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# Nigeria's quest for alternative clean energy through biofuels: an assessment

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## Abstract

Nigeria is rich in renewable energy resources, including diverse biomasses. However, this enormous endowment in renewable energy resources has not played any significant role in the country's energy mix. Nigeria is majorly reliant on its non-renewable sources to meet its energy needs. In pursuit of its commitment to transit to alternative clean energy, Nigeria developed the biofuels policy document in 2007. The major aspiration of the policy is to harness the country's biomass potentials and deploy same to meeting Nigeria's energy needs. This paper assesses the state of the biofuels sector vis-à-vis the stated aspirations of the Nigerian state as captured in the biofuels policy document. In doing so, this paper uses primary data generated from key informant interviews and augmented with secondary data. It finds a disconnect between the aspirations of the biofuels policy document and the actual state of the biofuels sector. In other words, the biofuels sector has no discernible contribution to Nigeria's energy mix. The recommendation of this paper is in the realm of rejigging the biofuels policy in order to extract greater government commitment in evolving national capacity for biofuels development.

## 1. Introduction

Nigeria's biofuel policy was birthed by two interrelated factors: the pressure to subscribe to the global efforts to save the world from the negative consequences of fossil fuels in the form of greenhouse gases (GHGs), and the imperative of broadening its energy mix to meet national energy demands. Both of these factors demand that Nigeria choose the path of developing its renewable energy resources. Thus, the biofuel policy represents an attempt to meet global aspirations of cutting down on fossil fuel use and attendant impacts on the environment as well as achieving the tripartite goals of gradual cutback in the country's reliance on fossil fuels and environmental pollution; leveraging on the biofuel economy to create a commercially viable sector and sustainable domestic green jobs, and integrating the agricultural sector with the downstream petroleum sector[1].

Nigeria's biofuel policy, which focuses on the production of ethanol fuel and biodiesel specifically for automotive, thermal and power generation, provides alternative energy sources to meet both domestic demands and earn foreign exchange. The wider positive implication of Nigeria's biofuel policy is immediate reduction in the use of fossil fuels, which would lead to a dip in its



contributions to the global volume of greenhouse gases (GHGs). Thus, the more Nigeria develops, expands and deploys biofuels, the more it enhances the quality of the environment.

Notwithstanding the lofty aspirations of Nigeria's biofuel policy and its well-endowed biomass feedstocks to actualize the key objectives of the policy, it would appear that the anticipated progress has not been made. The key projections of Nigeria's biofuel policy and incentives, which was adopted on 24<sup>th</sup> July 2007, consisted of using biofuels to enhance the quality of petroleum products with the ultimate aim of reducing tailpipe emissions and ozone pollution, raising additional tax revenue and creating green jobs, which would empower farmers and rural communities. The policy's implementation plan and targets provided a timeline of between 5 and 10 years to develop sufficient capacity and capability to birth a vibrant biofuel industry.

Recognizing that a lot is at stake in connection with the development of a vibrant biofuel economy, this paper undertook the task of evaluating Nigeria's biofuel sector within the context of the objectives and key deliverables contained in the 2007 biofuel policy and incentives. Thus, the major question, which the paper grappled with, is how Nigeria's biofuel sector has fared vis-à-vis its overarching objective of evolving a vibrant biofuel industry with capacity to cut back on the country's reliance on fossil fuels and resultant environmental pollution. The paper found that although some modest progress has been made in establishing biofuel industries, the coordination of the biofuel sector is poor and as such, the actualization of a commercially viable biofuels economy is still in the woods. The paper recommends policy reconnaissance to re-evaluate the biofuel policy in view of new scientific and technological developments as well as government's greater commitment in establishing a flourishing biofuel economy considering its potential contributions to national development.

## **2. Methodology**

This paper draws from a larger study that focuses on the interconnections between Nigeria's policy trajectory and the quest for green energy transition. In investigating the extent to which the overarching goals of the biofuel policy have been realized, this paper adopted key informant technique to generate the relevant data. It mobilized twelve key informants for this study. The key informants were interviewed based on the criteria of their established knowledge of the subject-matter and their varying experience in bioenergy development. The identities of our respondents have been shielded in accordance with our previously agreed arrangement. The data generated from the key informants were complemented with robust data from documentary sources, especially policy documents and scholarly works. The data were qualitatively analyzed.

## **3. Background to Nigeria's Biofuel Policy**

Nigeria is an energy-rich country in every ramification. However, the country has not demonstrated the capacity to harness its diverse energy sources to meet its national energy needs for national development. Nigeria is rich in hydrocarbons, which are currently its major source of foreign exchange. The proven reserves of Nigeria's hydrocarbon holdings place it among the major producers in the world. Although Nigeria's stock of proven crude oil reserves dropped from its 2017 level of 37,453 to 36,972 billion barrels in 2018, the aspiration of the government to increase the country's crude oil reserves to the 40-billion-barrel mark by 2020 is still vigorously being emphasized [2],[3].

Although the aspiration of Nigeria to expand its hydrocarbon reserves might seem to contradict its avowals to mainstream renewable energy in its bouquet of energies, its various policy thrusts have tended to emphasize its commitment to contain the menace of climate change in line with the global quest and aspiration. Nigeria was signatory to the Kyoto Protocol, which became defunct in 2012 [4]. Not only is the country signatory to the Paris Agreement, the successor to the Kyoto Protocol, it ratified it on 16<sup>th</sup> May 2017 [5].

The key thrusts of global collaboration on climate change, as encapsulated in the various Conferences of Parties (COPs), center on providing veritable climate action protocols to contain its threats and devastations. Although the Paris Agreement is based on voluntary emission reduction pledges, its key emphasis is on industrialized countries to cut their greenhouse gas emissions. Developing countries are also expected to adopt policies and take actions that would promote greener

growth as a means of reducing environmental carbon burden[6]. Nigeria has formulated various climate policies aimed at ensuring the reduction of human-induced activities that could contribute to higher levels of greenhouse gases (GHG) emissions, notwithstanding that there is no legal framework that binds members' voluntary pledges[4].

Nigeria's commitment to climate change has also catalyzed various policies aimed at evolving the capability to harness its abundant bio-resources for renewable energy development. Since the submission of its first national communication to the United Nations Framework Convention on Climate Change (UNFCCC) in 2003, Nigeria has been active on many fronts in the climate change response. The country has prepared various climate response documents like National Adaptation Strategy and Plan of Action to aid its response to climate change. It also developed the second National Communication to the UNFCCC, which comprehensively presented the progress in climate change actions that the country had initiated and pursued since the first communication as well as a summary of future actions towards climate-proofing the country's environment[7].

In addition to communications to the UNFCCC, Nigeria has initiated various specific policies to harness its potentials. The paradox of the Nigeria's energy scenario is that it is energy deficient in the midst of enormous energy resources [7]. The inadequacy and inefficiency associated with energy production in Nigeria is exemplified by overreliance on non-renewable sources, especially thermal plants fired by gas and the dominance of private production of electricity through generators powered by gasoline and diesel. All of these have had impacts on the environment necessitating the country's greater emphasis on renewable energy sources[3].

Apart from evolving strategies to reduce GHGs in line with global emphases and demand, Nigeria was further motivated to act in order to address and reverse climate change-related challenges. The policies focused attention on land-based vulnerabilities exemplified by floods, erosion and landslides, droughts and desert encroachment, extreme temperatures and heat waves, among others; and economic vulnerabilities arising from loss of revenue from fossil fuel due to the discovery of alternative energy sources. Others included population-based vulnerabilities resulting from the negative effects of climate change on livelihood opportunities with the potentiality of worsening the poverty burden and deepening human misery; and security vulnerabilities, which are induced by conflicts over resources as a result of scarcities[8],[9],[10],[11].

Thus, since 2003 when Nigeria sent its first national communication to the UNFCCC[12], it has produced several generic and specific policy documents on energy development aimed at addressing fallouts from climate change. A catalogue of such policy documents would include the National Energy Policy (NEP) of 2003, which was updated in 2013, the Renewable Energy Master Plan (REMP) of 2005 and updated in 2011, the Biofuel Policy and Incentives of 2007, the National Policy on Climate Change and Response Strategy (NPCC-RS) of 2012, National Energy Master Plan of 2014, and the National Energy Policy of 2018 among others. The country's aborted national development plan, Vision 20:2020, recognized climate change as a serious threat to its economic prosperity and future development and therefore included it as part of the key issues to be addressed[13].

#### **4. Renewable Energy Resources: Biofuels Potentials in Nigeria**

The strategic goal of Nigeria's NPCC-RS revolves around building a climate resilient society by deploying adaptation and mitigation strategies. Thus, the major justification for evolving policies for renewable energy spans both the mitigation and adaptation spectra. Not only are mitigation and adaptation measures able to promote low carbon and enhance economic growth, they could provide platforms for research and development necessary to strengthen the capacity of national institutions for climate change governance[13].

Nigeria possesses enormous potentials for the development of not only biofuels but also other renewable energy resources. Nigeria's Renewable Energy Master Plan (REMP) was developed to harness these potentials to boost its energy security[3]. The REMP is all-encompassing and undergirds Nigeria's energy vision and roadmap for expanding the role of renewable energy in its energy mix[14]. Thus, the key interrelated focus of REMP is both to address Nigeria's energy challenges by

exploiting renewable energy sources to meet the country's energy needs as well as actualizing its commitment to reducing GHG emissions and spearheading the country's transition to clean and environmentally friendly energy sources[9],[3].

A component of the renewable energy resources captured by the REMP are biofuels. The abundant biomass in Nigeria, from where biofuels are naturally derived, led to the development of a separate policy document to facilitate its harnessing. According to the REMP, the ubiquitous availability and simple conversion technologies of biomass resources in Nigeria make them the most widely used source of energy in the country[14]. By biofuels, we are referring to fuels derived from biomass such as bio-oil, bioethanol, biodiesel, and biogas among others[1],[2]. These fuels could be used for automotive, thermal and power generation purposes.

Essentially, biomass encapsulates agricultural raw materials, which are available on a renewable basis. Notwithstanding its prospects for high-level contributions to Nigeria's energy mix, biomass has been the dominant traditional source of energy for household needs in the country. For instance, the total primary energy consumed in Nigeria in 2013 was estimated by the U.S. Energy Information Administration at about 4.8 quadrillion British thermal units. Out of this amount, traditional biomass and waste accounted for 74 percent [15]. The spectrum of biomass resources in Nigeria covers trees, crops, forage grasses and shrubs, animal wastes, industrial wastes, biodegradable component of municipal solid waste and other wastes from forestry[14]. According to Nigeria's biofuels policy, the overall anticipated benefits linked to the economic activities of the biofuels industry include: the generation of additional revenue through tax, the creation of wealth through green jobs, the spillover effect of improved farming techniques in the form of higher yields, and environmental benefits in terms of reduction in GHG emissions[1].

Nigeria's biofuels potentials are primarily embedded in its ecological diversity in terms of landmass and ecological zones, large population and wastes from its municipalities and industries. Nigeria has a total of 92.4 million hectares, out of which 79 million hectares are arable and only about 32 million hectares or 34.63 percent are under cultivation[16],[17]. It is approximated that about 70 percent of Nigerians are directly and indirectly involved in smallholder agricultural ventures. Nigeria has seven distinct ecological zones with unique attributes. These major ecological zones, which include: Mangrove Swamp and Coastal Vegetation, Lowland Rain Forest, Fresh Water Swamp Forest, Derived Savanna, Sahel Savanna, Sudan Savanna and Guinea Savanna, contribute in diverse forms to the prospects of developing biofuel capability by Nigeria[18].

Biomass feedstock, from which biofuels are derived, principally consist of conventional agricultural products and lignocellulosic products and residues. It is from these biomass feedstock that bio-oil, bioethanol, biohydrogen, biogas, syngas and biodiesel among others are derived[19]. Scholars have emphasized that lignocellulosic biomass is a promising renewable source for biofuels because of its cheapness and abundance [20],[21],[19]. This contrasts sharply with conventional agricultural products as sources of biofuels. This is so because lignocellulosic feedstock are not resource-demanding as they can be produced on marginal and poor lands[21]. Despite the promise of biomass to contribute to Nigeria's energy mix and thus catalyze and revolutionize its energy sector, it has failed to do so. The practice of felling trees for firewood and charcoal to meet both household energy and socioeconomic needs is still prevalent. According to data from the FAO, Nigeria was a major player in the 2.6-million-ton global charcoal trade in 2015. It shared the top spot with Indonesia, Myanmar, Namibia and Poland as top charcoal-exporting countries[22].

The uniqueness of the various ecological zones means that they have different areas of strength in the broad spectrum of the components of biomass. Thus, the ecological zones have their different strengths. While the rain forest zones generate more woody biomasses, the savannah zones produce more crop residues [21].

Scholars have raised concerns about the sustainability of lignocellulosic feedstock supplies and the environmental impacts resulting from their use[23]. However, agricultural and forest residues provide the possibility of contributing to sustainable supply of biomass energy as they are generated during harvesting activities and do not require additional cultivation of the land[21]. Essentially, agricultural residues are byproducts in the course of harvesting and processing agricultural crops.

Agricultural residues could be classified as primary or field-based (residues generated during harvest) and secondary or process-based (residues produced during processing)[24],[23].

Solid waste is another biomass feedstock. Solid waste and its management have posed a serious challenge to successive Nigerian governments at all levels in an incrementally worsening manner. Essentially, wastes encompass all unwanted byproducts that are discarded because of their limited or no usefulness[25],[9]. In Nigeria, mountains of waste have become permanent features of the landscape in major cities. It is estimated that Nigeria generates an average of between 32 and 42 million tons of solid waste on annual basis and out of this volume, only between 20-30 percent is collected and properly disposed[25],[26],[27]. The deployment of appropriate waste disposal strategy is a major challenge in the country. In most cities in Nigeria, most residents adopt self-help strategies to dispose their household and industrial wastes despite the existence of waste management authorities in every state in the country. It is estimated that up to 80 percent of residents in most Nigerian cities dispose their waste illegally, with some dumping them on the streets and drainages, burning or burying them indiscriminately[28],[9],[26].

The major drivers of the waste management challenge in Nigeria are in the realms poor policy initiatives. One, Nigerian policymakers failed to anticipate an expansion in the volume and complexity of waste generated as a result of the combination of rapid increase in population, socioeconomic development and modernization, urbanization, industrialization, technological advancements, and changing consumption patterns among the citizenry[29],[9],[30]. Two, the municipal waste management authorities (MWMA) did not evolve by developing the necessary capacity and facilities to adequately address the waste management challenge in their domains[28]. As a result of the human resource and infrastructural incapacity of these MWMA, they became overwhelmed and redundant. Thus, it can safely be contended that the country's poor waste management credential is a direct product of inadequate funding and lack of modern infrastructural facilities to sustainably manage the enormous amount of waste generated across major cities.

The enormous waste in Nigeria need not be a problem considering that it could be feeders for biodigesters. Nigeria's waste is not harnessed for the generation of bioenergy. There is methane in solid wastes and it can be captured and converted to biogas. Not only would such harnessed biogas add to Nigeria's energy basket, it could contribute to powering motorized vehicles and generating electricity through the deployment of appropriate technologies [9]. Thus, considering the various estimations by scholars in terms of average daily per capita waste generation of 0.44 to 0.66 kg by Nigerians, it means that the country can sustainably generate bioenergy from its waste[28],[25],[9]. Its sustainability is underpinned by the evident daily generation of enormous municipal solid waste in towns and cities across Nigeria.

## **5. The trajectories of Nigeria's Biofuels Policy and Incentives**

Nigeria is suffused with energy resources that could meet its present and future energy needs if adequately harnessed. However, notwithstanding these enormous energy resources, Nigeria is an energy poor country as it is unable to meet the energy needs of its teeming population. Thus, majority of Nigeria's 198.1 million people[31] are entrapped in energy poverty due to the triple challenges of non-availability, lack of access, and financial incapacity to pay for energy resources needed by household. A major driver of Nigeria's energy poverty is that it overly relies on non-renewable energy sources. For instance, in the area of electricity, the country's thermal stations are powered by natural gas. The inefficiency of the thermal stations is underscored by the fact that they only operate at 25 percent of their total installed capacity of 10,142 megawatts[3]. Most often, the blame for the inefficiency of the thermal stations is heaped on shortfall in gas supply[32]. Additionally, Nigeria lacks the technological capability to refine its hydrocarbons to satisfy domestic demands for refined petroleum products. As a result of this incapability, it imports these products. Fuel importation has been a source of tension between organized labor and the government because the subsidy regimes that tend to support it. It is estimated that Nigeria subsidizes the importation of refined petroleum products by up to US\$ 3.85 billion yearly[3].

Nigeria developed its biofuel policy in 2007 with the key aim of facilitating the gradual reduction of the country's dependence on fossil fuel and attendant environmental pollution while at the same time creating the platform for a commercially viable alternative industry that could also provide sustainable domestic green jobs[1]. Scholars have pointed out that biofuel economy has similar potentials to boost national economies and unleash development like the fossil fuel economy. Such boosts would result from the multiplier effects in the biofuel economy[33],[9]. The agriculturally produced raw materials would entail the engagement of farmers and result in the diversification of their farming operations. Such diversifications, with attendant assurances from the end-users of the biofuel feedstock, would have direct positive impact on the quality of life of these farmers. The biofuel economy could also spur rural development through industrialization, investment and trade as well as boost nation-wide development through foreign exchange earnings from bioethanol and biodiesel [33].

Nigeria's biofuel policy has various components, all of which are designed to facilitate the realization of the key objectives of the policy. The policy is specific in its focus, which is the conversion of the biomass abundant in the country to fuel ethanol and bio-diesel primarily for usage in automotive, thermal and power generation[1]. Although the abundance of biomass feedstock in the country has been emphasized, the policy also incorporated provisions that would enable seamless and sustainable availability of feedstock. To this end, the policy identified crops that would qualify as biofuel feedstock and as well mechanisms for their sustainable availability. The policy specifically identified the crops that qualify as biofuel feedstock to include "cassava, sugarcane, oil palm, jatropha, cellulose-based materials and any other crop as may be approved by the Biofuel Energy Commission"[1]. The out-growers scheme, which is an arrangement whereby farmers are mobilized to exclusively produce a range of crops for a particular industry is adopted as the mechanism to ensure steady and uninterrupted supply of biofuel feedstock. The key advantage of out-growers scheme is guaranteed supply for the biofuel mill owner and guaranteed market and income for the farmers.

The major attraction of Nigeria's biofuel policy is the numerous potential benefits embedded therein. Thus, any meaningful assessment of the policy must factor these potential benefits. Besides the contributions of biofuels in frontally remedying climate-related impacts of fossil fuel, they also have direct socioeconomic benefits in terms of creation of jobs and generation of wealth with consequences on poverty profile of the country.

The policy also has an impressive synergic institutional framework under the coordination of the Nigeria National Petroleum Corporation (NNPC). The major attraction of the institutional framework of Nigeria's biofuel policy is that it is anchored on inter-agency collaboration. These government institutions work hand-in-hand focusing on different aspects of the policy to ensure its overall success.

The biofuel policy provided two major phases within which the biofuel sector would mature and deliver on the expectations of boosting Nigeria's energy sector through the establishment of a thriving fuel ethanol industry. The phases comprise the seeding and biofuel production program phases. The seeding phase involves establishing the market by initially importing bioethanol and developing domestic capacity and capability for large scale production of required biofuel feedstock for biofuel plants. The biofuel production program phase is envisaged to commence concurrently with the seeding program with specific emphasis on establishing plantations and constructing biofuel distilleries and plants. The takeoff of the phases would, therefore, entail the enthronement of some policy directives, namely, issuing specific regulations to guide the issuance of importation licenses, blending, transportation and marketing of biofuels; granting relevant import duty waivers, conferring pioneer status on biofuel industry; and formulating protocols for revamping retail outlets and recertifying them for the sale and marketing of biofuels[1].

A major component of Nigeria's biofuel policy is its incentive regime. Despite the array of government institutions saddled with diverse responsibilities, the biofuel policy was conceived to be private sector-driven. In other words, the private sector is expected to drive investment in the domestic production of bio-fuels. The government, through its various agencies, plays the role of providing appropriate and conducive operational environment. In order to facilitate a robust private

sector involvement and participation, the biofuel policy made provisions for a wide range of incentives, such as conferment of pioneer status on the sector with attendant tax holiday, exemption from taxation, including withholding tax, granting of waivers on import and custom duties as well as value-added tax (VAT), provision of long-term preferential loans (LPL), and adequate coverage of inherent operational risks through insurance cover [1]. Thus, the policy possesses the necessary ingredients to successfully facilitate the development of the country's biofuels sector.

## **6. An Assessment of the Pitfalls and Prospects of Nigeria's Biofuels Economy**

By the provisions of the biofuel policy, Nigeria would have been a dominant player in the global biofuel economy by now. Nigeria's biofuel policy was designed to utilize the abundant biomass feedstock in the country to produce alternative energy sources, particularly fuel ethanol and biodiesel. However, the policy has multifaceted goals. One, it aims to contribute to environmental sustainability by deemphasizing the use of fossil fuels. Two, it aspires to expand its energy mix where biofuels would be gradually elevated to a major position in its energy basket. Three, it targets to reduce the country's contributions to the global volume of GHGs. Four, it strives to cut back environmental pollution while in the same vein create a viable biofuel industry capable of precipitating sustainable green jobs. Five, it envisages to catalyze Nigeria's agricultural sector from the doldrums of neglect. Six and lastly, contribute to the expansion of the revenue base of the government through tax on the economic activities attributable to the biofuel industry [33], [34], [35].

Although the biofuel policy appears to have kicked off, the pool of information required to objectively evaluate its progress is not in the public domain. In other words, not much information is available to provide the basis to determine the extent to which the key deliverables and timelines in the biofuel policy document have been implemented. What exists are snippets of information in the popular media about government's intentions in the sector [36], [37]. There is no doubt that a preliminary attempt at driving the policy was made by the NNPC in the period following the adoption of the biofuel policy. For instance, the NNPC conducted feasibility studies on ethanol and biodiesel production using major Nigerian staple crops including cassava, sugarcane and palm oil as feedstock. It also initiated series of discussions with prospective investors, which resulted in the flag-off of the construction of about 20 bioethanol factories with 14 additional projects planned to follow subsequently [34]. Beyond this, not much is known with regard to the actual operations of biofuel factories. Neither the annual reports of Nigeria's National Bureau of Statistics nor of the Central Bank of Nigeria since the flag-off of the policy has captured any form of progress in the sector. Even the Nigeria Economic Recovery and Growth Plan 2017-2020, which was designed to "propel the country towards sustainable accelerated development", did not capture development of the bioenergy sector in its projected growth [38].

What is clear from the limited progress made in the biofuel sector is that various factories already established or in the process of being established rely on first generation feedstock for the production of biofuels [39]. This creates the challenge of sustaining the production of the required feedstock in view of the parlous state of food security in Nigeria. What is required is to reposition the biofuel policy to focus on the use of lignocellulosic feedstock to produce second and third generation biofuels.

Nigeria's total energy consumption per annum is dominated by biofuels but not in the form envisaged by the policy. The 2012 data of Nigeria's total energy consumption showed that biofuels accounted for 85 percent of the 99.3 million tonnes of oil equivalent (Mtoe) consumed that year [40]. Interestingly, the biofuels consumed were not in the form envisaged by the biofuel policy, namely, ethanol fuel and biodiesel. Rather, they were in the form of firewood used for cooking. It is estimated that Nigeria consumes about 43 million tonnes of fuel-wood annually [41].

The mechanism for actualizing Nigeria's biofuel policy is through the establishment of Biofuels Energy Commission and the Biofuels Research Agency. The Commission is saddled with the task of initiating and executing the necessary strategies for biofuels development in the country. The centrality of the Commission in actualizing the varied objectives of the biofuel policy makes its establishment the first principle in the matrix of Nigeria's biofuel economy. However, this commission



has not been established after about 13 year of adopting the biofuel policy. This could be interpreted as lack of commitment on the part of the government to the development of the biofuel economy.

There are several pitfalls in the policy that could be linked to its seeming deceleration, if not stagnancy. A major flaw in the biofuel policy is saddling the NNPC with the task of coordinating its emergence. The NNPC already has enormous responsibility running the country's oil sector, a responsibility that many analysts believe has not been professionally executed judging by sustained agitations by stakeholders and observers for NNPC's comprehensive reform [42],[43][44]. Thus, adding the task of midwifing the biofuel sector might not be such a smart idea as attested by the stagnation and redundancy of the sector. Although scholars have pointed out progress made in the biofuel sector to include installing biofuel handling facilities in some NNPC's depots and some designated retail outlets, training relevant staff of both the NNPC and other ministries, developing quality assurance guidelines by the Standard Organization of Nigeria (SON) for biofuel production and importation and creating awareness campaigns [34], however, these "successes" are still in the realm of policy initiatives.

Another major challenge is policy discordance. There is no serious policy link between Nigeria's biofuel policy and various agricultural policies. The major and unique aspiration at the epicenter of the biofuel policy is the integration of the agricultural sector with the downstream petroleum sector. Thus, national agricultural policies ought to have factored this in their calculations in a clear and methodical manner. However, no such clarity exists in the various agricultural policies enunciated and run by the Nigerian government since 2010. Since 2010, Nigeria has developed important policy documents on agricultural transformation, namely the National Agricultural Investment Plan (NAIP), 2010-2013, which was developed under the auspices of the ECOWAS Common Agricultural Policy and Comprehensive Africa Agricultural Development Program (ECOWAP/CAADP), the Agricultural Transformation Agenda (ATA), 2011-2015 and the current Agriculture Promotion Policy (APP) (also referred to as the Green Alternative) which was designed and launched in August 2016. The bottom-line is that no integration between the agricultural and the downstream petroleum sectors of the economy has been achieved.

A related pitfall is food insecurity and the destructive activities of Fulani herders. While the government designated some crops such as rice, cassava, sorghum, cowpeas, cashew, oil palm, ginger, sesame, cocoa, and cotton as "priority crops" for both the domestic and export markets, no specific measure was put in place to sustain productivity and ensure continued growth [45],[46]. Apart from the restructuring of the protocol for fertilizer procurement and distribution under the aegis of ATA's Growth Enhancement Support Scheme (GESS), there was no guaranteed minimum price for food crops [45]. The aggression orchestrated by Fulani herders against farming communities across the country, in terms of invading their farms, destroying crops and killing people, has had untoward consequences on food insecurity, including the production of energy crops necessary for the advancement of the biofuels agenda [17],[6].

A contributory factor to the pitfalls in the actualization of the biofuel agenda is the non-establishment of the Biofuels Research Agency (BRA). The BRA, which is critical in charting the course of research in the biofuel economy, would have been well-positioned to resolve the potential food versus fuel conflicts arising from the designation of food crops as biofuel feedstock if it had been established. The revenue, green jobs and other business opportunities expected to naturally flow from the implementation of the policy have remained a mirage. This is so because the revenue and jobs can only come from the supply of feedstock in the face of functional biofuel plants.

The prospects of putting back the biofuel aspirations of the country on track are feasible. As suggested by [34], Nigeria must expand the scope of its biofuels program beyond the first generation. The first generation biofuels are obtained from food and oil crops such as wheat, maize, sugar beets, sugarcane, rapeseed and sunflowers. There is a raging controversy that the use of food crops to produce biofuels potentially threatens food security [47],[39]. Thus, the contemporary bioenergy argument is strongly in support of second and third generations lignocellulosic biomasses, which are seen as having high potentials to produce biofuels and other bio-based chemicals without undermining food security [48]. Lignocellulosic biomass can be used to produce a wide-range of biofuels including

biomethanol, dimethyl ether (DME), ethyl-tert-butyl ether (ETBE), biogas, biohydrogen, biosyngas, and other chemicals[34],[48]. The advantages of lignocellulosic feedstock are that since they are by-products of crop production, their utilization ensures sustainable practice, non-interference with food crop production with limited possibility of food energy feud, elimination of land competition and unlikelihood of food pricespiking[24].

A further prospect of Nigeria's biofuel program is the unrelenting global quest for green energy. The promotion of biofuels production and utilization is part of the global strategies for the reduction of dependence on the use of fossil fuels. The overall idea is that biofuels would help to cut fossil fuel use and subsequently contribute in phasing them out. Some scholars have pointed out the imperative of focusing on the right biomass resources and developing same in holistic ways and at appropriate measures as an important key to sustainable biofuel program [24]. It has been suggested that biofuels could be combined with fossil fuels. Scholars have contended that co-firing solid fuel with fossil fuel is a relatively low-cost, relatively safe method of adding biomass capacity compared to a dedicated biomass plant [24].

## 7. Conclusion

The overall idea of Nigeria's biofuel policy has been to develop an alternative source of energy that would add to the country's energy mix while at the same time cutback its contribution to the global volume of GHGs. The policy is also intended to birth a biofuel economy with attendant contribution to the country's revenue base as well as in the creation of green jobs. As lofty as the objectives of Nigeria's biofuel policy might be, its implementation has left much to be desired. None of the targets set in the implementation phases has been realized. Although the NNPC conducted feasibility studies on the potentials of major Nigerian staple crops, including cassava, sugarcane and palm oil, as feedstock, for ethanol and biodiesel production and also initiated series of discussions that resulted in the commencement of the construction of some bioethanol factories[34], the expectations from the policy are far from being realized. The policy projected that between 5 and 10 years, biofuels production would have been consolidated so that the NNPC could blend gasoline with bioethanol by 10 percent and diesel with biodiesel by 20 percent to form E10 and B20 blends respectively [1].

The major setbacks to the realization of the policy could be seen in the domain of policy discordance and lack of continuity. The NNPC is not the most appropriate agency of the government to have been saddled with the task of midwifing the biofuel sector, given its serial demonstration of bureaucratic fatigue and unwieldiness. In addition, successive administrations since the adoption of the policy did not pursue the policy with the vigor it merited, especially in the area of integrating the policy with the agricultural sector as initially envisaged. Notwithstanding the prevalent shortcomings in the implementation of Nigeria's biofuel agenda, the pursuit of its objective is still relevant and important. However, the biofuel policy document must be reviewed to bring it to the level of current trends in the bioenergy sector.

## References

- [1] Federal Republic of Nigeria, "Official Gazette of the Nigerian Bio-fuel Policy and Incentives." p. 22, 2007.
- [2] OPEC, "OPEC Annual Statistical Bulletin 2018," 2019.
- [3] A. Nwozor, S. Oshewolo, and O. Ogundele, "Energy poverty and environmental sustainability in Nigeria: An exploratory assessment," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 331, no. 1, 2019.
- [4] S. N. Seo, *The Behavioral Economics of Climate Change: Adaptation Behaviors, Global Public Goods, Breakthrough Technologies, and Policy-Making*. London: Academic Press, 2017.
- [5] UNFCCC, "Nigeria | UNFCCC." [Online]. Available: <https://unfccc.int/node/61130>. [Accessed: 21-Mar-2020].
- [6] T. E. Odetoeye, E. O. Ajala, and J. O. Titiloye, "A Review of a Bioenergy Policy

- Implementation in Sub-Saharan Africa: Opportunities and Challenges- A Case of Nigeria, Ghana and Malawi \* 1,” *FUOYE J. Eng. Technol.*, vol. 4, no. 1, pp. 87–91, 2019.
- [7] Federal Ministry of Environment, “Nigeria’s second national communication under the United Nations Framework Convention on Climate Change,” 2014.
- [8] B. Anwadike, “Kyoto Protocol and the Challenges of Implementation in Nigeria,” *J. Geogr. Environ. Earth Sci. Int.*, vol. 13, no. 1, pp. 1–9, 2017.
- [9] Z. A. Elum, D. M. Modise, and G. Nhamo, “Climate change mitigation: the potential of agriculture as a renewable energy source in Nigeria,” *Environ. Sci. Pollut. Res.*, vol. 24, no. 4, pp. 3260–3273, 2017.
- [10] H. Haider, “Climate change in Nigeria: impacts and responses,” *K4D Help. Rep.*, pp. 1–38, 2019.
- [11] K. Awotokun, A. Nwozor, and J. S. Olanrewaju, “Conflicts and the Retrogression of Sustainable Development : The Political Economy of Herders- Farmers ’ Conflicts in Nigeria,” *Humanit. Soc. Sci. Rev.*, vol. 8, no. 1, pp. 624–633, 2020.
- [12] Federal Ministry of Environment, “Nigeria’s First National Communication Under the United Nations Framework Convention on Climate Change,” p. 147, 2003.
- [13] Federal Ministry of Environment, “Nigeria’s intended nationally determined contribution,” 2015.
- [14] ECN & UNDP, “Renewable Energy Master Plan (REMP),” 2005.
- [15] U.S. Energy Information Administration, “Country Analysis Brief: Nigeria,” 2016.
- [16] FMARD, “ECOWAP/CAADP Process: National Agricultural Investment Plan (NAIP), 2010–2013,” Abuja, 2010.
- [17] A. Nwozor, J. S. Olanrewaju, and M. B. Ake, “National Insecurity and the Challenges of Food Security in Nigeria,” *Acad. J. Interdiscip. Stud.*, vol. 8, no. 4, pp. 9–20, 2019.
- [18] Federal Department of Forestry, “National Forest Reference Emission Level ( FREL ) for the Federal Republic of Nigeria,” no. January, pp. 1–54, 2019.
- [19] A. K. Kumar and S. Sharma, “Recent updates on different methods of pretreatment of lignocellulosic feedstocks: a review,” *Bioresour. Bioprocess.*, vol. 4, no. 1, 2017.
- [20] M. Bosch and S. P. Hazen, “Lignocellulosic feedstocks: Research progress and challenges in optimizing biomass quality and yield,” *Front. Plant Sci.*, vol. 4, no. NOV, pp. 1–4, 2013.
- [21] K. J. Simonyan and O. Fasina, “Biomass resources and bioenergy potentials in Nigeria,” *African J. Agric. Res.*, vol. 8, no. 40, pp. 4975–4989, 2013.
- [22] FAO, *The state of the world’s Forests 2018: forest pathways to sustainable development*. 2018.
- [23] C. Okello, S. Pindozi, S. Faugno, and L. Boccia, “Bioenergy potential of agricultural and forest residues in Uganda,” *Biomass and Bioenergy*, vol. 56, no. July 2019, pp. 515–525, 2013.
- [24] N. I. Mohammed, N. Kabbashi, and A. Abass, “Significance of agricultural residues in sustainable biofuel development,” in *Agricultural Waste and Residues*, A. Aladjadjiyan, Ed. London: Intech Open, 2018, pp. 71–88.
- [25] D. O. Omole, S. A. Isiorho, and J. M. Ndambuki, “Waste management practices in Nigeria: Impacts and mitigation,” in *Geoscience for the Public Good and Global Development: Toward a Sustainable Future*, G. R. Wessel and J. K. Greenberg, Eds. Boulder, Colorado: Geological Society of America, 2016, pp. 377–386.
- [26] C. C. Ike, C. C. Ezeibe, S. C. Anijiofor, and N. N. Nik Daud, “Solid waste management in Nigeria: Problems, prospects, and policies,” *J. Solid Waste Technol. Manag.*, vol. 44, no. 2, pp. 163–172, 2018.
- [27] W. Bakare, “Solid Waste Management in Nigeria,” *Bioenergy Consult*, 11-Feb-2020.
- [28] C. C. Nnaji, “Status of municipal solid waste generation and disposal in Nigeria,” *Manag. Environ. Qual. An Int. J.*, vol. 26, no. 1, pp. 53–71, 2015.
- [29] J. C. Agunwamba, “Solid waste management in Nigeria: Problems and issues,” *Environ. Manage.*, vol. 22, no. 6, pp. 849–856, 1998.
- [30] O. E. Ogunmakinde, W. Sher, and K. Maund, “An assessment of material waste disposal

- methods in the Nigerian construction industry,” *Recycling*, vol. 4, no. 1, 2019.
- [31] CBN, *Central Bank of Nigeria Annual Report 2018*. Abuja: Central Bank of Nigeria, 2018.
  - [32] FGN, “Nigeria Power Baseline Report,” 2015.
  - [33] E. I. Ohimain, “A review of the Nigerian biofuel policy and incentives (2007),” *Renew. Sustain. Energy Rev.*, vol. 22, pp. 246–256, 2013.
  - [34] E. I. Ohimain, “Can the Nigerian biofuel policy and incentives (2007) transform Nigeria into a biofuel economy?,” *Energy Policy*, vol. 54, pp. 352–359, 2013.
  - [35] Z. A. Elum and A. S. Momodu, “Climate change mitigation and renewable energy for sustainable development in Nigeria: A discourse approach,” *Renewable and Sustainable Energy Reviews*. 2017.
  - [36] M. Sapp, “Nigeria announces \$ 246 million in Green Bonds for 19 projects including jatropa biofuels,” 16-Nov-2016.
  - [37] Financial Nigeria, “Nigeria to set up \$50 billion biofuel equity fund,” *Development and Finance*, pp. 1–3, 08-Feb-2017.
  - [38] Ministry of Budget and National Planning, “Nigeria economic recovery and growth plan, 2017–2020,” 2017.
  - [39] N. Abila, “Biofuels development and adoption in Nigeria: Synthesis of drivers, incentives and enablers,” *Energy Policy*, vol. 43, pp. 387–395, 2012.
  - [40] NESP, “The Nigerian Energy Sector - An Overview with a Special Emphasis on Renewable Energy, Energy Efficiency and Rural Electrification,” 2015.
  - [41] Energy Commission of Nigeria, “ENERGY IMPLICATIONS OF VISION 20: 2020 AND BEYOND,” 2014.
  - [42] A. Sayne, A. Gillies, and C. Katsouris, “Inside NNPC Oil Sales: A Case for Reform in Nigeria,” 2015.
  - [43] A. Ogbuigwe, “Refining in Nigeria: history, challenges and prospects,” *Appl. Petrochemical Res.*, vol. 8, no. 4, pp. 181–192, 2018.
  - [44] A. Nwozor, J. S. Olanrewaju, S. A. Adedire, and E. E. Lawal, “Reform in a Limbo: The Politics and Politicization of Reforms in Nigeria’s Petroleum Sector,” *Int. J. Energy Econ. Policy*, vol. In press, 2020.
  - [45] FMARD, “Agricultural Transformation Agenda: We will grow Nigeria’s Agricultural Sector,” Abuja, 2011.
  - [46] FMARD, “The Agriculture Promotion Policy (2016 – 2020): Building on the Successes of the ATA, Closing Key Gaps Policy,” Abuja, 2016.
  - [47] S. Oshewolo, “Designed To Fail? Nigeria’s Quest for Biofuel,” *Afro Asian J. Soc. Sci.*, vol. 3, no. 3.3, pp. 1–15, 2012.
  - [48] A. Zoghلامي and G. Paës, “Lignocellulosic Biomass: Understanding Recalcitrance and Predicting Hydrolysis,” *Front. Chem.*, vol. 7, no. December, 2019.