapid shrinking of Africa’s rainforests and woodlands. The 1998–2002 G8 Action Programme on Forests highlighted illegal logging as one of five issues affecting the world's forests.

According to Reboredo (2013), illegal logging occurs all over the world but mainly in Africa and Asia where sustainable forest management and respective forest certification schemes are almost absent. For example, the certified forest as a percentage of total forest area is 1.4 and 1.1 %, in Asia and Africa, respectively, while Western European countries have 50.8 % and North America 32.7 %. But even in North America, European Union (EU-27) and Europe as a whole, illegal logging occurs regardless of the observation of sustainable forestry rules. The main causes of illegal logging are poverty, weak governance and the absence of sustainable forest management. Illegal logging which is often associated with organized crime, corruption, human rights abuse, violent conflict and money laundering, undermines proper forest management, reduces the income of the producer countries and encourages tax evasion and corruption. Illegal logging has a devastating impact on some of the world's most valuable remaining forests, and on the people who live in them and rely on the resources that forests provide. It undermines the legitimacy of the forest sector and hinders the efforts of governments to implement sustainable forest management. (European Forest Institute, 2014).

Chatam House (2016) categorized the impact of illegal logging to include environmental, economic and social aspects. Environmental impacts include the loss or degradation of forests, as illegal logging tends to be associated with poor forest management. This can result in the loss of habitats and biodiversity.
Deforestation and forest degradation also have implications for climate change, as forests have a crucial role in both mitigating against and adapting to climate change. Illegal logging which often results in significant loss of government revenue undermines

efforts to place the forest sector on a more sustainable footing, as lost revenue cannot be reinvested in the sector. Illegal logging is often unsustainable because future sources of employment and export revenues are not realized. Illegal logging distorts global markets and undermines incentives for sustainable forest management, as illegal timber is often cheaper than legal timber. Illegal logging also undermines the rule of law and is often associated with corruption. It entails a lack of recognition of the land and resource use rights of forest communities, or of the rights of other concession-holders. This can have negative impacts on the livelihoods of local people and result in conflict.
Logging in Nigeria is enshrouded in controversy, corruption and illegality (Pambazuka News, 2004; Friends of the Earth, 2015; FAMESO, 2013; Lemuel, 2013; Oyerinde, 2013).

According to Aiyetan (2016), corruption by local officials and sharp practices by Chinese businessmen drive a thriving illegal trade in timber from Nigeria and a large part of West Africa with grave consequences for the economy, ecosystem and the environment. Oke and Oyadare (2008), Mfon and Bisong (2011), Akintoye et al (2013) and Cazzolla *et al* (2015) reported that logging has overall adverse impacts on the forest ecosystem in Nigeria.

Similar to Nigeria, corruption and illegal logging are widespread and thus serious issues of concern in the Ghanaian forestry sector (Agyarko, 2001; Hansen, 2012; Teye, 2013; Global Witness, 2013; EU FLEGT Facility, 2015; Boakye, 2015; Hance, 2015; and Ghana Business News, 2016). The authors observed that illegal logging and associated trade in timber products have been a severe policy problem for Ghana over the years. Illegal logging has contributed in no small way to: reduction in the forest covers of Ghana over the years, undermining the resource base of the timber industry, causing distress to the formal timber sector, loss of revenue to land owners as well as government and degradation of the environment. Hansen and Treue (2008) reported that 70% of the total harvest, or 2.3 - 2.7 million m^3 annually is estimated to be illegally cut. Chainsaw operators, who supply most of the domestic lumber demand, account for two-thirds and the export oriented timber industry account for one-third of the illegal harvest. The most valuable timber species dominate the illegal harvest and they appear to originate mostly from forest reserves, which consequently makes these species to be seriously threatened.

Chatam House (2016) and Forest Legality Alliance, (2013) argued that despite significant progress in tackling illegal logging in Ghana, inconsistency, lack of transparency, and large amounts of illegal logging remain. Illegal logging remains a considerable problem in the country, and a number of enforcement and administrative challenges persist. Weak law enforcement, poor domestic production standards, and a large export market have continued to drive illegal chainsaw milling in the country. Although, the majority of illegal logging is by artisanal chainsaw loggers to supply the domestic market, illegality is also an issue in supply chains for export.

3.2.3. Charcoal production

Out of the selected studied countries, Nigeria accounts for 42.4% and 13.5% of charcoal production in West Africa and Africa respectively. Followed by Ghana which respectively accounts for 17. 9% and 5.7% of charcoal production in West Africa and Africa. Furthermore, Niger respectively accounts for 6.53 and 2.1% of charcoal production in West Africa and Africa, and lastly Mali accounts for 1.7% and 0.6% of charcoal production respectively in West Africa and Africa respectively (ChartsBin, 2016; Knoena (2016). In low-rainfall areas, where regenerative capacity is relatively low, unplanned and unmanaged charcoal production can accelerate desertification processes.

Furthermore, charcoal production as an aftermath of farmers' clear felling of land for agriculture coupled with selective cutting or opportunistic harvesting of wood for charcoal production contribute largely to deforestation and forest degradation. Charcoal producers prefer tree species that yield dense, slow-burning charcoal. These tree species are slow growing and are therefore particularly vulnerable to overexploitation. The concentrated exploitation of a few species with a high density can adversely affect biodiversity. Furthermore, some dense tree species which have a high economic value are unrecognized by the charcoal producers and are thus used for charcoal production leading to great economic loss.

Worldatlas (2016) reported that large tracts of land have been subjected to deforestation in Africa due to unsustainable charcoal production. Africa alone consumed about half of the total world production of charcoal between 2003 and 2007 (NL Agency, Ministry of Economic Affairs, Agriculture and Innovation, 2010). This is because the uses of charcoal are many causing deforestation resulting to many trees being cut down to meet the demand for it.

It is expected that demand for charcoal will further increase even in SSA countries where large volumes of charcoal are already being consumed because of population increase (often 2-3% per year, which leads to a doubling of the population in about 20 to 25 years); increased urbanization and rising prices for alternative fuels such as liquefied petroleum gas (LPG), natural gas, or electricity resulting in people continuing to using charcoal, despite rising incomes.

3.3 NEXUS OF FOOD, FUEL AND FIBRE

The relationship among food, fuel and fibre is multidimensional and intertwined. Food security is one of the major concerns surrounding the use of biofuels. Energy plantations have direct impacts which include possible dispossession of land among the poor in areas with insecure land tenure, with attendant increase in poverty and food insecurity. Therefore, large-scale modern biomass energy development without appropriate, sensitive, and equitable management, can lead to further marginalization of the rural poor. Biofuel feedstock production competes with food, fiber and timber for land, water and fertilizers.

There are therefore concerns that this competition could affect food security, as food crops may be used as fuel and agricultural land may be used for feedstock production. As energy production competes with food for land, the production of food declines and the price of food goes up (UNECA-ACPC, 2011). Intensive cultivation of energy crops is expected to produce adverse environmental impacts on soil and groundwater, and to result in deforestation and loss of biodiversity. The efficient exploitation of existing agricultural wastes presents significant potential for developing bioenergy without unduly disrupting existing agricultural practices and food production or requiring new land to come into production. Some of the most common crop wastes suitable for bioenergy development include sugarcane bagasse, sisal waste, coffee husks, rice husks, maize cobs, and banana leaves. Unlike many other crop wastes, these waste products are generated during agro processing and are rarely returned to the field (Karekezi and Kithyoma, 2006). In this regard, it is imperative to consider the impacts of bioenergy production and use on food security, biodiversity and land security.

Charcoal and fuelwood are the principal forms of biomass energy used in the study area, though there is also some level of use of biofuel made from Jatropha (Reegle, 2013a; Reegle, 2013b; Reegle, 2014a; Reegle, 2014b). Oguntunde et al (2008), Fontodji et al (2009), Ogundele et al (2011), Oriola and Omofoyewa (2013) and Wahabu et al. (2015) observed an increase in soil nutrients and organic matter in charcoal production sites in Nigeria and Ghana. These results however differed from the work of Ogundele et al (2012). This difference is likely to be a result of differences in the latitudinal position and slight climatic differences between humid and drier ecosystems as well as the type of kiln used in the production of charcoal. According to Kouami et al. (2009), selective logging for charcoal production has serious adverse effects on biodiversity and dendrometric characteristics such as density, height and diameter of the stands, basal area etc. in Togo. This has a greater consequence in the savannas and dry forest biomass than in the semi-deciduous forest. Adedeji and Aiyeloja (2014) also observed that honeybees' habitats were considerably altered and there are increasing disturbance in the core niches of the forests by charcoal burners in Imeko, Nigeria. This has consequence on the quality and quantity of honey produced in the area.

According to Addo et al (2014), biofuel production in Ghana is an income generating venture with significant contribution to food security especially in the Northern Region of Ghana where farming is feasible for small holder farmers only in the rainy season. Nevertheless, Boamah (2010) iterated that analyses of the effects of biofuels on food security should be situated within specific contexts, viz: local variations in land use patterns, land availability, farming seasons, household composition and resilience of livelihoods in biofuel producing areas, and the strategy of biofuel investors as well as the biological characteristics of the biofuel feedstock. These factors determine the amount of resources that will be diverted from food production to biofuel production which is in turn decisive of the extent of competition between biofuels and food. Boamah (2010) observed that the organization of Jatropha plantations in three communities in Northern Ghana increased farmland areas under crop production during the project compared to the period before.

Because of the Jatropha plants' suitability to marginal land, the Jatropha plantation was established on a land abandoned by most farmers. Moreover, some portions of the Jatropha plantation such as the Jatropha rows as well as the edges on the plantation were used for maize production during the project. A total of 1100 ha of land was cleared of which 16 ha of maize farms for the communities as well as 10 ha of maize farm for workers of the company were used. In sum, the Jatropha project reduced vulnerabilities in household food security in all the three Ghanaian villages whose livelihoods depended on the land areas earmarked for the Jatropha project. However, in some other studies, Timko *et al* (2014) as well as Acheampong and Campion (2014) observed that the cultivation of Jatropha plantations yielded both positive and negative results. The cultivation of Jatropha plantations in Ghana, though created employment and increased income, has nevertheless led to decreases in household landholdings which further precipitated negative impacts on household socio-economic status, food security, fallow periods, and fodder availability.

In Mali, both non governmental organizations (NGOs) and European companies are producing biofuels feedstocks, mostly through small scale projects based in the immediate vicinity of the company's or NGO's processing facilities (IIED, 2009). At community and household levels, Jatropha offers the potential to contribute to rural development and diversify farmers' livelihood strategies. It is widely used to demarcate field boundaries and avoid land tenure conflicts, to produce soap and to reduce soil erosion. Local communities' expectations remain high with regards to future generation of revenues that would allow a shift between different capital assets and a diversification of farmers' livelihood strategies. Such revenues can be used to buy cereals in times of shortage, clothes, and school materials and to repair agricultural equipment. Jatropha is also perceived as an "easy-to-grow" crop that could substitute cotton farming, providing a diverse and more immediate source of liquidity to face the problems experienced in the past decade in the Malian cotton sector (Favretto *et al*, 2012). Meanwhile, Favretto (2013), observed that the cultivation of Jatropha in Mali does not pose a problem to food security since it is usually intercropped with cereals and grown in small scale, rather Jatropha apart from generating extra income to the farmers, is also used as living fence to delimit food crops and mitigate soil erosion.

The NL Agency in 2013 reported that cultivation of Jatropha in Mali contributed to an increased biodiversity by planting Jatropha on fallow land, fertilizing food crops with the seed cake, and reducing soil erosion, albeit, the conversion of fallow, savannah and high-biodiverse forest and woodland to Jatropha plantations calls for concern.

3.4 INSTITUTIONAL ARRANGEMENTS FOR DEVELOPMENT OF BIOENERGY IN THE SELECTED COUNTRIES

Institutional arrangements for development of biomass energy encompass institutions and administrative structures such as ministries, departments, agencies, research institutes and organisations as well as policies, legislations and strategies that are directly or indirectly concerned with the development of bioenergy at national and sub-regional level.

Bioenergy development in most of the ECOWAS Member States follows an ad-hoc and unsustainable path. This is because of: weak legal and regulatory regimes and enforcements for wood and charcoal production and trade; lack or inadequate clear-cut policy on bioenergy development; lack of capacities of institutions and individuals in the member states; lack of adequate information and data for planning and investment; lack of awareness on the resource potentials; benefits for bioenergy use and investment opportunities; lack of financing opportunities and investment programmes; and lack of demonstration projects that showcase the socio-economic and technical feasibility of bioenergy projects for regional scaling-up (ECREEE, 2013). In response to these challenges of providing bioenergy services in a sustainable and efficient manner, the ECOWAS ECREEE was inaugurated in 2010, to lead and coordinate efforts at the regional level with a mandate to develop and promote clean, efficient and sustainable energy supply.

To achieve its mandate, ECREEE in 2012 developed the ECOWAS Bioenergy Strategy Framework which was aimed at increasing food and energy security in the ECOWAS Region through sustainable production and utilization of bioenergy resources. Implemented as part of this strategy in 2012, is the WACCA, developed to disseminate clean, efficient and affordable cooking fuels (woodfuels, charcoal, briquettes, LPG, bioethanol etc.) and devices to all ECOWAS citizens by 2030 (Yeboa, 2015). ECREEE also initiated the REDD+ in 2013 to promote effective and efficient management of the forest resources through participatory forest management by the local people and provide opportunity to the rural people to harvest and trade their biomass in a sustainable and efficient manner among other things.

ECOWAS in 2015 developed the ECOWAS Bioenergy Policy with the main objective of promoting a modern, sustainable and vibrant bioenergy sector in the ECOWAS region by removing the institutional, legal, financial, social, environmental and capacity gaps and barriers (ECREEE, 2015). In addition to the efforts of ECOWAS geared towards sustainable development of bioenergy, there are two other sub-regional noteworthy initiatives in the Sahel of West Africa. The Programme Régional de Promotion des Énergies Domestiques et Alternatives au Sahel (PREDAS), implemented by CILSS and the state members of ECOWAS, with financial support of the EU and the German Development Cooperation aims at helping the country members to organise sustainable supply and rational use of domestic energies, by avoiding harmful impact on the environment. Also, PRBE implemented by the ECOWAS/Union Economique et Monetaire Ouest Africaine (UEMOA) with the financial support of the Netherlands, fits into the framework of the implemented Politique Energétique Commune (PEC) or Common Energy Policy) of the UEMOA, and contributes to the long-term management of biomass in a policy to fight poverty and promote environmental protection (RIAED, 2006; REEGLE, 2013a).

3.4.1. Bioenergy development framework for Niger

Biomass accounts for about 93% of energy supply in the Republic of Niger, where household biomass use is amongst the highest in Africa, with the vast majority relying on fuel wood for heating, lighting and domestic tasks. Hence, bioenergy development somewhat constitutes greater part of strategies for development of renewable and domestic energies in the country, since the energy sector is dominated by the high consumption of the residential sub-sector, which is mainly based on wood resources (wood and biomass remnants). The statement for energy policy adopted by the government in 2004 has been followed by many action plans for the promotion of renewable energy and sustainable development of domestic energy. The Department of Environment in the Ministry of Water and Environment is responsible for the development, coordination and implementation of policies, strategies, plans and programmes, legislations and regulations in the fight against desertification, reforestation, land restoration, forest management, land management, conservation of the environment and improving the living environment (Centre d'Echange d'Informations sur la Biodiversité du Niger, 2016).

The Directorate of Renewable Energy and Domestic Energy which is situated within the Ministry of Energy and Petroleum, is on the other hand responsible to promote and coordinate the use of renewable energies as part of the national strategy to promote access, and to achieve an efficient management of wood and other sources of domestic energy. Two major strategies formulated for the development of biomass energy in Republic of Niger are SNER and SNED. The National Renewable Energy Strategy for Niger Republic of 2003, aims to increase the contribution of renewable energy to the national energy balance from less than 0.1% in 2003, to 10% by 2020, by facilitating the promotion of renewable energy supply systems; reducing the impact on forest resources; promoting rural electrification on the basis of renewable energy resources; and promoting education, training, research and development related to renewable energy technologies.

The National Strategy for Domestic Energies in its own case aims at creating a coherent framework for the domestic energies sub-sector, by assuring the sustainable use of forest resources and better reforestation; promoting alternative sources of energy (other than wood) and improving the efficiency of the appliances used; strengthening the capacity of the main market actors for a better management of the sector; and setting up communication to inform and educate the actors on issues related to the production and use of domestic energies. The Strategy for Rural Development (La Stratégie du Développement Rural (SDR) also considers the promotion of the use of alternative sources of energy as a substitute for wood.

3.4.2 Bioenergy development framework for Mali

The energy demand in Mali is dominated by the residential sector, which accounts for about 70% of the country’s total consumption. This consumption is itself dominated by wood and charcoal for cooking, hence biomass accounts for 78% of the national energy supply. This situation makes the issue of bioenergy development to take frontline position in all the action plans for energy development in Mali. According to Favretto (Ibid.), Mali is one of the few SSA countries with policies that encourage Jatropha cultivation. These target fuel production primarily, and a range of initiatives have been supported across the country since the 1990s by a variety of actors including development agencies, government, private sector and NGOs.

Jatropha production and use in Mali are promoted by the MMEE through its specialized agencies which include ANADEB; AMADER; and National Centre for Solar and Renewable Energies. Essential support to the MMEE is provided by other major ministerial departments, including the Ministry of Agriculture, Ministry of Secondary and Higher Education and Scientific Research (MESSRS) and Ministry of Industry, Investments and Trade.

From an environmental perspective, the promotion of renewable energy is supported by the Ministry of the Environment and Sanitation, which approves Clean Development Mechanism (CDM) projects – and the attached Environment and Sustainable Development Agency, while the Ministry of Agriculture promotes Jatropha uptake through awareness-raising and farmer support to improve production at the village level. Furthermore, a variety of Jatropha Research and Development activities are carried out under the supervision of both the Ministry of Agriculture – through the attached Institute of Rural Economy, which carries out research on ecotypes and production techniques – and MESSRS, which orients the work of two high education schools. The Rural Polytechnic Institute is active in agronomic research on Jatropha as well as in testing the use of the oil on engines, while the National School of Engineers carries out engine performance testing under a formal collaboration signed with ANADEB.

The Malian NSBD aims to increase local energy production by developing biofuels to meet the country's socio-economic needs and substitute imported oil. The specific objectives of the NSBD are to increase vegetable oil-based biofuel production; create the village-level and industrial infrastructures required for biofuel production, transformation and commercialization; and establish institutional, legal, regulatory and financial frameworks for biofuel development.

3.4.3. Bioenergy development framework for Ghana

The Forestry Commission under the Ministry of Lands and Natural Resources and the Energy Commission are the institutions whose mandates in a way cover biomass energy development in Ghana. The United Nations Development Programme (UNDP) Low Emission Capacity Building (LECB) Programme (2015) presented the relevant national and sector strategies and policies for biomass energy development in Ghana. This include the Bioenergy Policy for Ghana (2010), which is a major initiative by the Government of Ghana geared towards modernizing and maximizing the benefits of bioenergy on a sustainable basis.

The National Energy Policy (2010), is to *inter-alia:* support sustained regeneration of woody biomass resources through legislation; fiscal incentives; and attractive pricing; promote the establishment of dedicated woodlots for wood fuel production; encourage the production and use of improved and more efficient biomass utilization technologies such as improved cook stoves; promote the use of alternative fuels such as LPG as substitute for fuel wood and charcoal by addressing the institutional and market constraints that hamper increasing access of LPG in Ghana; and tax and levy wood fuels to promote the alternative fuel such as LPG. The Ghana SE4ALL, 2012 has the main objective of ensuring access to modern energy for cooking particularly the promotion of LPG and improved cook stoves. The use of improved cook stoves will bring greater wood energy use efficiency since less firewood will be required for cooking at any point in time and this will ultimately reduce the quantity of firewood used for cooking in the country. Although, the fundamental goal of the National Policy of LPG Promotion is to ensure at least 50% of Ghanaians have access to safe and environmentally friendly LPG for commercial, industrial and domestic use by 2020, increased use of LPG has the overall advantage of reducing the quantity of firewood and charcoal used for cooking in the country and in a way that will stem down forest degradation and deforestation caused by unsustainable wood harvesting practices for wood fuel production.

Other relevant strategy and initiative relevant to bioenergy development in Ghana is the Strategic National Energy Plan which was formulated by the Energy Commission in 2006. Aspects of this strategy relevant to biomass energy development include the reduction of the average wood fuel energy intensity per urban household by 30% by 2015 and by 50% by 2020; reduction of wood fuel intensity per rural household by 10% by 2020; increase LPG penetration by 20% by 2015 and 30% by 2020; curtail wood fuel share of energy at 50% by 2015 with subsequent reduction to 40% by 2020; achieve 5% penetration in the use of improved efficiency cook stoves by 2015 and 10% penetration by 2020; achieve 1% penetration of biogas for cooking in hotels, restaurants and institutional kitchens by 2015 and 2% by 2020; reduce the wood intensity of charcoal production (ratio of wood input to charcoal) from the existing 4:1 to 3:1 in the Savannah zone and from 5-6:1 to 4:1 in the forest zone by 2015; ensure that the energy share of traditional biomass in the national final energy mix is reduced from about 60% to at most 50% by 2015 and eventually to 40% by 2020 and increase the supply of renewable energy and modern biomass in the Ghanaian final energy supply to achieve at least 10% penetration by 2020.

3.4.4. Bioenergy development framework for Nigeria

Institutional arrangement specifically meant for bioenergy development in Nigeria is virtually non-existent, thus there are no institutions or strategies or initiatives that focus on sustainable development of charcoal and firewood which are the major forms of bioenergy used by the majority of Nigerians. The Federal Department of Forestry in the Ministry of Environment which is the main institution in Nigeria whose mandate covers forestry development does not have any department to oversee biomass energy development yet. The goal of the National Forest Policy of 2006 which encapsulates the strategies for forestry development in Nigeria is to encourage and support an aggressive establishment of plantations of economic trees of both exotic species, such as teak and indigenous species; and foster the re-direction of development resources (Federal Department of Forestry, 2006). Moreover, none of the Nigerian National

Biofuels Programme and Policy of 2005 addressed the development of bioenergy particularly charcoal and firewood.

The main objective of Energising Access to Sustainable Energy (EASE) (Reglee, 2014b), was to address the massive deforestation and cutting of trees for fuel wood, which is the main energy source for the majority of the population, by planting more trees. It also aimed at improving the enabling framework conditions for renewable energy and energy efficiency in Nigeria and in particular, with a focus on the use of renewable energies by SMEs and households.

3.5 STRATEGIES FOR DEVELOPMENT OF VIABLE BIOENERGY BUSINESS USING A CASE OF RURAL FIREWOOD MARKETS IN THE REPUBLIC OF NIGER AND MALI

The analysis of this business strategy is divided into three sections, viz: the problem, the intervention and the gains.

3.5.1 Problem

Under traditional wood fuel supply arrangements in the Republic Niger, urban fuelwood traders were given a cutting permit from the forest service specifying a permitted quantity of fuelwood and the location from which it may be taken. These woodcutters took the allocated quantity of wood from the natural woodlands with little or no consideration for the sustainability of supply. Villagers in the areas where the woods were being harvested have no power to regulate the cutting and receive no benefit from it. The forest service also because of lack of resources, was not able to exercise effective control over how much wood is taken or where it was obtained. The quantities specified in the cutting permit were thus effectively ignored and the urban fuelwood traders consequently realize substantial profits fraudulently.

3.5.1.2 Intervention

The RFM, a component of the World Bank – Government of Niger household energy project was developed and implemented between 1989 and 1996. According to Foley et al. (2002), RFM was defined as a place of firewood sale where an organized local management body exists (Government Order No 92-037, 1992). The goal of RFM was to check forest degradation and increasing desertification as well as to promote sustainable forestry development through controlled exploitation of forest resources. Under RFM, an organized local management body signs an agreement with the government to manage a woodland sustainably. The community was then given a formal control over its own area of natural woodland and exclusive rights to the sale of all the firewood produced from it. The community in return, got part of the money it generated.

The task of the local management organization was to exploit, guard, manage and ensure the regeneration of the agreed area of natural woodland supplying the market. The rural market was authorized to collect tax on the firewood sold. Between 40 and

60% of tax revenues were assigned to the work of forest management such as agroforestry plantations, nurseries, firebreak, and fight against erosion. A share of the revenues was retained by the villages for development work. The rest went to investments in the free choice of the villagers. Under RFM, the firewood cutting permit was abolished and instead, the transport of harvested firewood to the towns became subject to tax called transport coupons.

The transport coupons specify the amount, source (rural market/uncontrolled woodland) and the distance of the zone relative to the urban area from which the firewood had been obtained. The coupons served the purpose of providing a financial incentive to firewood traders to differentiate between the rural markets and uncontrolled zones as sources of supply; encouraging the firewood traders to patronize the controlled over the directed markets and encouraging dealers to obtain their supplies from further away, where forest resources are less heavily exploited than those close to the urban areas.

3.5.1.3 Gains

The establishment of a rural market gave village people exclusive control over their own woodlands. At the end of 1995, a year before termination of the scheduled funding period, a total of 85 markets were in operation and total turnover through the markets was estimated to be FCFA 100 million (about US$ 200,000). By 1999, the total number of rural markets had risen to 102.A number of villages adjacent to functioning markets, but without intervention yet, had begun to refuse access to firewood dealers while they were waiting for the establishment of their own market.

In one area, a number of markets banded together to harmonize their prices and prevent themselves from being played off against one another by firewood dealers. Collection rates for firewood taxes increased from an average of 15% in 1988 before the RFM project, to an average of 47% during the years 1989-93. RFM preserves biodiversity, brings income to the villagers and increased tax revenues of the state. The promising progress made in developing and implementing the rural fuelwood market concept in Niger during the late 1980s and early 1990s led to its rapid replication in Mali and elsewhere. The RFM in Mali was an improvement over that of the Niger, because the actors of the programme used the Niger model as a template for an improved RFM.
The RFM is a somewhat microcosmic model of forest certification and public private participation and therefore can serve as a template for the African indigenous forest certification and participatory forest development.

CHAPTER 4: CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

Bioenergy in form of firewood and charcoal will continue to dominate energy demand particularly at household levels for cooking, heating and lightning in the studied countries. This is because the modern energy such as LPG, kerosene and electricity are not readily available or affordable by the majority of the populace. Moreover, alternative renewable energy are also at no significant level of development. Incidentally, wood fuels in these countries are largely in the informal sector without any serious control or regulation.

The current prevailing methods of charcoal production as a by-product of clearance of land for agriculture or through selective cutting ultimately leads to forest degradation and under valuation of the charcoal since it is difficult to get a realistic economic value of the tree feedstock for charcoal production. In these two methods, very little, if anything is paid for the harvested forest stands. Consequently, in spite of growing scarcity of wood, charcoal generally remains under- priced by more than 20 to 50% relative to its economic cost in most African countries, as only the opportunity cost of labour and capital required for charcoal production and transport are reflected. Appropriate production price for the raw material is often not reflected when wood is exploited from the natural forests which are most of the time unsustainably managed and to make the situation worse these undervalued dues are ineffectively collected. Undervaluation translates into wasteful and inefficient production and consumption, and creates a formidable disincentive for forest management and tree growing.

Furthermore, it has been observed that the negligible portion of the African forest (1.1%) that is certified compared to 50.8% and 32.7% for Western European countries and North America respectively, has been a major factor contributing to illegal logging in Africa. This places a great challenge on the regional and sub regional as well as other international and national key forestry stakeholders, organizations and institutions to work concertedly in increasing the area of forest under certification in Africa particularly in West Africa and more importantly in the four countries under study in West Africa in order to effectively reduce the menace of illegal logging.

Finally, the effects of bioenergy development on food security, land security, biodiversity and fibre production can be net positive if bioenergy development is properly planned and the community is carried along and involved in it right from the onset

4.2 RECOMMENDATIONS

Lack of coherent policies and strategies for sustainable development of biomass energy made its production, transportation, and distribution informal and unregulated with consequent inefficient and risky production methods. Organizations such as AFF should therefore in collaboration with development partners' work towards the formalization of the bioenergy sector through formulation of appropriate intervention policy and strategies for sustainable development of this sector particularly in Ghana and Nigeria.

In order to reduce charcoal production induced deforestation and forest degradation, it will be necessary that wood for production of charcoal is harvested from purposely-established plantations. It is therefore very imperative for institutions such as AFF to partner with national governments in Africa and development agencies to encourage communities, groups and individuals to establish agroforestry plots, woodlots and forest plantations planted with fast growing multipurpose energy trees on marginal, degraded or fallow lands using the business model approach.

NOTS (2012) argued in favour of the use of dedicated plantations and presented a business model approach to sustainable production of charcoal. The business model consists of two main pillars: (I) efficient charcoal ovens (retorts) for increasing efficiency of production; these retorts require only 3 kg of wood for 1 kg of charcoal instead of 7; in addition the combustion times of the retorts are much shorter, 2 days instead of 14; and (II) an agroforestry system for the production of wood (80%) and food crops (20%). The advantages of such model include bringing an end to charcoal-driven deforestation; production of sufficient charcoal and food for the participating communities; increase in income by at least 20% for the participating community and recuperation of initial investments in less than three years.

However, in view of the possible deleterious effects of bioenergy production, the implementation of the business model for sustainable production of bioenergy (charcoal) has to be guided by sustainability criteria and principles for biomass energy production. In this regard, Cramer (2007) and World Energy Council (2010), have developed sustainability criteria for biomass production which should serve as guiding principles for the business model approach to sustainable production of charcoal.

Another way to alleviate deforestation and forest degradation informed by the production and utilization of wood fuels in the studied countries and by extension West Africa, is for forest stakeholders to work concertedly to promote and support sustainable ways of producing and using of wood for biomass energy. Such include the use of energy efficient stoves and conversion of agricultural and wood wastes to high calories bioenergy such as briquette, green charcoal, etc. The “green charcoal” which can be produced by compressing agricultural waste, into briquettes and then carbonizing them using a machine, has the look and feel of traditional charcoal and burns similarly. The technology is efficient, effective and economical because it can produce a substitute for charcoal at half the price (IRIN, 2016).

Regional and sub regional as well as other international and national key forestry stakeholders, organizations and institutions such as the African Union, ECOWAS, AFF will have to work concertedly in increasing the area of forest under certification in Africa particularly in West Africa and more importantly in the four countries under study in West Africa in order to effectively reduce the menace of illegal logging. In this regard, AFF can commission a study on the rural firewood market in Niger and Mali with the aim of using it to develop a template for the African indigenous forest certification and private public partnership.

4.3 EMERGED ISSUES

The public forest in many parts of Africa will for a long time be given way to mineral resource extraction and agriculture because of the notion that these alternative uses provide higher economic returns than the forest. Strategies for sustainable forestry development will therefore have to be all inclusive and will include increasing the multiple use value and the attachment of people to the public forest through ecotourism and recreational forestry as well as integrating local social and economic development projects into the protected area management. Furthermore, private participation in forestry development has to be encouraged through creation of awareness of incentives and facilities available for forestry development. Consequently, there is a need to increase tree cover in the cities and to encourage development partners EU, World Bank, African Development Bank (ADB), FAO etc. to support private forestry development in African countries

REFERENCES

Acheampong, E. and Campion, B. B. (2014): The Effects of Biofuel Feedstock Production on Farmers' Livelihoods in Ghana: The Case of Jatropha curcas . Sustainability 6, 4587-4607; doi:10.3390/su6074587.

Addo, A., Bessah, E. and Amponsah. S.K. (2014): Uncertainty of Food Security in Ghana by Biofuel Production (Jatropha curcas) Production as an Adaptation and Mitigation Strategy to Climate Change. Ethiopian Journal of Environmental Studies & Management 7 Suppl.: 790 – 800, 2014. ISSN:1998-0507.

Adedeji, G.A. and Aiyeloja, A.A (2014): Effect of Commercial Charcoal Production on the Availability of Wood Cavity and Survival of Genetic Honeybee's Resource in Imeko, Nigeria. Nature and Science 2014;12(12) :123-132. (ISSN: 1545-0740). http://www.sciencepub.net/nature.

Answersafrica (2016): West African Countries: List of Countries in West Africa.http://answersafrica.com/west-african-countries-list.html.

Agyarko, T. (2001): FOSA Country Report – Ghana. http://www.fao.org/docrep/003/AB567E/AB567E03.html

Aiyetan, D. (2016): How China Fuels Deforestation In Nigeria, West Africa. *International Centre for investigative reporting. January 2016* http://icirnigeria.org/how-china-fuels-deforestation-in-nigeria-west-africa/.

Akintoye, O. A., Bisong, F. E.,Utang, P. B. and Andrew-Essien, E. (2013): Impact of Logging on Non-Logged Species in the Moist Forest Region of South Eastern Nigeria. Journal of Environment and Earth Science. Vol. 3, No.3: 62-70. ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online), http://www.iiste.org/Journals/index.php/JEES/article/viewFile/4775/4854

Alternative Energy (2016): Biomass. http://www.altenergy.org/renewables/biomass.html.

Boakye J. (2015): Estimation of Illegal Logging by the Formal Timber Sector in Ghana: Implications for Forest Law Compliance, Enforcement and EU-Ghana Voluntary Partnership Agreement. International Forestry Review 17(2):117-12. doi: http://dx.doi.org/10.1505/146554815815500598

Boamah, F. (2010): Competition between Biofuel and Food? The Case of a Jatropha Biodiesel Project and its Effects on food Security in the Affected Communities in Northern Ghana. Masters Project in Resources and Human Adaptations, Department of Geography, University of Bergen. 146pp

Bradford, A. (2015): Deforestation: Facts, Causes & Effects. http://www.livescience.com/27692-deforestation.html

Business Dictionary, (2016): Deforestation.

http://www.businessdictionary.com/definition/deforestation.html

Cazzola, G. R., Castaldi, S., Lidsell, J.A., Coomes, D.A., Marchetti, M., Maesano, M., Paola, A.D., Paparella, F. and R. Valentini. (2015): The impact of selective logging and clearcutting on forest structure, tree diversity and above-ground biomass of African tropical forests. Ecological Research 30: 119. doi:10.1007/s11284-014-1217-3.
http://link.springer.com/article/10.1007/s11284-014-1217-3

Centre d'Echange d'Informations sur la Biodiversité du Niger (2016). Le Conseil National de l'Environnement pour un Développement Durable (CNEDD)..
http://ne.chm-cbd.net/implementation/les-institutions-de-gestion-de-la-diversite/le-conseil-national-de-lenvironnement-pour-un-43636.

Centre for Renewable Energy Sources and Savings, (2016): Types of Biomass Residues. http://www.cres.gr/kape/ Types of Biomass Residues.html

ChartsBin (2016): Final Consumption of Charcoal by Country

Chatam House (2016): Illegal Logging Portal: Ghana.
http://www.illegal-logging.info/regions/ghana.

CIA (2014): The World Factbook.
https://www.cia.gov/library/publications/the-world-factbook/geos/print_gh.html.

CIA (2016)): The World Factbook.
https://www.cia.gov/library/publications/the-world-factbook/geos/ml.html.

Ciesin Columbia University (2016): Republic of Niger.
http://www.ciesin.columbia.edu//English/CaseStudies/niger_e.html.

Climate and Weather (2014): Deforestation. http://www.climateandweather.net/global-warming/deforestation.html

Conserve Energy Future (2016): Advantages and Disadvantages of Biomass Energy. http://www.conserve-energy-future.com/Advantages_Disadvantages_BiomassEnergy.php.

Coulibaly, A., (2003): Country Pasture/Forage Resources Profiles: Mali.
http://www.fao.org/ag/agp/agpc/doc/counprof/Mali/mali.html

Cramer, J. (2007): Testing framework for sustainable biomass. Final report from the project group “Sustainable production of biomass”. http://www.globalbioenergy.org/bioenergyinfo/sort-by-date/detail/fi/c/1202/

Earth Eclipse (2016): How does Deforestation Affect Climate Change.
http://www.climateandweather.net/global-warming/deforestation.html

ECREEE (2013): ECOWAS Bioenergy Program.

http://www.ecreee.org/page/ecowas-bioenergy-program.

ECREEE (2015): ECOWAS Bioenergy Policy and Implementation Plan. http://www.ecreee.org/sites/default/files/event-att/bioenergy_policy.pdf**.**

Encyclopedia Britannica, (2016): Ghana. http://www.britannica.com/place/Ghana.

Energypedia (2015): Biogas Basics. https://energypedia.info/wiki/Biogas_Basics.

Energypedia, (2016a). Biomass and biogas- Bioenergy in Developing countries. www.energypedia.info/bioenergy.

Energypedia, (2016b): Advantages and Disadvantages of Biomass https://energypedia.info/wiki/Advantages_and_Disadvantages_of_Biomass.

EU FLEGT Facility, (2015): Ghana grapples with illegality in its domestic timber market

European Forest Institute, (2014). What is FLEGT? http://www.euflegt.efi.int/en/web/guest/43

Fameso, (2013): Survey and Study on Timber Flows to Identify the Extent of Illegal Logging In Nigeria. http://www.illegal-logging.info/sites/files/chlogging/Tom%20Fameso_Nigeria.pdf.

FAO (1983): Integrating crops and livestock in West Africa. FAO Animal Production and Health Paper 41.

FAO (1999): FRA 2000 Annotated Bibliography Forest Cover Change Guatemala. ftp://ftp.fao.org/docrep/fao/005/ac631e/ac631e.pdf.

FAO (2000): West Africa .http://www.fao.org/docrep/004/y1997e/y1997e0j.htm#bm19.

FAO (2003): African Forests: A View To 2020.

FAO (2004): Unified Bioenergy Terminology.

FAO (2014): FAO's Bioenergy and Food Security Approach Implementation Guide.

FAO (2015): Global Forest Resources Assessment 2015 Desk reference.

FAO, (2016): Niger. http://www.fao.org/countryprofiles/index/en/?iso3=NER.

Favretto, N. (2013): "Is Jatropha curcas Energy Crop Cultivation a Viable Land Management and Poverty Reduction Strategy? Livelihood lessons from Mali. School of Earth and Environment, Institute for Climate and Atmospheric Science, Sustainability Research Institute (SRI) UNCCD 2nd Scientific Conference, Bonn, 9-12 April, 2013.

Favretto N., Stringer. L.C. and Dougill A.J. (2012): Cultivating clean energy in Mali: policy analysis and livelihood impacts of Jatropha curcas. Sustainability Research Institute Paper No. 28. Centre for Climate Change Economics and Policy Working Paper No. 84 . SRI Papers (Online) ISSN 1753-1330

Federal Department of Forestry, Abuja, Nigeria(2006)**:** Approved National Forest Policy.

Foley, G., Kerkhof, P. and Madougou, D. (2002): A Review of the Rural Firewood Market Strategy in West Africa. Africa Region Working Paper Series No. 35. World Bank.

Fontodji J. K., Mawussi. G., Nuto. Y. and Kokou. K (2009): Effects of charcoal production on soil biodiversity and soil physical and chemical properties in Togo, West Africa. Int. J. Biol. Chem. Sci. 3(5): 870-879. ISSN 1991-8631. Available online at http://ajol.info/index.php/ijbcs

Forest Legality Alliance (2013): Ghana. http://www.forestlegality.org/risk-tool/country/ghana

Friends of the Earth Europe (2010): Africa: up for grabs- The scale and impact of land grabbing for agrofuels. http://www.foeeurope.org

Friends of the Earth Europe (2016): Extractive Industries in depth.
http://www.foeeurope.org/extractive-industries

Friends of the Earth, (2015): Exploitation and empty promises: Wilmar's Nigerian land grab.
http://www.foeeurope.org

Geesing D and Djibo H. (2001): Country Pasture/Forage Resource Profiles.
http://www.fao.org/ag/agp/agpc/doc/counprof/niger/niger.html

Ghana Business News, (2016): Ghana government takes measures to tackle illegal logging. https://www.ghanabusinessnews.com/2016/04/09/ghana-government-takes-measures-to-tackle-illegal-logging/

GIZ HERA(2015.): Charcoal Production: Social, Economic and Environmental Impacts. GIZ HERA Cooking Energy Compendium. A practical guidebook for implementers of cooking energy competitions.
https://energypedia.info/wiki/Charcoal_Production#Social.2C_Economic_and_Environmental_Impacts

Global Witness, (2013): Three Quarters of Ghana's Logging Permits Could Break Europe's New Timber Law. https://www.globalwitness.org/en/archive/ghanapermits/.

Greentumble, (2016): Biomass Energy Advantages and Disadvantages.
http://greentumble.com/?s=biomass+energy.

Hance, J. (2015): Illegal logging decimating birds in Ghana: 'These numbers are shocking'. https://news.mongabay.com/2015/10/illegal-logging-decimating-birds-in-ghana-these-numbers-are-shocking/.

Hansen, C. P. (2012). How domestic timber markets challenge reforms to curb illegal logging: The case of Ghana. Development Briefs. Policy, (21).

Hansen, C.P. and T. Treue (2008): Assessing illegal logging in Ghana. http://www.tropenbos.org/publications/assessing+illegal+logging+in+ghana.
International Forestry Review, Volume 10, Number 4, December 2008, pp. 573-590 (18).

Hazell, P. and Pachauri, R. K. (2006): Bioenergy and Agriculture: Promises and Challenges for Food, Agriculture and the Environment. Overview. Focus 14 • Brief 1 of 12 . International Food Policy Research Institute.

Hosonuma, N., Herold, M., Sy, V. D., De Fries, R.S., Brockhaus, M., Verchot, L., Angelsen, A. and Romijn, E. (2012): An assessment of deforestation and forest degradation drivers in developing countries. Environmental Research Letters, Vol 7., No4. IOP Publishing Ltd.

IAASTD (2008): Issues in Brief. IAASTD Intergovernmental Plenary in Johannesburg Published by Island Press.

IIED (2009): Biofuels in Africa: growing small-scale opportunities. Briefing business models for sustainable development.

IRIN (2016): Can "green charcoal" help save the trees?
http://www.irinnews.org/report/84015/senegal-can-green-charcoal-help-save-trees.
Kanouté, S. (2010): Facilitating Financing for Sustainable Forest Management in Small Islands Developing States and Low Forest Cover Countries. An analytical report prepared by Indufor for the United Nations Forum on Forests. Country Case Study: Mali.

Karekezi, S. and Kithyoma, W. (2006): Bioenergy and Agriculture: Promises and Challenges for Food, Agriculture and the Environment. FOCUS 14• Brief 11 of 12 International Food Policy Research Institute.

Kouami, K., Yaovi, N. and Honan, A. (2009): Impact of Charcoal Production on Woody Plant Species in West Africa: A case study in Togo. Scientific Research and Essay Vol.4 (9), pp. 881-893, September 2009 Available online at http://www.academicjournals.org/SRE ISSN 1992-2248 © 2009 Academic Journals.

Knoena (2016): AFDB Socioeconomic Database 1960-2016.

Larsen, R. K. and Mamosso, C. A. (2013): Environmental Governance of Uranium Mining in Niger – A Blind Spot for Development Cooperation? DIIS Working Paper 2013:02.
https://www.files.ethz.ch/isn/162387/WP2013-02-Uranium-mining-in%20Niger_web.pdf.

Lemuel, T. (2013): Nigeria hopeful of ending illegal logging by February 2013. Royal Times Nigeria.
http://royaltimes.net/nigeria-hopeful-of-ending-illegal-logging-by-february-2013/*Y 6,13* Mamane Abdou (Undated):Niger. Comment contrôlerl'exploitation du bois d'énergie : Les marchésruraux et la « stratégieénergiedomestique » (SED) au Niger.
http://www.unesco.org/mab/doc/ekocd/fr/niger.html. Accessed on 02 September 2016.

Maehium, M. A. (2012): Biomass Energy Pros and Cons. http://energyinformative.org/biomass-energy-pros-and-cons/.

Mfon, P. Jr. and Bisong, E. F. (2011): Impact of Logging on non Timber Forest Products (ntfps) in the Rainforest of South Eastern Nigeria. *Mediterranean Journal of Social Sciences Vol. 2, No. 3, September 2011. ISSN 2039-2117.*
http://www.mcser.org/images/stories/2_journal/mjssso203september2011/12.%20bisong.pdf

Mirzabaew, A., Dawit, G., Jann, G., Varun, G., Jan, B., Detlef, V., Manfred, D. and Joachim, B. (2014): Bioenergy, Food Security and Poverty Reduction: Mitigating tradeoffs and promoting synergies along the Water Energy-Food Security Nexus. ZEF- Zentrum für Entwicklungsforschung Center for Development Research University of Bonn Working Paper 135.

News Ghana (2016). Forest Degradation/Deforestation in Ghana.

NL Agency, Ministry of Economic Affairs, Agriculture and Innovation, (2010): Making charcoal production in Sub Sahara Africa sustainable.
http://english.rvo.nl/sites/default/files/2013/12/Report%20Charcoal%20-%20BTG%20-%20NPSB_0.pdf.

NOTS (2012): Business Model for Sustainable Charcoal Production.
http://www.annesandbrink.com/wp-content/uploads/2012/09/Factsheet-Charcoal-General-EN.pdf.

Ogundele, A. T., Eludoyin, O. S. and Oladapo, O. S. (2011): Assessment of impacts of charcoal production on soil properties in the derived savanna, Oyo state, Nigeria. Journal of Soil Science and Environmental Management Vol. 2(5), pp. 142-146, May 2011 Available online at http://www.academicjournals.org/JSSEM ISSN 2141-2391 ©2011 Academic Journals.

Oguntunde P.G., Abiodun B.J., Ajayi A. E., van de Giesen N (2008): Effect Of Charcoal Production On Soil Physical Properties In Ghana. Journal Of Plant Nutrition And Soil Science (Wiley-VCH), 171: 591-596

Oke, S.O. and Oyedare, P.F. 2008. Effects of Logging Activities on the Floristics and Structure of the Vegetation in Isokan Area of Southwestern Nigeria. *Journal of Plant Sciences, 3: 157-167. http://scialert.net/fulltext/?doi=jps.2008.157.167&org=10.*

Oriola, E. and Olayiwola, O. (2013): Impact of Charcoal Production on Nutrients of Soils under Woodland Savanna Part of Oyo State, Nigeria. Journal of Environment and Earth Science www.iiste.org. ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) Vol. 3, No.3, 2013 46.
Our Energy (2016): Benefits of Biomass. http://www.our-energy.com/benefits_of_biomass.html.

Oyerinde, V. (2013): Illegal Logging and Encroachment: Which Way, Nigeria?http://beahrselp.berkeley.edu/uncategorized/illegal-logging-and-encroachment-which-way-nigeria/.

Pambazuka News, (2004): Nigeria: Either Legal or Illegal, commercial logging in cross river state must be banned. http://www.pambazuka.org/land-environment/nigeria-either-legal-or-illegal-commercial-logging-cross-river-state-forest-must-be.

Reboredo, F. (2013): Socio-economic, environmental, and governance impacts of illegal logging. Environ Syst Decis (2013) 33:295–304 DOI 10.1007/s10669-013-9444-7. https://www.researchgate.net/publication/244059467_Socio-economic_environmental_and_governance_impacts_of_illegal_logging.

Reegle (2013a): Niger 2012. http://www.reegle.info/policy-and-regulatory-overviews/NE.

Reegle (2013b): Mali 2012. http://www.reegle.info/policy-and-regulatory-overviews/ML.

Reegle (2014a). Ghana 2014. http://www.reegle.info/policy-and-regulatory-overviews/GH.

Reegle (2014b): Nigeria (2014). http://www.reegle.info/policy-and-regulatory-overviews/NG.

ReEnergy (2011): Environmental Benefits. http://www.reenergyholdings.com/renewable-energy/environmental-benefits/.

RIAED 2006): Programme régional de promotion des énergies domestiques et alternatives au Sahel. http://www.riaed.net/?Programme-regional-de-promotion.

Schueler, V., Kuemmerle, T. and Schroder, H. (2011): Impacts of Surface Gold Mining on Land Use Systems in Western Ghana. Ambio 40 (5), 528-539.

Teye, J. K. (2013): Corruption and illegal logging in Ghana. International Development Planning Review, 35 (1) 2013 doi:10.3828/idpr.2013.2.

Timko, J. A.,, Amsalu, A., Acheampong, E. and Teferi, M. K. (2014): Local Perceptions about the Effects of Jatropha (Jatropha curcas) and Castor (Ricinus communis) Plantations on Households in Ghana and Ethiopia. Sustainability 6, 7224-7241; doi:10.3390/su6107224. ISSN 2071-1050.

The American Heritage Idioms Dictionary, (2002): Logging.
http://www.dictionary.com/browse/logging.

TREE AID (2015): Mali. https://www.treeaid.org.uk/our-work/where-we-work/mali/.

UNDP Low Emission Capacity Building (LECB) Programme(2015):Nationally Appropriate Mitigation Action on access to clean energy through establishment of market-based solutions
UNECA-ACPC (2011) Critical Issues IN Bioenergy for Africa: Exploring THE Opportunities, Constraints and Trade-Offs. Working Paper 11.

UNEP (2016): Understanding the Long-Term Impacts of Natural Resource Extraction. http://www.unep.org/stories/ Understanding the Long-Term Impacts of Natural Resource Extraction.asp.

UNEP (2006): Forest losses and gains: where do we stand?
http://www.unep.org/vitalforest/Report/VFG-02-Forest-losses-and-gains.pdf.

Wahabu. S., Fosu-Mensah. B. Y. and Nyame. F. K. (2015): Impact of Charcoal Production on Physical and Chemical Properties of Soil in the Central Gonja District of the Northern Region, Ghana. Environment and Natural Resources Research; Vol. 5, No. 3: 11-15. ISSN 1927-0488 E-ISSN 1927-0496 Published by Canadian Center of Science and Education

Wikipedia (2016a). Logging. https://en.wikipedia.org/wiki/Logging.

Wikipedia, (2016b): West Africa. https://en.wikipedia.org/wiki/West_Africa.Wikipedia, (2016c):
Wikipedia (2016). Niger. https://en.wikipedia.org/wiki/Niger.

Wikipedia, (2016d): Mali. https://en.wikipedia.org/wiki/Mali.

Wikipedia (2016e): Deforestation by Region: https://en.wikipedia.org/wiki/Deforestation_by_region.

Wikipedia (2016f): Deforestation in Nigeria https://en.wikipedia.org/wiki/Deforestation_in_Nigeria/.

World Energy Council (2010): Sustainability Criteria for Biomass and Biofuels. In Biofuels: Policies, Standards and Technologies. https://www.worldenergy.org/wp-content/uploads/2012/10/PUB_Biofuels_Policies_Standards_and_Technologies_2010_Annex8_WEC.pdf.

Worldatlas (2016): Deforestation Triggered By Charcoal Production around the World. http://www.worldatlas.com/articles/world-regions-with-the-highestdeforestation-triggered-by-unsustainable-charcoal-production.html.

Yeboa, J. (2015): Bioenergy Strategy Development in the ECOWAS Region. http://www.ecreee.org/sites/default/files/event-att/bioenergy_strategy_devt_dakar_presentation.pdf.

APPENDIX

DEFINITIONS OF OPERATIONAL TERMS

1. **Biomass energy** or bioenergy is defined as "energy contained in living or recently living biological organisms; unlike fossil fuels which are obtained from organic materials that have been dead and decayed over hundreds of millions of years. Biomass energy is contained inside organic matter of all kinds, namely: plants, animals, or waste products from organic sources. Bioenergy can be differentiated into three different types of bioenergy: biofuels, biogas and solid biomass (Energypedia, 2016a).

2. **Biofuels** are liquid or gaseous fuels produced from biomass that are generally high in sugar (such as sugarcane, sugarbeet, and sweet sorghum), starch (such as corn and cassava) or oils (such as soybeans, rapeseed, coconut, sunflowers, and palms). Thus types of biofuel include bio ethanol, bio diesel and vegetable oil, although ethanol and biodiesel are two most commonly used (Energypedia, 2016b). FAO (2004) classified biofuel according to the nature of the biofuel (Primary and Secondary) and according to source of the biofuel (Woodfuel, Agrofuel and Municipal by products).

3. **Primary biofuels** are those unprocessed organic materials used essentially in their natural form (as harvested). Such fuels are directly combusted usually to supply cooking, space heating, or electricity production needs, although there are also small- and large-scale industrial applications for steam raising and other processes requiring low-to-medium temperature process heat.

4. **Secondary biofuels** are those processed in the form of solids (e. g. charcoal), liquids (e. g. alcohol, vegetable oil), or gases (e. g. biogas as a mixture of methane and CO_2), can be used for a wider range of applications with higher efficiency rates on average, including transport and high-temperature industrial processes.

5. **Woodfuels** include all types of biofuels derived directly and indirectly from trees and shrubs grown on forests and non-forest lands. Woodfuels include solid: fuelwood (wood in the rough chips, sawdust, pellets) charcoal; liquid: black liquor, methanol and pyrolitic oil; and gasses which comprise products from gasification and pyrolysis gasses of the foregoing fuels. Woodfuels also include biomass derived from silvicultural activities (thinning and pruning), harvesting and logging (tops, roots, branches etc.) as well as industrial by products derived from primary and secondary forest industries which are used as fuel.

6. **Agrofuels** are fuels obtained as a product of agriculture biomass and by products at farming level and /or industrial processing of raw materials (agro industries). The term covers mainly biomass materials derived directly from fuel crops and agricultural, agro-industrial and animal by products. Agro-fuels include solid: straw, stalk, husks, bagasse and green charcoal from these aforementioned biofuels; liquid ethanol, raw vegetable oil, oil diester, methanol, pyrolitic oil from solid agrofuels: gasses: biogas, producer gas, pyrolysis gasses from agrofuel.

7. **Municipal by-products** refer to biomass by-products produced by the urban population and comprise two types: solid municipal by-products and gas/liquid municipal by products produced

in cities and villages. Solid municipal biofuels: comprises by-products produced by the residential, commercial, industrial, public and tertiary sectors that are collected by local authorities for disposal in a central location, where they are generally incinerated (combusted directly) to produce heat and/or power. Hospital waste is also included in this category.

8. **Gas/liquid municipal biofuels** are derived principally from the anaerobic fermentation (biogas) of solid and liquid municipal wastes which may be land-fill gas or sewage sludge gas.

   However, Energypedia (2016b) classified biofuel into first generation, second generation and third generation. In this regard,

9. **First-generation biofuels** are made from sugar, starch, vegetable oil, or animal fats using conventional technology. These are generally produced from grains high in sugar or starch fermented into bioethanol; or seeds that are pressed into vegetable oil used in biodiesel.

10. **Second-generation biofuels** are produced from non-food crops, such as cellulosic biofuels and waste biomass (stalks of wheat and corn, and wood).

11. **Third-generation biofuels** are produced from extracting oil of algae – sometimes referred to as “oilgae”. Its production is supposed to be low cost and high-yielding – giving up to nearly 30 times the energy per unit area as can be realized from current, conventional ‘first-generation’ biofuel feedstocks.

12. **Biogas** which is the second form of biomass energy typically refers to a gas produced by the anaerobic digestion of organic matter including manure, sewage sludge, municipal solid waste, biodegradable waste or any other biodegradable feedstock, under anaerobic conditions. Biogas is comprised primarily of methane and CO_2. It also contains smaller amounts of hydrogen sulphide, nitrogen, hydrogen, methyl mercaptans and oxygen (Energypedia 2015).

13. **Solid biomass**, the third form of biomass energy, include firewood, charcoal and biomass residues.

14. **Agricultural biomass** is defined as biomass residues from field agricultural crops (stalks, branches, leaves, straw, waste from pruning, etc.) and biomass from byproducts of the processing of agricultural products (residue from cotton ginning, olive pits, fruit pits, etc.) Biomass from animal waste includes primarily waste from intensive livestock operations, from poultry farms, pig farms, cattle farms and slaughter houses. (Centre for Renewable Energy Sources and Savings, 2016).

15. **Forest biomass** consists of firewood, forestry residues (from thinning and logging), material cleared from forests to protect them from fires, as well as byproducts from wood industries. Municipal waste a form of biomass residue, is the biodegradable fraction of municipal waste which can be used for generation of biomass energy.

16. **A briquette** is a block of flammable matter used as fuel to start and maintain a fire. Briquetting or pelletizing is the process to improve the characteristics of biomass as a renewable energy

resource by densification. Residues from agriculture and forestry e.g. bagasse, coffee husks, saw-dust, and coconut husks are a valuable source of raw material and can be used for producing briquettes (GIZ HERA, 2015).

17. **Deforestation** can be described as the clearing of forests, or intentional destruction or removal of trees and other vegetation for agricultural, commercial, housing, or firewood use without replanting (reforesting) and without allowing time for the forest to regenerate itself (Business Dictionary, 2016).

18. **Logging** is the process, work, or business of cutting, skidding, on-site processing, and loading
19. of trees or logs onto trucks for onward transmission to mills, markets or the consumer (Wikipedia, 2016a; The American Heritage Idioms

African Forest Forum

A platform for stakeholders in African forestry

For more information please contact:

The Executive Secretary
African Forest Forum
c/o World Agroforestry Centre (ICRAF)
United Nations Avenue, Gigiri
P.O.Box 30677-00100, Nairobi, Kenya
Phone: +254 20 722 4000, Fax: +254 20 722 4001
Email: exec.sec@afforum.org; Website: www.afforum.org