

Review Article

Sustainable Biomass Energy Management in Nigeria

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Abstract

In order to address energy security as part of a broader climate change management strategy, bioenergy can play an important role in climate change mitigation. This review is based on the need for sustainable forest operational linkages and critically assesses the relevant literature on sustainable biomass management in Nigeria, to generate knowledge, capabilities and opportunities for a more sustainable energy future. A better understanding of the role of biodiversity in sustainable development in relation to the maintenance of healthy agroecosystems, is emphasized.

This paper provides a common understanding on fuel wood management strategies for healthy agro ecosystems in general. Overall, contributions of synergies to sustainable biomass management highlight the importance of integrated planning and implementation of targeted interventions. Securing indigenous and community forestlands tenure is a governance solution that can help achieve climate mitigation goals. A key issue is to integrate stakeholder involvement in the biomass energy value chain including alternative energy sources. Policy and scientific coherence within and across clean energy production in Nigeria is germane to climate change management that delivers on both the Sustainable Development Goals and the Paris Climate Agreement.

1. Introduction

Forest resources and trees outside forests provide multiple benefits and have direct and measurable impacts on people's lives and national economies. Forests, trees on farms, and agroforestry systems play important roles in the livelihoods of rural people by providing employment, energy, nutritious foods and a wide range of goods and ecosystem services in most regions of the world [1]. Over 1.3 billion people rely on forests, fisheries and agriculture for their livelihoods, accounting for nearly half of all worldwide. Natural resources are also essential sources of food, energy, shelter and medicine. In Africa, more than seven out of every ten poor people live in rural areas, where their livelihoods are renewable resource dependent [2]. The State of the World's Forests: Enhancing the Socioeconomic Benefits of Forests, contains the following five key findings: (i) Socioeconomic benefits from forests are the basic human needs and improvements in quality of life (higher order needs) that are satisfied by the consumption of goods and services from forests and trees or are supported indirectly by income and employment in the forest sector, (ii) the formal forest sector employs some 13.2 million people across the world and at least another 41 million are employed in the informal sector, (iii) Wood energy is often the only energy source in rural areas of less developed countries and is particularly important for poor people, (iv) forest products make a significant contribution to the shelter of at least 1.3 billion people, or 18% of the world's population, and (v) a major contribution of forests to food security and health is the provision of woodfuel to cook and sterilize water [1].

Besides supplying basic human necessities, natural resources in developing countries – such as export crops and minerals – underpin national economic growth and incomes. Natural capital – including land, minerals and forests – constitutes 5% of the world's wealth but more than 40% of the wealth of developing countries [3]. The Food and Agriculture Organization recommends that every country should have forest covering at least 25% of its total land area [4]; Nigeria has only 10% of its land area covered by forest and therefore does not meet this recommendation. For that reason, Nigeria is categorized among the countries referred to as low forest cover countries (LFCC) [5]. Furthermore, even within the 10% of land under forest, studies have

shown that only about 1.3% of the country's total land area (12,114 k sq) is considered undisturbed forest cover [5]. This is an indication of how extensively the vegetation cover is utilized. Fuelwood is a fuel such as firewood, charcoal, chips, sheets, pellets, and sawdust. The particular form used depends upon factors such as source, quantity, quality and application. In Nigeria, wood is the most easily available form of fuel, requiring no tools in the case of picking up dead wood, or few tools, such as wood splitters.

Biomass resources (both residues and trees on farms) from private farm-land are the main source of fuel in many rural areas. Currently, burning of wood is the largest use of energy derived from a solid fuel biomass. Wood fuel can be used for cooking and heating. Bioenergy can play an important role in climate change mitigation and there could be a high risk of failing to meet long-term climate targets without bioenergy. Approximately 30 million household and more than 100 million Nigerians depend on wood as a source of energy for cooking but this has come with collateral damage to human health, environment and economy. Community lands can provide major social, economic and environmental benefits for local populations and society. They are a primary source of livelihood in Nigeria.

This paper reviews options to make energy production from biomass sources more sustainable and efficient: causing less green house gas (GHG) emissions and sustaining incomes and livelihoods.

2. Methods

Multiple data sources were used including: general scientific data bases; an online search engine (Google scholar); global, regional and national specialist data bases; institutional websites; journal websites and subject experts/researchers. Information was analyzed identifying key elements and patterns.

3. Fuelwood Supply

Nigeria has estimated forest and woodland reserves of 11 million hectares and produces about 110,000 tonnes of fuelwood per day [6]. While Nigeria's forest area as a percentage of its total land mass is

less than 10% [4], the fuelwood utilization in the country (120,000 tonnes/day) surpasses its production, making it the only energy source where utilization surpasses production in the country. This is potentially catastrophic given that Nigeria has been experiencing problems with its forest management [5], and most areas in the north have been declared unsustainable in terms of fuelwood production. Over-dependence on fuelwood in Nigeria can be attributed to its availability and affordability compared to other energy sources (like cooking gas and electricity), which have been described as a sign of fuel poverty [7]. Biomass is any organic material which can be used for energy production. Biomass fuels include: woodfuels such as wood, charcoal and forestry residues. Harvesting wood for stoves and charcoal production degrades forests if not done sustainably.

This could result in a decline in environmental health, increased soil erosion and time fetching fuel. Also, smoke released by these fuels, when burnt inside homes, more than doubles the risk of respiratory illnesses, such as bronchitis and pneumonia [8]. Switching from biomass to more efficient fuels, such as liquefied petroleum gas (LPG) and biogas, provides the greatest reduction in indoor smoke. Biogas is a clean, efficient and renewable fuel produced during anaerobic digestion (AD) of wastewater, organic wastes and biomass. Biological conversion of this organic material is carried out in an oxygen-free environment that generates only biogas and bio-fertilizers as useful by-products. Biogas can be used in simple gas stoves for cooking and in lamps used for lighting in rural areas. Biogas can be produced from cow dung mixed with water. Simple biogas units can anaerobically ferment the mixture and produce a gas which is 65% methane, which can be used directly for cooking or energy production [9]. Bioenergy projects could provide opportunities for income generation and employment.

3.1 Fuelwood Demand

In Africa, wood is depended upon for up to 58% of all energy requirements and in many savanna areas, demand for wood supplies far exceeds the rate of growth [10]. Regional analysis of the use of wood as a major source of energy requirements indicates that in Eastern, Western and Southern Africa, more than 90 percent of rural households depend on fuelwood and charcoal. In Nigeria, records of fuelwood consumption are relatively scanty and the available ones not reliable. Several reports have confirmed these inaccurate measures of fuelwood consumption [11-14]. Most of them at best give estimates. It is reported that fuelwood is the most dominant and widespread source of energy used for domestic purposes in the Jos Tin mining region of Plateau State, Nigeria [15]. FAO's "Scenario Analysis" on Nigeria [16], observed that in Nigeria, "The land and environment is very highly devastated by climate, farming, fires, erosion and population pressures." The report further projected that by 2020, "oil is deemphasized and the demand for renewable natural resources including wood and non-wood forest products is on the increase." In addition, it is asserted that during the period from 1981-1990, the rate of deforestation in Nigeria was 0.7 percent [17], and this indicates that this rate was further exacerbated by the fuelwood extraction rate, approximately 3.85 times the rate of re-growth and almost 10 times the rate of regeneration [18].

Empirical evidence indicates that this unfortunate scenario persists across the forest reserves of Nigeria located in Kogi, and five other states [19]. The findings of the African Institute of Applied Economics [20] demonstrate that real fuelwood prices in various parts of the country were doubling in the last few decades. Daily consumption of firewood by the rural communities in Nigeria is estimated at 27.5 million kg/day [21]. The Solar Cooking Archive [22] which put the estimate of Nigeria's fuel wood consumption as percentage of energy at about 87%. Therefore, majority of the Nigerian rural people have been using and will continue to use the dried biomass fuels for energy for many years to come. To achieve sustainable use of biomass and its production, it would be necessary to address the following: Competition with food production;

Stable land ownership and accessibility due to the long term commitment required; and technical and market support for the private sector. There are two basic approaches for managing demand: Speeding up the transition to alternative fuels (Liquefied petroleum gas (LPG), Biogas, Solar, Electricity) and increasing efficiency of fuelwood. There is need to resolve challenges of affordability, availability, accessibility and acceptability in rolling out of liquefied petroleum gas (LPG) on a large scale.

3.2 Greenhouse gases

Atmospheric concentrations of key greenhouse gases (GHG) are higher now than over the past 800,000 years (Global Carbon Project). As a result of human activity, such as fossil fuel burning and land-use change, greenhouse gas emissions have increased significantly since the pre-industrial era. The human influence on the climate system is clear, and it is very likely the dominant cause of recent observed warming [23]. Evidence abound that global climate change is occurring and is the result of man-made emissions of greenhouse gases (GHG) – primarily carbon dioxide (CO₂), methane and nitrous oxide. Wood burning creates more atmospheric CO₂ than biodegradation of wood in a forest (in a given period of time) because by the time the bark of a dead tree has rotted, the log has already been occupied by other plants and micro-organisms which continue to sequester the CO₂ by integrating the hydrocarbons of the wood into their own life cycle. Wood harvesting and transport operations produce varying degrees of greenhouse gas pollution. Inefficient and incomplete combustion of wood can result in elevated levels of greenhouse gases other than CO₂, which may result in positive emissions where the byproducts have greater Carbon dioxide equivalent values [24]. The intentional and controlled charring of wood and its incorporation into the soil is an effective method for carbon sequestration as well as an important technique to improve soil conditions for agriculture, particularly in heavily forested regions. There is wide spread agreement in the scientific community that global warming is a consequence of anthropogenic release of greenhouse gases into the atmosphere.

3.3 Sustainable Forests

Our growing scientific understanding of the importance of forests in combating climate change places renewed emphasis on the objective of increasing forests cover. Land use change, principally deforestation, is responsible for the release of large amounts of carbon into the atmosphere. Mature forests contain huge stores in the trees, understorey vegetation and within the decaying matter in the soil, and when they are logged or burnt, the carbon is released. Deforestation accounts for an estimated 17% of global greenhouse gas (GHG) emissions; more than the entire transport sector [25]. The role of the forest conservation in carbon capture and climate change mitigation adds to the critical role played by forests in water conservation and management and in sustaining valuable, harvestable biodiversity for food, fuel, shelter and industrial use. Forest cover continues to decrease on a global scale. Some 40% of the world's forests are located in Latin America and Sub-Saharan Africa, which are the two most important regional contributors to global deforestation [3].

3.4 Clean Cook Stoves

Particulate matter levels from solid biomass fuel use – especially fuelwood – in households may be 10-50 times higher than the World Health Organization (WHO) guideline values [26,27]. Other routine problems for women such as coughs, headaches, stinging eyes and headaches, are commonly associated with traditional cooking methods [28]. Population growth, coupled with strong urbanization dynamics and relative price changes of alternative fuels, offset the important achievements made over the decade by significant investments in energy access, rural and urban electrification, off-grid energy developments, and the promotion of alternative energy sources [29]. According to the World Energy Outlook, the number of wood-based

biomass energy consumers in Sub-Saharan Africa will reach almost one billion by 2030 [30]. Improved cookstoves, based on higher performance standards, are also very important for reducing GHG emissions from wood-based biomass use; their characteristics include: efficiency of fuel use, additional reduction of GHG emission by an enhanced combustion process, and the reduction of air pollutants affecting the health of mainly women and children. A key element for promoting clean cook stoves requires providing financial resources to potential investors in the form of seed funding, input subsidy and micro-credit. The potential for reducing GHG emissions by promoting use of clean cook stoves is tremendous due to higher cooking efficiencies and health benefits. There is need for a strong value chain for efficient and clean cook stoves. This value chain would include policy framework, legislation, implementation, investment, infrastructure, education, finance and sector regulatory institutions. This would lead to sustainable production and adoption of clean cook stoves in Nigeria.

3.5 Funding Mechanisms: Green bonds

Green (or Climate) bonds are fixed income financial instruments issued in order to raise finance for climate change solutions. Like normal bonds, they are issued by governments, multi-national banks or corporations. The issuing entity guarantees to repay the bond over a certain period of time, plus either a fixed or variable rate of return. Green bonds have the potential to deliver the low carbon, climate resilient infrastructure (Renewable energy, low carbon transport, sustainable agriculture) needed for development in Nigeria. Nigeria's Intended Nationally Determined Contributions (INDC) document put forth the stated targets for the nation's contribution towards climate improvement and following a low carbon path to development. The resource needed to finance the NDCs is estimated to cost \$142m between now and 2030. There is need for key stakeholders in the capital market to set up operational modalities including policy direction that meet global best practice.

The Luxembourg Stock Exchange (LGX) has recently (September 2016) introduced the world's pioneer exchange that will trade green securities. The exchange will trade green bonds and other environmentally-focused financial instruments to help reduce ambiguity in the market. Its issuers would be obliged to provide 'a full set of documentation that is readily available with pre and post-reporting.

The Paris Agreement reached in 2015 recognizes that Governments have agreed to pursue efforts to limit warming to 1.5°C above pre-industrial levels. To achieve the Paris Agreement, rapid implementation of climate markets and existing climate finance institutions will contribute to achieve the scale of finance needed to trigger the transition towards low carbon development. Nigeria ratified the agreement on 22 September, 2016. The Clean Development Mechanism (CDM) is the first international crediting scheme that has attracted considerable sums of finance for emission reduction projects in developing countries. The mechanism offers years of experience on implementing mitigation action in developing countries in a transparent manner. Over 220 methodologies have been approved with the CDM, with 150 being applied in projects or programmes that have issued certified emission reductions (CERs). To date, 1.7 billion tonnes of CO₂e have been verified and issued in the form of CERs from nearly 10,000 CDM activities [31].

3.6 Reducing Emissions from Deforestation and Forest Degradation (REDD+)

This is a global initiative designed to pay groups or countries for protecting their forests and reducing emissions of greenhouse gas pollutants, especially carbon dioxide (CO₂). The Federal Ministry of Environment drives the REDD+ process in Nigeria and have been taking institutional steps towards implementing its REDD+ Readiness Plan related to forest monitoring and emissions referencing through operational documents for both the National Forest Monitoring System

Action Plan (NFMS AP) and the National Forest Reference Emission Level/Forest Emission Levels (FRELs/FRLs). The NFMS AP provides the standard activities that should be carried out to ensure the establishment and implementation of a robust and transparent NFMS, according to the UNFCCC (United Nations Framework Convention on Climate Change) Decision 4/15 on "Methodological guidance to REDD+ Strategy. The FRELs/FRLs, on the other hand, are important tools for judging the effectiveness or the impact of REDD+ activities and policies on forest carbon emissions in line with the Decision 12/COP.17 of the UNFCCC. It aims to establish a reference point from which actual emissions are compared without which country emissions reductions cannot be demonstrated or proven. Cross River State (CRS), which is hosting the site of the nation's flagship UN-REDD Programme project site, has signed the Carbon Emissions Bill into law. Furthermore, REDD+ has gained momentum with the first sub national level strategy for CRS as well as a National REDD+ Framework strategy at the completion stage. The National Framework strategy will provide the overall enabling and guiding framework for REDD+ in Nigeria, while the CRS strategy is specific to the State with interventions that aim to have impacts on the ground in forestry, agriculture, energy and land use planning including for minerals, quarrying and infrastructure development.

3.7 Policy Environment

Two major international processes were adopted in 2016. The Sustainable Development Goals (SDGs) by the United Nations General Assembly (UNGA) as part of the 2030 Agenda for Sustainable Development, and the Paris agreement, under the United Nations Framework Convention on Climate Change (UNFCCC). The 4th of November 2016 marks the historical entry into force of the Paris Agreement- an epic landmark global agreement to combat climate change. In his statement at the 22nd session of the Conference of Parties (COP 22) to the UNFCCC that took place November 2016 at Morocco, President Buhari outlined the administration's plan towards aligning with the global objectives on climate change and ensuring inclusive growth and environmental sustainability. He added that the issuance of green bonds would serve as an alternative means of raising climate finance to implement Nigeria's Intended Nationally Determined Contributions (INDCs) The INDCs covering all emissions from all parts of the economy, are geared towards plans to reduce emissions by 20% by 2030, with intention to raise target to 45% with international support. In line with making the Paris agreement operational, the Global Environment Facility (GEF) has launched the Capacity Building Initiative for Transparency (CBIT) which will allow early actions on the ground and help countries to scale up their efforts to deliver their climate plans or NDCs. A national gas policy that will adopt the liquefied petroleum gas (LPG) as a choice of fuel is being produced. The National Energy Policy plan of Nigeria emphasize that the use of fuelwood should be discouraged by promoting alternative energy sources to fuelwood [32]. Policy coherence within and across clean energy production is key to climate change management.

4. Conclusion

A major factor for slow progress in environmental policy has been the failure of the Nigerian government to regard the environment as a critical aspect of all policy development, rather than as something which require attention when there is an environmental crisis. There is a need to mainstream environmental policy in forest management, which would impact on sustainable forest systems. The Sustainable development Goal (SDG) 15 is important in integrating environmental policy to sustainably managed forests, combating desertification, halting and reversing land degradation and biodiversity loss. The opportunity to link SDG 15 clearly comes up through improved cooking stoves and good health. Securing indigenous and community forestlands tenure is a governance solution that can help achieve climate mitigation goals.

5. Recommendations

The following recommendations are proposed for the sustainable management of biomass energy in Nigeria:

- 1) Awareness raising campaigns to all stakeholders to increase acceptance of biomass energy;
- 2) Build capacities of different stakeholders involved in biomass energy management;
- 3) Promote marketing systems for biomass energy products in local markets;
- 4) Integrate stakeholder involvement in the biomass energy value chain;
- 5) Enhance accessibility of biomass energy products to local communities and the most vulnerable in society;
- 6) Build capacity of NGOs/CBOs to better monitor sustainable biomass energy management;
- 7) Support development of realistic national standards reflecting national contexts;
- 8) Support development of capacities that collect, analyze and disseminate statistics on the biomass energy sector; and
- 9) Undertake continuous cost and benefit of biomass energy utilization.

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