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Research Article

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Biomass to Biofuels: A sure Sustainable Energy Strategy in Nigeria

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Abstract

The utilization of biomass resources as feedstocks for biofuel production is gaining traction globally leading to increasing quantity of biofuel from 187 thousand barrels of oil equivalent per day in 2000 to 1.75 million barrels of oil equivalent per day in 2021. This increase is attributed to high demand, and favourable policy initaited by various government of the world including tax credit and subsidy in the quest to mitigate climate change. Nigeria government in 2007, gazetted the Nigerian Biofuels Policy aimed at promoting the utilization, importation and production of biofues in Nigeria. It encourages investment in biofuels through tax waiver including importation and exportation, waiver on import and customs duties, and insurance. The biomass resources of Nigeria include agricultural and residues, forest products and residues, and municipal solid wastes amounting to over 200 billion kg/yr with energy potential greater than 61 Mtoe. To realize this energy potential, there is a need for the Nigerian government to implement its biofuel policy completely, and to expand the current approved biomass (cassava, sugarcane, palm oil, jatroph, and cellulosic materials) for biofuel production to include the use of lignocellulosic biomass, non-edible oil other jatropha, and algae. The production and utilization of the biofuel will help to increase energy reserve, improve the quality of automotive fossil-based fuels, develop the agricultural sector, mitigate climate change, reduce importation of fuels and create jobs.

Keywords: *Biofuels; biodiesel; bioethanol, biomass; biofuels policy*

Introduction

For several decades, Nigeria was the largest producer of crude oil in Africa, until recently, when it dropped to the 4th position behind Angola, Algeria and Libya. This decline was attributed to theft and sabotage leading to unprecedented loss of over 200,000 barrels per day [1]. This also impacted negatively to the revenue of the country reducing the contribution of oil to the national GDP which usually was the highest giving way to the information and communications technology, and trade during the second quarter of 2022. Despite the decline, Nigeria's four oil refineries still operate below its capacities causing the country to import 95 % of refined petroleum for domestic consumption unlike other OPEC members [2]. The cost of which was $37.85 billion between 2015 and 2019 [3]. Despite the subsidy on petroleum products, the pump prices are still very high and have worsen the standard of living of an average Nigerian. For instance, the average cost of the premium motor spirit [Petrol], per litre and Automotive Gas Oil [Diesel] per litre in Nigeria as at February, 2023 was two hundred and sixty three naira, seventy six kobo [N263.76], and eight hundred and thirty six naira, ninty one kobo [N836.91] [4]. However, biofuels which are produced from biomass have the potential to liberate Nigeria from over dependence on fuel importation and the rural dwellers from poverty. Nigeria is the most populous country in Africa with a population of 225,082,083 which grows by 2.53 %. The arable land area in Nigeria is 34 million hectares out of which 6.5 million hectares are designated for permanent crops, and 28.6 million hectares for meadows and pastures [5]. The major agricultural products of the country include cassava, yam, maize, oil palm fruit, rice, vegetables, sorghum, groundnuts, fruit and sweet potatoes [6].

The quantity of rice production is increasing as seen from the 3.7 million metric tons and 4.0 million metric tons produced in 2017 and 2018, respectively [7]. Nigeria was the highest producer of cassava in the world in 2019 producing 21.06 % of the total quantity of cassava in that year [8]. According to [9], Nigeria has a biomass resource of more than 200 billion kg/yr culminating from agricultural wastes, municipal solid wastes, human and animal wastes. The energy equivalent of these resource is approximately 62 Mtoe. The biomass resources of Nigeria include agricultural waste, municipal solid waste, human and animal wastes. These biomasses can be used as feedstocks to produce biofuel in order to complement the energy obtained from other sources. The approved for the production of biofuel in Nigeria include cassava, sugarcane, oil palm, jatropha and cellulose based materials [10]. In this work, efforts are made to discuss biomass

resources in Nigeria, energy situation in Nigeria and biofuels.

Biomass

This term is used to describe energy stored in organic material that is renewable with time. Biomass is the predominant source of energy in Nigeria, especially in the rural areas. In Nigeria, biomass distribution is connected with vegetation, with the largest proportion of woody biomass dominant in the rain forest in the south, and greater percentage of the crop residues being prevalent in the Guinea Savannah in the North central region compared to the Sudan and Sahel Savannahs in the North west and North east, respectively. The majority of the municipal solid wastes are generated in the urban densely populated region [11].

The predominantly used biomasses for households in Nigeria for cooking and heating are wood fuel and charcoal, accounting for over 80 % of the energy consumption in 2019 [9].

Agricultural crops and residues

Numerous agricultural crops are grown in Nigeria across different regions depending on the pravailing vegetation as described previously [see Figure 1]. Some of these crops can be used as feedstock for biofuel production. Crops like maize, cassava, sorghum, and sugarcane can be used in the production of biofuels such as bioethanol as they are reach in carbohydrate. The oil bearing crops like oil palm, cocunut, and

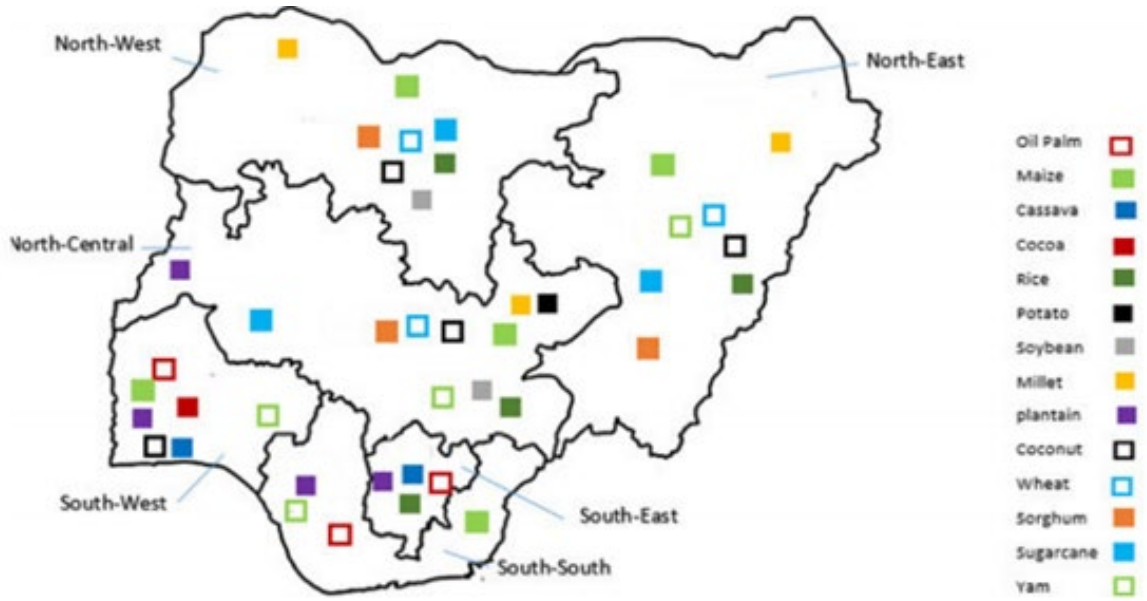

Figure 1: Agricultural crops cultivated in different regions in Nigeria Okafor et al. (2022)

soybean can be used for the production of biodiesel due to the presence of high lipid yield. The agricultural crops are produced in aboundance in Nigeria especially cassava as shown in Table 1. The table also shows that these crops have high yield, and thus can be used for biofuel production, although, the major constraints are fear of food shortage, high cost, and expected competition with the use of land for other purposes [13]. The wastes from these crops are the most abundant biomass in Nigeria. The current practice is to dispose these wastes by burning or using them for composite manure to increase the fertility of the soil. Converting these residues or wastes to biofuels could help to reduce; the emission of greenhouse gases during the combustion of fossil fuels, cost of transportation and by extension cost of foodstuffs, and the solid residues can be used in electricity generation [9].

Table 1: Some crop products produced in Nigeria 2018-2021 [7].

Crop	Parameter	Year			
		2018	2019	2020	2021
Cassava	Area harvested (ha)	6949400	9776650	7290381	9085736
	Yield (hg/ha)	94038	58271	81015	69374
	Production (ton)	65350850	56969160	59063109.47	63031376.66
Cocoa beans	Area harvested (ha)	974173	913097	1076093	1055833
	Yield (hg/ha)	2772	2738	2695	2652
	Production (ton)	270000	250000	290000	280000
Coconuts, in shell	Area harvested (ha)	30267	30093	29274	28629
	Yield (hg/ha)	75330	76096	77202	78308

	Production (ton)	228000	229000	226000	224184.26
Coffee, green	Area harvested (ha)	1495	1466	1432	1398
	Yield (hg/ha)	13113	12983	12984	12984
	Production (ton)	1960.23	1903.72	1859.43	1815.14
Green corn (maize)	Area harvested (ha)	199787	201849	203145	204527
	Yield (hg/ha)	38680	38747	38056	37941
	Production (ton)	772769.95	782103.16	773095.75	775989.62
Groundnuts, excluding shelled	Area harvested (ha)	3757889	3941360	4119066	4271859
	Yield (hg/ha)	12241	11447	10977	10786
	Production (ton)	4600000	4511778.87	4521626.64	4607669.46
Maize (corn)	Area harvested (ha)	6541183	6543376	5500000	6000000
	Yield (hg/ha)	16716	19255	22545	21242
	Production (ton)	10934149	12598945	12400000	12745000
Millet	Area harvested (ha)	1734330	1747800	2000000	2000000
	Yield (hg/ha)	10836	11014	9525	9610
	Production (ton)	1879340	1925075	1905000	1922000
Oil palm fruit	Area harvested (ha)	3736228	3784800	3878183	3937865
	Yield (hg/ha)	25694	25645	25600	25554
	Production (ton)	9600000	9706116.22	9928000	10062917.05
Potatoes	Area harvested (ha)	319164	319352	319024	319180
	Yield (hg/ha)	38172	37919	38286	38125
	Production (ton)	1218313.3	1210935.65	1221405.66	1216884.87
Rice	Area harvested (ha)	4065510	4126670	4195100	4320100
	Yield (hg/ha)	26709	20441	19479	19310
	Production (ton)	10858537	8435510	8171800	8342000
Seed cotton, unginned	Area harvested (ha)	374620	365680	373648	371316
	Yield (hg/ha)	7337	7492	7289	7371
	Production (ton)	274847.41	273955.55	272333.73	273712.23
Sorghum	Area harvested (ha)	5590557	5397000	5600000	5700000
	Yield (hg/ha)	12163	12349	11768	11798
	Production (ton)	6800000	6665000	6590000	6725000
Soya beans	Area harvested (ha)	710792	847647	972053	1057861
	Yield (hg/ha)	9285	9438	9259	9264
	Production (ton)	660000	800000	900000	980000
Sugar cane	Area harvested (ha)	85271	85355	85016	85214
	Yield (hg/ha)	173563	175492	178341	175796
	Production (ton)	1479983.99	1497910.27	1516175.49	1498023.25
Sweet potatoes	Area harvested (ha)	1516091	1503891	1511243	1510408
	Yield (hg/ha)	25896	26258	26165	26106
	Production (ton)	3926036.96	3948968.65	3954131.47	3943045.69
Taro cocoa yam)	Area harvested (ha)	821880	820239	806175	816098
	Yield (hg/ha)	39288	39173	39771	39408
	Production (ton)	3229015.49	3213120.65	3206211.87	3216116
Wheat	Area harvested (ha)	51548	51646	50000	80000
	Yield (hg/ha)	17142	16826	11000	11250
	Production (ton)	88362	86900	55000	90000

Yam	Area harvested (ha)	5427899	6778080	6200472	5902180
	Yield (hg/ha)	101999	78068	80724	85354
	Production (ton)	55363999	52914910	50052977	50377344.2
Tobacco (unmanufactured)	Area harvested (ha)	10364	8718	8369	7998
	Yield (hg/ha)	6086	5947	5903	5904
	Production (ton)	6307.67	5184.67	4940.77	4721.53

Forest Products and Residues

Nigeria produces and trades in forestry. The forestry production and trade in Nigeria in 2021 is presented in Table 2. As shown in the table, with a volume of 67239649 m3, wood fuel is the most aboundant source of wood fuel in Nigeria [14]. During lumbering and processing of the forestry, residues such as wastes obtained from logging operations including cutting of the forest tops and branches, sawing and wood demolition are obtained. The quantity of forest residues was estimated to be 19 billion kg/yr according to [9]. Other residues include the wastes resulting from industrial wood processing operation such as sawdust leading to the production of wood products like wood pulp, wood fuel, wood charcoal, paperboard, particle board, plywood, sawn wood, veneer sheets, recovered paper, printing, and writing papers [see Table 2]. Compared to similar results presented by [15], the quantity of other products such as pulpwood, sawnwood, plywood, printing and writing papers remained constant between 2018 and 2023, with the exception of wood fuel [non-coniferous] and wood charcoal which increased slightly.

Table 2: Forestry production and trade in Nigeria for 2021 [16].

Item	Unit	Value
Wood fuel, non-coniferous	m^3	67239649
Sawlogs and veneer logs, non-coniferous	m^3	7600000
Pulpwood, round and split, non-coniferous (production)	m^3	22000
Other industrial roundwood, non-coniferous (production)	m^3	2400000
Wood charcoal	tonnes	4828689
Sawnwood, coniferous	m^3	2000
Sawnwood, non-coniferous all	m^3	2000000
Veneer sheets	m^3	1500
Plywood	m^3	56000
Particle board	m^3	40000
Mechanical and semi-chemical wood pulp	tonnes	9000
Chemical wood pulp	tonnes	14000
Chemical wood pulp, sulphate, unbleached	tonnes	14000
Recovered paper	tonnes	20000
Printing and writing papers	tonnes	1000
Other paper and paperboard	tonnes	18000

Municipal Solid Wastes [MSWs]

These are wastes collected from households, commerce and trade, office building, institutions and small businesses, garden waste, street sweeping, and industry. In Nigeria, the municipal solid waste generated in major cities are shown in Table 3. As shown in the table, Lagos generated the highest amount of 5,747,616 kg/day of MSW, and the least quantity was obtained from Nsukka in 2014 [17]. Depending on the composition, biofuels such as biogas can be produced from MSW, and citing a biogas company in a city like Lagos would be a good idea.

Table 3: MSW generated in most cities in Nigera [17].

City	Per capita waste generation (kg/ppd)	Organic wastes component (%)	Combustible wastes component (%)	Daily waste generation estimate (kg)
Lagos	0.63	68	21	5,747,616
Kano	0.56	43	50	1,970,920
Benin	0.43	78.7	13.1	452,188
Onitsha	0.53	30.7	53.9	530,530
Ile-ife	0.46	77.9	12.6	144,164
Akure	0.54	59.5	16.2	199,638
Ado-Ekiti	0.71	60.4	25.7	371,543
Abeokuta	0.6	57.8	34.9	418,860
Ibadan	0.71	64.9	24.1	2,605,984
Makurdi	0.54	49.2	17.3	134,460
Abuja	0.57	56.4	36.4	322,107
Maiduguri	0.25	25.8	29.5	242,925
Nsukka	0.44	56	34.7	44,308
Port Harcourt	0.6	39.4	29.9	714,360
Ilorin	0.43	38.3	26	325,252
Average	0.53	53.7	28.4	-
National				74,428,848.70

Human and Animal Wastes

The population of Nigeria is currently 225,082,083 and it grows by 2.53 %. With this population, high quantity of human waste mostly in form of faecs is generated per person per day. Table 4 shows some animal products produced in Nigeria between 2018 and 2021. Some wastes in form of dungs can be obtained from each animals. Wastes such as waste water can also be obtained when the animals are slaughtered and undergoes processing. These wastes are mostly used for the production of biogas.

Table 4: Some animal products produced in Nigeria 2018-2021 |FAO, 2022]

Animal	Parameter	Year			
		2018	2019	2020	2021
Cattle fat*	Production (tonnes)	9384.58	9599.42	9563.43	9552.38
Cattle**	Production (tonnes)	49604.22	50739.77	50549.56	50491.17
Goat**	Production (tonnes)	42618.59	42715.72	41391.91	41202.99
Pigs**	Production (tonnes)	13370.5	13393.36	13497.38	13759.19
Sheep**	Production (tonnes)	28763.01	28033.71	27571.57	27535.05
Fat of pigs	Production (tonnes)	16713.13	16741.7	16871.72	17198.99
Game meat***	Production (tonnes)	178303.44	174375.14	175925.81	175925.81
Goat fat	Production (tonnes)	6392.79	6407.36	6208.79	6180.45
Meat of cattle with the bone, fresh or chilled	Production (tonnes)	328460.38	335979.53	334720.08	334333.43
Hen eggs in shell, fresh	Production (tonnes)	640000	640000	576040.59	577091.94
Hen eggs in shell, fresh	Production (1000 No)	16000000	16000000	14401015	14427299
Meat of chickens, fresh or chilled	Production (tonnes)	262539.25	242326.58	241233.08	241188.1
Meat of goat, fresh or chilled	Production (tonnes)	266366.17	266973.22	258699.42	257518.7
Meat of pig with bone, fresh or chilled	Production (tonnes)	300836.28	301350.55	303691.03	309581.75
Meat of sheep, fresh or chilled	Production (tonnes)	158038.51	154031.36	151492.12	151291.47

* unrendered; ** edible offal of cattle, fresh, chilled or frozen; ***fresh, chilled or frozen

Based on the research conducted by [18], and [9], respectively, the biomass resources of Nigeria is increasing. This may be due to increasing population, and growing need for alternative source of energy leading to the cultivation of energy crops and forestry [see Table 5]. Similarly, the bioenergy potential is also increasing as was estimated to be 48.06 Mtoe and, obtained 61.67 Mtoe. This increase may be attributed to the increase in the quantity of the biomass generated in the country [18, 9].

Table 5: Quantity of biomass in Nigeria

Biomass	Biomass weight (billion kg/yr)		Potential energy (GJ)	
	Simonyan and Fasina (2013)	Olanrewaju, et. (2019)	Simonyan and Fasina (2013)	Olanrewaju, et. (2019)
Agricultural crops	145.62	153.76	1958.94×10^6	2,033.85
Plantation crops	4.47	2.35	54.60×10^6	28.88
Forest residues	-	19	0.02	362.95
Municipal solid waste	3.17	4.51	186.33	21.36
Animal waste	15.76	17.69	29.25	106.39
Human waste	2.59	2.87	8.13	28.83
Total		200.18	$2,013.54 \times 10^6$ (48.06 Mtoe)	2,582.26 (61.67 Mtoe)

Energy Situation in Nigeria

According to [19], the total energy supplied including both non-renewable and renewable energy in 2014 was 6127948 TJ and that in 2019 was 6591012 TJ. Majority of this energy emnated from renewable energy mostly bioenergy from wood fuel [see Figure 2]. The increase in energy supply is impacted on its consumption as more than 90 % of the energy was consumed in the household/others. This is because, greater population of Nigerians reside in the rural where wood fuel is the most predominant source of energy [see Table 6]. Unfortunaely, despite being among the highest oil producers in the world, Nigeria's growing population are deprived of a constant power supply, and there is insufficient supply of energy in the industrial and transport sector.

Table 6: Energy consumption by different sectors in Nigeria

Sector	Oil products		Coal		Natural gas		Biofuels/waste		Electricity	
	Mtoe(EJ)	%	Mtoe(EJ)	%	Mtoe(EJ)	%	Mtoe(EJ)	%	Mtoe(EJ)	%
Industry	0.40(0.02)	5.26	0.00(0.00)	0.00	2.60(0.11)	34.21	4.20(0.18)	55.60	0.40(0.02)	5.26
Transport	8.40(0.35)	100	0.00(0.00)	0.00	0.00(0.00)	0.00	0.00(0.00)	0.00	0.00(0.00)	0.00
Household/ Others	2.70(0.11)	2.62	0.00(0.00)	0.00	0.00(0.00)	0.00	98.70(4.14)	95.64	1.80(0.08)	1.74
Non-energy use	0.00(0.00)	0.00	0.00(0.00)	0.00	1.40(0.06)	100.00	0.00(0.00)	0.00	0.00(0.00)	0.00

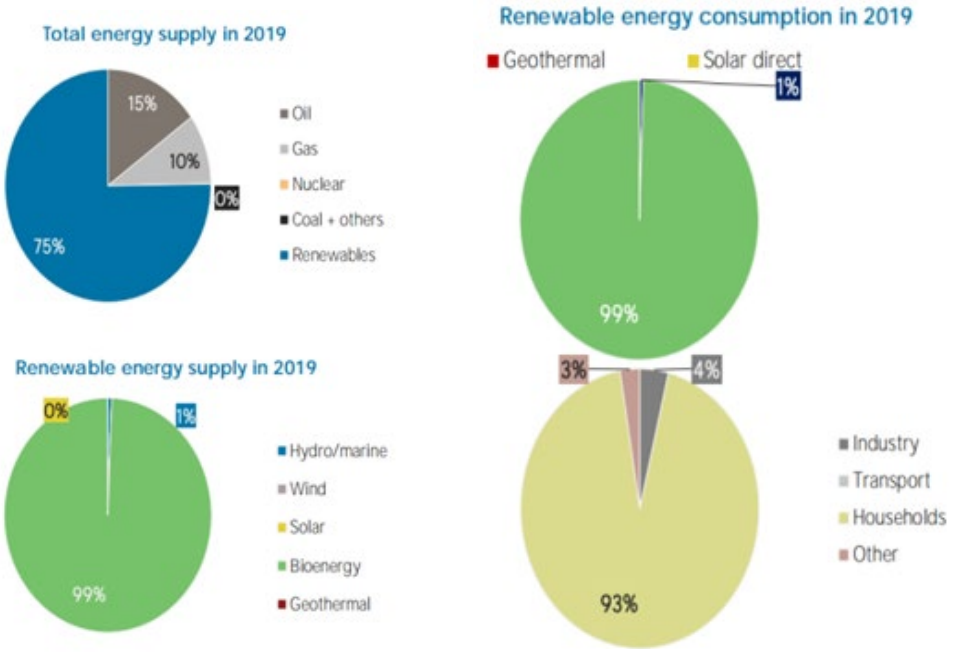

Figure 2: Energy supply and consumption in Nigeria IRENA (2022)

Biomass Processing Technologies

These involve processing of biomass into biofuels such as biogas, bioethanol and biodiesel which can be used to produce electricity, heat and as transport fuel [see Figure 3]. The processing technologies include thermochemical, biochemical and chemical routes. The thermochemical route involves combustion, torrefaction, pyrolysis, gasification, and hydrothermal processes leading to the production of fuels such as fuel for heat and/power, solid fuel [bio char], liquid fuel [bio-oil and biocrude] and gaseous fuel [syngas] [18, 20].

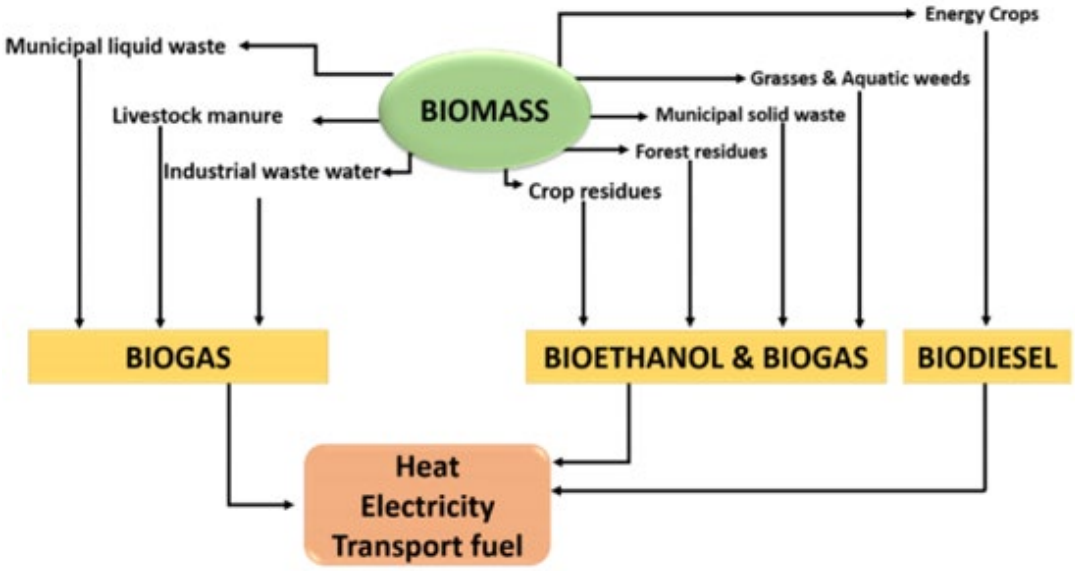

Figure 3: Biomass processing technologies [21].

The biochemical conversion route involve anaerobic digestion and alcoholic fermentation. Anaerobic digestion involves the use of bacteria to break down organic matter in the absence of oxygen to produce CO2 and CH4 [biogas or landfil gas], and alcoholic fermentation uses yeasts to convert sugars to ethanol, carbon dioxide, and other metabolic products. The chemical conversion routes may be either esterification or transesterification. Esterification involves a reaction between fatty acids [such as oleic acid and palmitic acid] and alcohol in the presence of catalyst to produce ester [biodiesel] and water. Transesterification is a reaction between triglyceride and alcohol in the presence of a catalyst to produce ester [biodiesel] and glycerol [18].

World Biofuel Production

Biofuels include bioethanol and biodiesel, and are produced from biomass [for instance maize, sugarcane, cassava, and molasses]. In the contemporary times, about 60 %, 25 %, 3 %, and 2 % of bioethanol are produced globally from maize, sugarcane, wheat, molasses, respectively. The remaining 10 % of bioethanol are produced using grains such as cassava and sugar beets. Similarly, about 20 %, 25 %, 30 %, and 20 % of biodiesel are produced globally from rapeseed oil, soybean oil, palm oil and used cooking oil, respectively, and the remainder of the biodiesel are made using more advanced technologies from cellulosic feedstocks such as crop residues, dedicated energy crops, or wood [22]. The major feedstocks used globally for the biofuel production are presented in Table 7.

Table 7: Biofuel production ranking and major feedstock (OECD/FAO (2021)

Country	Major feedstock	
	Ethanol	Biodiesel
United States	Maize	Soybean oil, used cooking oils
European Union	Sugar beet/wheat/maize	Rapeseed oil/Palm oil/used cooking oils
Brazil	Sugarcane/maize	Soybean oil
China	Maize/cassava	Used cooking oils
India	Molasses	Used cooking oils
Canada	Maize/wheat	Canola oil/used cooking oil/soybean oil
Indonesia	Molasses	Palm oil
Argentina	Molasses/sugarcane/maize	Soybean oil
Thailand	Molasses/cassava/sugarcane	Palm oil
Colombia	Sugarcane	Palm oil
Paraguay	Maize/sugarcane	Jatropha

The quantity of biofuel produced globally is increasing gradually with 187 thousand barrels of oil equivalent per day in 2000 to 1.75 million barrels of oil equivalent per day in 2021 with the United States producing 41%, making it the largest producer of biofuel in 2021. This was probably due to government policies favouring the reduction in GHG emission and promoting the production of biofuels, blending targets, and increased demand for biofuels [23]. For instance, a Volumetric Ethanol Excise Tax Credit was issued for blending ethanol into motor gasoline from 2005 through 2011, and a tax credit of $1.00 per gallon is currently given for blending biodiesel and renewable diesel into the conventional diesel fuel. The U.S government programs whose activities promoted increase in biofuel up to 2021 include the federal Renewable Fuel Standard [RFS] Program and California's Low Carbon Fuel Standard [LCFS]. The major biofuels produced in the United States include ethanol, biodiesel, renewable diesel, and others including heating oil, renewable heating oil, renewable jet fuel [sustainable aviation fuel, alternative jet fuels, biojet], renewable naphtha, renewable gasoline, and other emerging biofuels [see Table 8] [24]. Other leading producers of biofuel in the world in 2021 were Brazil, Indonesia, China, Germany, France, Thialand, Argentina, Netherlands and Spain [see Figure 4].

Table 8: U.S biofuels supply and disposition in 2021 [billion gallons]

	Production	Imports	Exports	Consumption
Fuel ethanol	15.01	0.06	1.25	13.94
Biodiesel	1.64	0.20	0.18	1.65
Renewable diesel	0.81	0.39	NA	1.16
Other biofuels	0.08	NA	NA	less than 1
Total	17.55	0.66	1.43	16.83

Source: U.S. Energy Information Administration, *Monthly Energy Review*, June 2022, preliminary data.
Note: Excludes stocks; NA is not available.

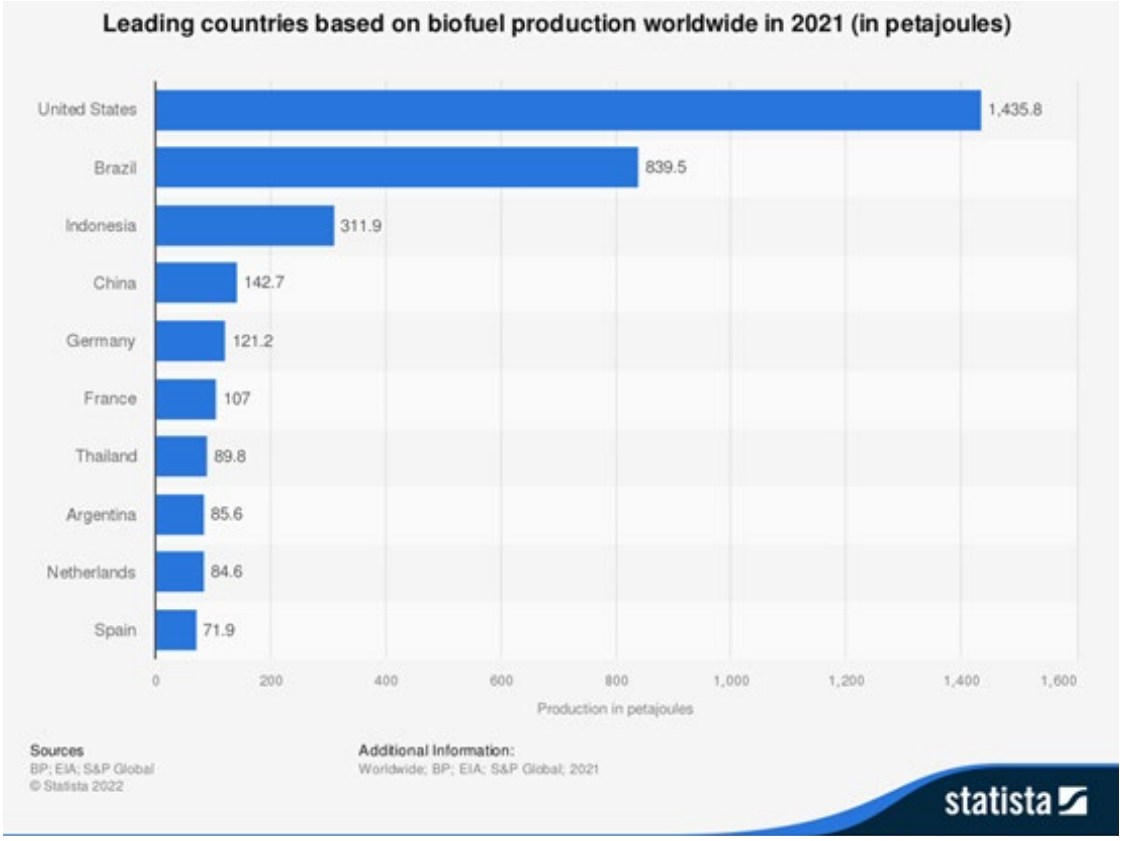

Figure 4: Top 10 biofuel producing countries in the world in 2021 [25].

Biofuels Production in Nigeria

These kind of fuels are renewable and are derived from the conversion of biomass. They include bio-oil, bioethanol, biodiesel and biogas which are usually used as source of fuel for the automotive engine, heating and power generation [26]. Biofuel is considered as a cleaner and cheaper alternatives to fossil fuel. In Nigeria, biofuels include ethanol, biodiesel and other fuels produced from biomass whose qualities conform to the specifications of the standards Organisation of Nigeria [SON], Department of Petroleum Resources [DPR], and any other qualified agency of the government, for use in automative, thermal and power generation [10].

The Federal Government of Nigeria mandated the Nigerian National Petroleum Corporation [NNPC] to establish an Automotive Biomass Programme in 2005. The NNPC aspires to exploit renewable fuel resources in Nigeria in order to make contributions towards the Paris Agreement of minimizing the emission of greenhouse gases through the use of renewable energy. Through the programme, National Biofuel Policy and Incentives was published in 2007. The objective was to achieve 100 % biofuel production in-country to be consumed in Nigeria by 2020 [27]. The biofuel such as bioethanol and biodiesel was to be blended with the conventional diesel and gasoline, respectively. This requires that 10 % bioethanol will be blended with 90 % gasoline, and 20 % biodiesel with 80 % petroleum diesel. The daily gasoline consumption in Nigeria as at July 2022 according to the Nigerian Midstream and Downstream Petroleum Regulation Authority [NMDPRA] was 66.89 million litres. To achieve the 10 % bioethanol blending, Nigeria will need to produce about 6.7 million litres of bioethanol per day. However, Nigeria produces approximately six percent [contributed by the Allied-Atlantic Distilleries and Unichem] of the total quantity of ethanol required in the country annually, and imports 300 - 350 million litres/year [28].

In 2021, Nigeria spent 91.36 million [USD] on ethanol in 2021 imported from the United States according to the data presented by the United State Department of Agriculture [29]. There exist an available market for ethanol in Nigeria. Although, the major problem to its production growth is unfavourable government policies which tend to discourage investors, but favour the importation of the product, and thereby giving rise to undue competition with indigenous producers, as the importer ethanol product is cheaper. To discourage the importation of bioethanol into the country, and promote the in-country production of bioethanol, there is need for the government to increase the tariff.

Biofuel Activities in Nigeria

The commercial production of biofuel in Nigeria is currently in its nascent stage and the development appears to be slow in the areas where they are produced [see Figure 5]. However, according to [30], bioethanol production companies are located in the South-West geopolitical region, probably due to the availability of market and nearer to Lagos seaport for potential transactions overseas. Bioethanol plant have also been situated in other region like South-South in Bayelsa and Ekiti states, respectively while it is envisgaed that the plants would also be located in some states in the North-Central, North-East and South-East [see Tables 9 and 10] [31]. The feedstock for biofuel production are produced from the North-Central and North-West geopolitical zone of the country, probably due to the abundance of marginal or unused land [30].

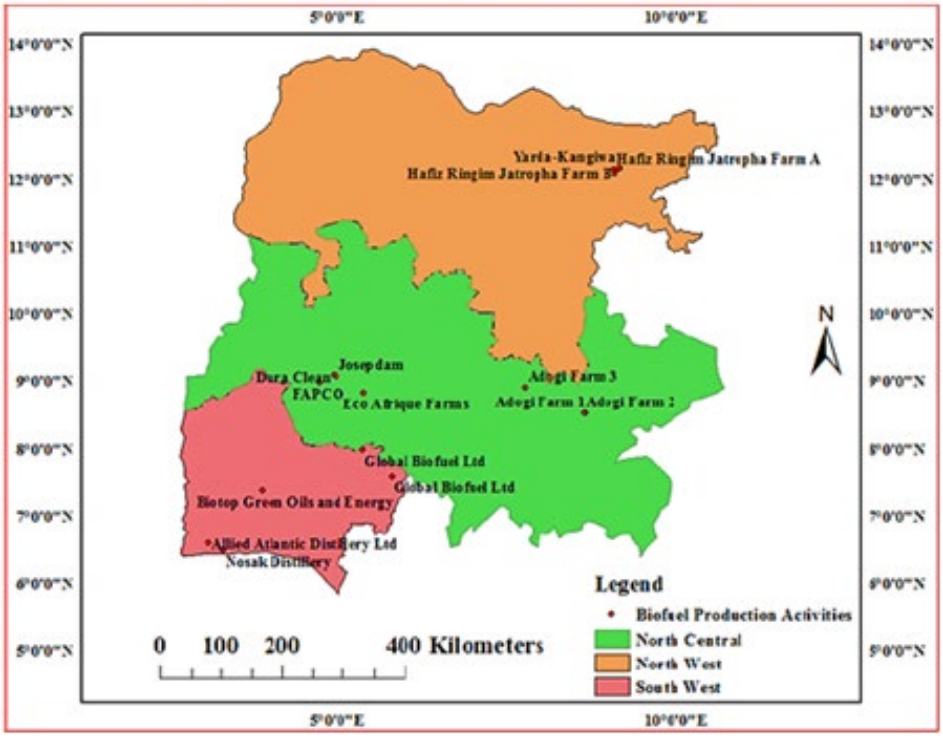

Figure 5: Some selected areas where biofuels are produced in Nigeria (Balogun and Salamin, 2016)

Table 9: Select bioethanol plant in Nigeria

Name of company	Plant location	Feedstock	Installing capacity (million liters/year)
Dura Clean	Bacita	Molasses/cassava	4.4
AADL	Sango Otta	Cassava	10.9
CrowNek	Ekiti	Cassava	64.0
CBU Energy Company	Bayelsa	Cassava	75.0
Akoni	Lagos	Cassava	53.0

Table 10: Select proposed plants in Nigeria

S/N	Name of company	**Project information** budget ($)
1.	Jigawa, Benue, Anambra and Ondo State Integrated and Bioethanol Refineries and Sugarcane Farm	$4 billion
2.	Nasarawa State Integrated Bioethanol Refinery and Cassava Farm	27 million
3.	Casplex Ethanol Refinery and Cassava Farm	Not available
4.	Ekiti State Integrated Bioethanol and Cassava Farm	100 million
5.	Petrobas Ethanol Plant	200 million
6.	Kogi State Ethanol Plant	1 million
7.	Taraba State Ethanol Plant	115 million
8.	Niger State Ethanol Plant	314 million
9.	Lemma Ethanol Plant	50 million

Biofuel Policies

Internationally, the biofuel sector is greatly influenced by national policies whose major objectives are to support the farmer, minimize greenhouse gas emission, and/or enhance energy independence [22]. In August, 2005, NNPC was issued a directive on an Automotive Biomass Programme for Nigeria by the Federal Government of Nigeria to provide enabling environment for the establishment of fuel ethanol industry in-country in order to minimize the dependence on the importation of gasoline and environmental pollution, improve the quality of automotive fossil-based fuels, and create jobs. This was envisaged to integrate the agricultural sector of the economy with the downstream petroleum sector. In addition, the programme was anticipated to provide revenue to the country, provide enabling environment to attract foreign investors, increased yield and production of agricultural products, and reduction in greenhouse gas [GHG] emission [10]. The first phase of the programme involves importation of fuel ethanol and blending of about 10 % with gasoline leading to the production of E-10. The second phase is the production of biofuel in-country and it was expected to run concurrently with the first phase. With a blending ratio of 10 %, up to 1.3 billion litres was required for the country and the quantity was anticipated to increase to approximately 2 billion litres in 2020. The blending ratio of biodiesel was 20 % with a corresponding quantity of 480 million litres which was anticipated to increase to about 900 million litres by 2020. This second phase was expected to achieve 100 % domestication of biofuel production in Nigeria by 2020.

In an attempt to implement the policy, the Nigerian National Petroleum Corporation [NNPC] secured 70,000 Euros from the Renewable Energy, Energy Efficiency Partnership [REEEP] from Germany as a grant to conduct feasibility studies for the establishment of biofuel plants at target locations [32]. The Corporation carried out the studies on bioethanol production with cassava and sugarcane as feedstocks, and on biodiesel production using palm oil as feedstock. In addition, it also attracted investors and the construction of about twenty bioethanol factories commenced some years back with fourteen others in view [33]. Unfortunately, information regarding the progress and operation of the biofuel factories is lean in the public domain, and are contained mostly in the newspaper. There have not been any report in the annual reports of Nigeria's Bureau of Statistics, Central Bank of Nigeria and was not contained in the Nigeria Economic Recovery and Growth Plan 2017-2020 [34]. However, NNPC according to some scholars have made some progress by installing biofuel handling facilities in some of the depots of the Corperation and selected outlets, staff training and developing quality assurance guidelines for biofuel production and importation through the help of the Standard Organization of Nigeria [SON], and public enlightenment [33]. Despite these achievements, it is speculated that the government has not shown substantial commitments towards the actualization of a biofuel economy through the biofuel policy after fifteen years of adopting the policy. This is evidenced in its inability to establish the Biofuels Energy Commission and the Biofuels Research Agency which are reposed with the responsibilities of implementing the policy [26].

Constraints to the Implementation of the Policy [35]

Competition of the scarce food for human consumption and their use for biofuel production, especially in view of the food production and consumption imbalance is one of the constraints hindering the realization of the biofuel policy. The food insufficiency in Nigeria is caused by factors such as archaic land legislation, poor irrigation technology, low access to credit, expensive farming inputs [like seedlings and fertilizers], and inadequate storage facilities [36- 43]. Other constraints include:

• Poor financial commitment
• The government may need to inject sufficient fund to realize the policy, and It could also set up an implementation committee to facilitate the establishment of biofuel across the country
• Lack of economic incentives
• Multiple taxation
• This involves tax charges by the local, state and federal government. In order to encourage investors, such payment should be reduced to the barest minimum and it is should be collected centrally.
• Unfavourable customs and excise duty. The current situation does not encourage easy importation of biofuel technology and equipment. The government can make importation of the technology attractive by granting duty free or subsidizing duty to promote the development of biofuel
• Land Use Act

The law bequeaths the control and management of the land situated with the urban areas of the state to the governor and any other land to the local government. Thus, acquisition of land within the urban areas from individual, group or community must be done with the approval of the state governor. Most at times, the process of obtaining such approval is quite rigorous and time consuming, especially as there is no consideration of timeline in the law. This contributes to the factors hindering the development of biofuel in Nigeria as land is required for the cultivation of the feedstock and the establishment of the biorefinery where biofuels are produced and refined into more useful products [32].

Promoting Biofuel Production Through the use of Some Existing Legislation
1. The pioneer status applied for as contained in the policy for a period of 10 years and possibility of 5-year extension should be granted by the government. There is no doubt would enable investors to make an appreciable profit during their formative years [32].
2. The policy also applied for the import duty waiver under section 13 of the Customs, Excise, Tariff, etc [Consolidation] for 10 years. This will stimulate the importation of technology and equipment required for biofuel production.
3. Biofuel industry should be included in the list of approved industries granted pioneer status
4. Investors in biofuel, if they provide basic infrastructures such as access roads, pipe borne water and electricity which ordinarily should have been made available by the government could be allowed to deduct twenty percent of such expenses in their tax.

Conclusion

The various biomass resources of Nigeria have been investigated, and it was observed that the country has the potential to generate over 200 billion per annum of biomass from agricultural crops, plantation crops, forest residues, municipal solid waste, animal and human wastes. The energy potential of this biomass has been estimated to be over 61 Mtoe. The production of biofuel in Nigeria, has numerous advantages including facilitating agricultural development, boosting economic activities in the rural araes, encouraging the development in the rural areas and reducing rural-urban migration. In order to realize the energy potential of the biomass, Nigerian government needs to implement the biofuel policy completely and expand the policy to include the use of lignocellulosic biomass, non-edible oil and algae as feedstocks for the production of second and third generations biofuels as a measure for resolving the energy-to-feed crises. Due to insufficient data on the biomass resources, there is a need for partnering with investors in acquiring data on the biomass available in the country. For biofuel production to thrive in-country, the Nigerian gevernment must discourage importation of biofuels and encourage 100 % in-country production
of biofuels

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