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Creating Renewable Energy from Agricultural Wastes in Nigeria and Enabling Policy and Legal Framework

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Abstract:- Agricultural wastes will continue to rise as the demand for agricultural produce continues to increase to feed the growing world population. The processing of the agricultural produce and the management system of the wastes require energy, making it imperative to look for the energy source that will reduce the dire environmental consequences of fossil fuel. This study therefore aimed to estimate the renewable energy (electricity) that will be available from agricultural wastes in Nigeria, while the objectives are to review literate to identify the types and quantities of agricultural wastes, estimate the biogas potentials of the identified agricultural wastes, to determine the energy equivalent in firewood, for kerosine, and electricity generation from the biogas, as well as review the enabling policy and legal framework that empowers corporate bodies and individuals to generate electricity from biomass. This study relied on current available secondary data. Results from this study revealed that crop residue from maize, cassava, rice, sorghum represent 16.4%, 22.3%, 12.1% and 19.3% respectively; millet contributed (7.2%); cowpea (4.9%); others ranged from 0.1% (wheat) to 3.0% (yam). The estimated biogas potential in billion m^3 $year^{-1}$ revealed that cattle manure represents 47.9%, followed by crop residue (15.5%). Abattoir wastes represent 11.1% while goat manure represents 10.5%. Others are sheep (6.48%), poultry (6.28%) and pig (2.3%). This study further reported 578.4 million tons $year^{-1}$ from cattle manure, 44.5 million tons $year^{-1}$ from sheep manure, 72.1 million tons $year^{-1}$ from goat manure. In terms of crop residues, this study reported a waste of about 6.2 billion tons $year^{-1}$ in total. The value of biogas potential from this study revealed about 19.1 billion m^3 from cattle manure, about 2.6 billion m^3 from sheep and about 4.2 billion m^3 from goat. In terms of potential electricity generation from these wastes, this study found about 18.7 billion kwh of electricity will be available for utilization. This study therefore recommends that Nigeria should consider the use of biomass as one of the ways to address her energy challenges, preserve her environment and become a self-reliant economy.

Keywords:- *Agricultural Wastes, Renewable Energy, Legal Framework, Self-Reliant Economy.*

I. INTRODUCTION

Population growth and economic development have astronomically increased wastes and equally made waste management challenging. Among several wastes generated by the huge and increasing population is agricultural waste (Obi *et al*., 2016). Agricultural wastes are diverse and such biomass resources of Nigeria can be identified as wood, forage, grasses and shrubs. organic wastes, crops residues, municipal and industrial wastes, animal and aquatic biomass. It is important to note that improper handling of agricultural wastes have always created significant environmental and health problems. Agriculture remains the largest sector of the Nigeria economy. It creates employment for about 70% of the population and contributes about 40% to the gross domestic product (GDP) with crops accounting for 80%, livestock 13% (Jekayinfa *et al*, 2015). Wastes from these could be converted to renewable energy to solve world's energy problem in a sustainable manner (Jekayinfa *et al*, 2020). Nigeria can comfortably and significantly reduce her current energy crisis through the application of the biogas technology. The term biogas is gas comprising primarily of methane and carbon dioxide produced by the biological breakdown of organic matter in the absence of oxygen (anaerobic digestion) or fermentation of biodegradable materials biomass, manure, sewage, municipal wastes and energy crops that can serve as a source of sustainable and renewable energy. With the awareness and acceptance of the technology in Nigeria (biomass conversion technologies {BCT}), the country can conveniently channel the large quantities of wastes from her agricultural activities into electricity generation and biofuel production. This will reduce the greenhouse gases (GHG), waste disposal load, create jobs, and engender value-additions to products. Agricultural wastes constitute the largest part of organic wastes which comprise 44%-66% of the total solid waste, and can be converted to useful energy known as biogas. The biogas has been found to have direct positive impacts and contributions to 12 out of the 17 sustainable development goals (SDGs). Other advantages of the biogas include ability to increase renewable energy, reduce climate change, enhance the waste management process, and create jobs (Obaideen *et al*., 2022). Other renewable energy sources available include solar, geothermal, wave, wind, tidal and biomass (Ogbu & Okey, 2023). Of all these sources, biomass can be converted to renewable energy that can exist in three forms i.e. solid, liquid and gaseous state (Patel *et al*., 2016).

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Electricity supply to the national grid in recent times have been grossly inadequate making social and economic development difficult. This condition has made the decentralization of energy generation and distribution imperative in Nigeria. Also, fossil fuel has become very expensive to mine and process in addition to its grievous impact on the environment, necessitating very serious consideration and use of alternative (renewable) sources of energy. Since biomass could be used to generate electricity, the huge agricultural wastes left to degrade in the environment could be digested and converted to useful energy for electricity generation. The aim of this study is to estimate the amount of renewable energy (electricity) that could be generated from agricultural wastes in Nigeria, while the objectives are to review literate to identify the types and quantities of agricultural wastes, estimate the biogas potential from quantities of the identified agricultural wastes, and to determine the energy equivalent in firewood, for kerosine and total electricity generation from the biomass.

II. LITERATURE REVIEW

A. Concept of Waste

Waste is variously referred to as refuse, trash, or garbage. It is essentially the unintended by-product of production and consumption. Simply put, waste is a product or substance which is no longer suited for its intended use (UNEP, 2024). Human activities generate wastes which have been increasing as a natural consequence of urbanization, economic development, and population growth. As nations and cities become more populated and prosperous, offering more products and services to citizens, and participate in global trade and exchange, they face corresponding increase of waste to manage through treatment and disposal. Global waste generation in 2016 was estimated to have reached 2.01 billion tons annually (Kaza, *et al.*, 2018). Figure 1 shows waste generation by regions of the world.

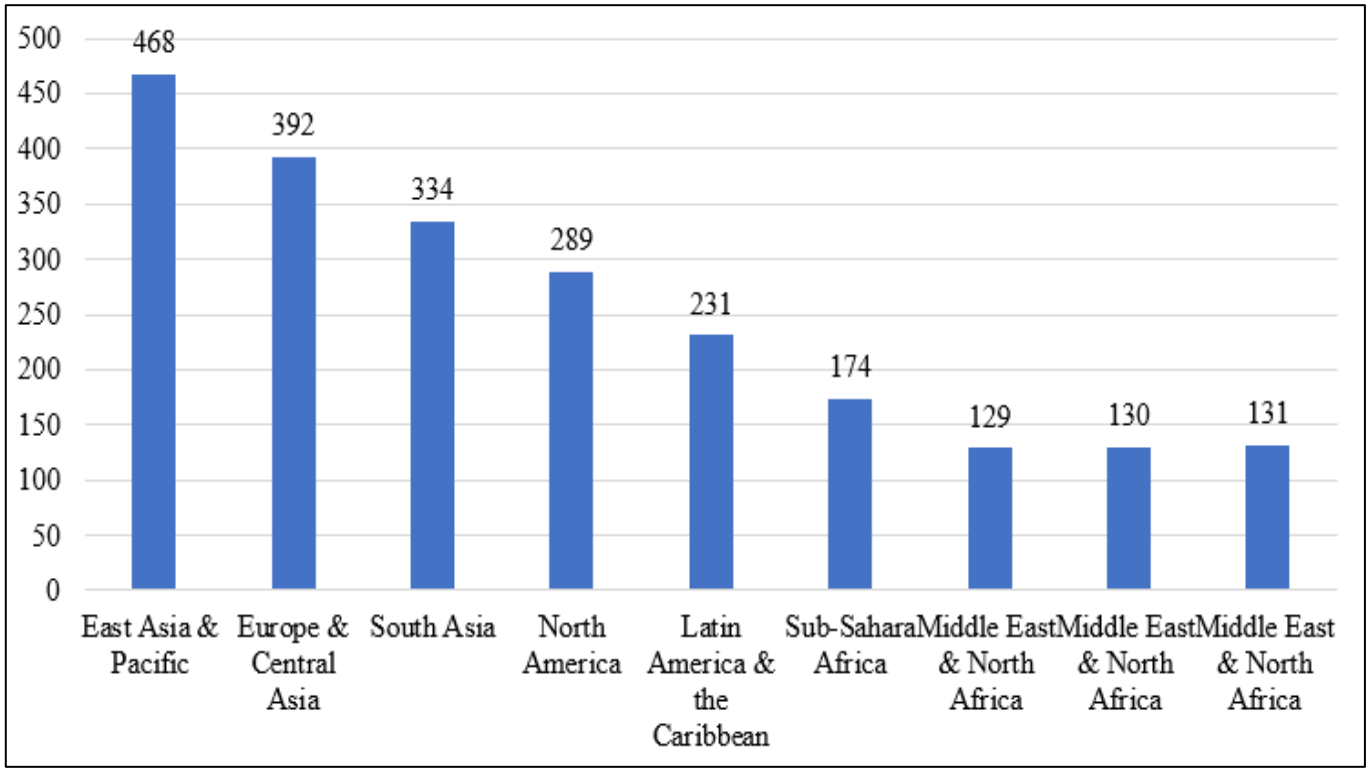

Fig 1: Annual Regional Generation of Waste in Million Tons
Source: Kaza, et al., 2018

B. Waste Generation in Nigeria

Waste generation in Nigeria is estimated at 0.65-0.95 kg/capita/day which gives an average of 42 million tons annually, and about 24% of the annual waste generated in sub-Sahara Africa. Where and how to channel these wastes have become a huge problem for our nation. It was equally noted that 52 % of wastes generated are organic wastes which create additional disposal problems (Ike, *et al.*, 2018).

C. Agricultural Wastes

Agricultural wastes are all forms of plant-derived and animal-derived material that are considered useless either because they have no known positive economic importance or because they are not grown/raised for any specific purpose (Adeyi, 2010). Agricultural wastes chiefly take the form of crop residues (residual stalks, straw, leaves, roots, husks, shells, etc.,) (Figure 2), and livestock wastes manure (Aruya *et al.*, 2016). Their composition will depend on the system and type of agricultural activities and they can be in the form of liquids, slurries, or solids (Obi, *et al.*, 2016).

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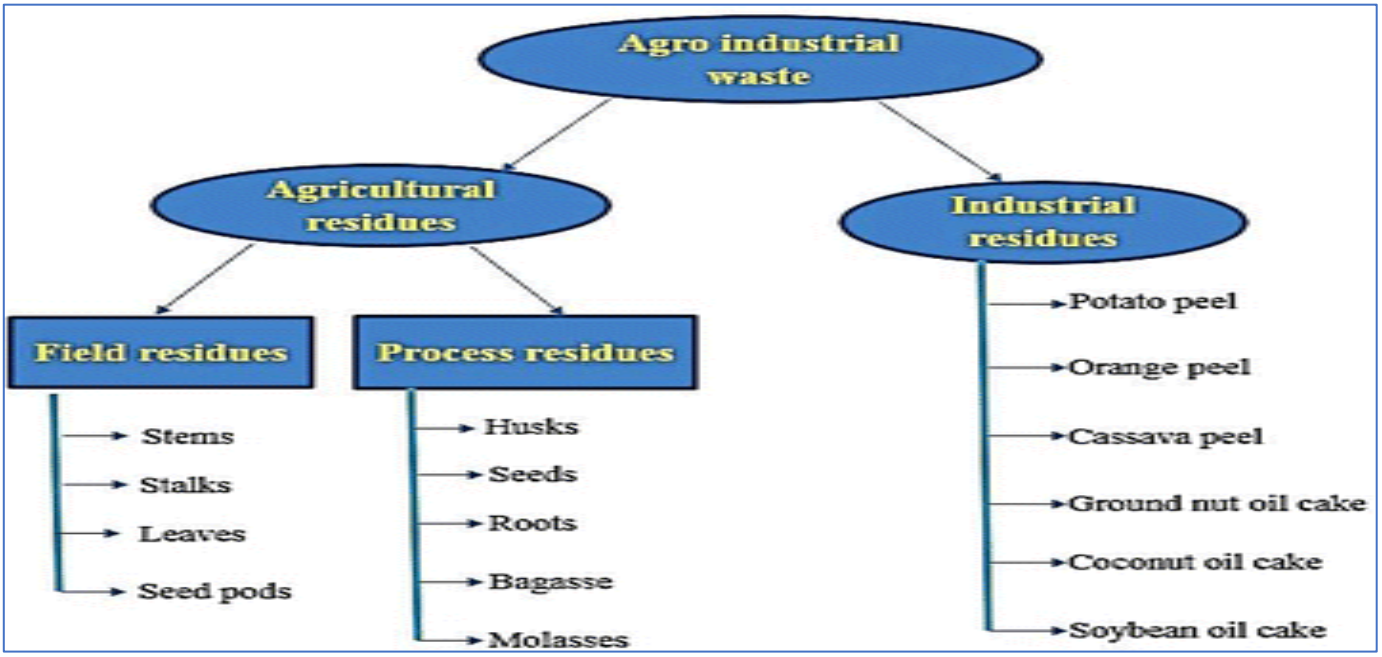

Fig 2: Components of Agro-Industrial Waste
Source: Sadh *et al*. (2018)

The benefits of recycling agricultural solid wastes include reduction in greenhouse gas emissions, contributing significantly to the development of new green markets, creation of jobs, production of bio-energy and bio-conversion of agricultural solid wastes (Adejumo and Adebiyi, 2020).

D. Effects of Improperly Managed Agricultural Wastes

Just as we cannot do without agriculture because food is a necessity for life and living across the globe, we can also not run away from the impact of ineffectively managed agricultural wastes. The negative impact of ill managed agricultural solid wastes on human health, animal health, and the environment is significant. Hence the need to effectively manage such wastes and possibly, convert them to useful resources cannot be over-emphasized. Suffice it to say that if agricultural wastes are not properly managed, they would lead to environmental degradation, low agricultural productivity and eventual food shortage (food insecurity).

E. Methods of Agricultural Waste Management

➢ *Some of the Methods used to Manage Agricultural Waste (Banga & Kumar, 2019) are:*

- Ploughing in roots and stubbles in the field as a sustainable farming practice which is often employed by our local farmers.
- Collected, stored and used for livestock feed e.g., cassava peels
- Used for animal comfort e.g., wood shavings/saw dust used as beddings for Day old chicks (DOC) and Piglets.
- Spent bedding treated with livestock feed etc.

However, agricultural wastes could be better managed through: recycling; incineration; landfill; animal feed; and biological processing. The biological processing of agricultural wastes are majorly aerobic composting and anaerobic digestion (Alhassan *et al*., 2019; Banga & Kumar, 2019).

Aerobic composting is the decomposition of organic matter using microorganisms that require oxygen. The microbes responsible for composting are naturally occurring and live in the moisture surrounding the organic matter. Oxygen from the air diffuses into the moisture and is taken up by the microbes. Anaerobic digestion on the other hand, is a process whereby bacteria break down organic matter—such as animal manure, wastewater, biosolids, and food wastes—in the absence of oxygen (Alhassan *et al*., 2019; Banga & Kumar, 2019).

F. Energy Generation/Distribution Situation in Nigeria

Power is a major index in rating a Nation's level of development. Unfortunately, Nigeria is grossly deficient in energy generation and distribution. Nigeria generates approximately 4,000 MW of electricity which is inadequate for its population of over 206.14 million energy demands (Olujobi, *et al.*, 2022). The 2020 World Bank Ease of Doing Business report ranked Nigeria 171 out of 190 countries in getting electricity and that electricity access is seen as one of the major constraints for the private sector. The report also noted that 85 million Nigerians do not have access to grid electricity which represent 43% percent of the country's population making Nigeria the country with the largest energy access deficit in the world. To worsen the case, it was all over the news media in the 2nd and 3rd quarter of 2022 that Nigeria's energy generation crashed from 3600MW to 900MW. Nigeria as at 2022 was generating a theoretical 3,900 MW of electricity while the demand was estimated at over 36,000 MW giving a shortage of over 30,000 MW that can never be met from the existing sources (Otobo *et al*., 2023). Also, the problem of transmitting grid-generated electricity to the rural areas through very difficult and

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insecure terrains make electricity supply to the rural communities herculean, making energy generation from biomass an attractive alternative.

G. Effects of Energy Shortage in Nigeria

This power supply deficit has made business to seek alternative energy sources like firewood, charcoal, Kerosine as well as gas and diesel-powered generators. These alternatives are relatively expensive, non-renewable, and highly environmentally unfriendly. A better option is electricity generation from biomass (biodegradable wastes) as a source of energy which is renewable, cleans the environment, conserves resources, preserves the ecosystem, prevents pollution of air and aquifers, besides creating green jobs.

III. ENABLING POLICY AND LEGAL FRAMEWORK

The foregoing study and analysis reveal that Nigeria has a stock of renewable energy in form of biomass and biogas. These renewable energy resources constitute natural capitals that make up the tangible assets and wealth of the nation and which must be captured in wealth accounting in a well thought out wealth economy framework. The Wealth Economy framework emphasizes the importance of investing in sustainable infrastructure that takes into account the long-term impact on the environment and future generations. This includes investments in renewable energy, public transportation, and energy-efficient buildings, as well as investments in natural resource conservation and biodiversity protection. By prioritizing sustainable infrastructure, countries can build a more resilient and sustainable economy that is better equipped to meet the challenges of the future. To account for a nation's physical capital, the Wealth Economy framework proposes the use of "wealth accounting," which takes into consideration the full value of a country's natural resources, infrastructure, and other physical assets. This includes not just the market value of these assets, but also their contribution to overall well-being and sustainability. By including the value of physical capital in national accounts, countries can better understand their true economic and social progress and make more informed policy decisions.

Energy occupies a central position in human existence. The level of energy utilization in an economy, coupled with the efficiency of conversion of energy resources to useful energy, is directly indicative of the level of development of the economy. Furthermore, how energy is generated and used in Nigeria is of immense importance given the grave consequences associated with negative patterns. In 2018, the energy sector reportedly contributed to 60% of total GHG emissions.

The energy sector plays a major role in driving the nation's development objectives. A well-articulated national policy and properly designed legal framework are essentials for wealth economy to promote national development. The following section presents a summary of the policy and legal framework that govern harnessing renewable energy resources in Nigeria.

A. International and Regional Treaties

- United Nations Framework Convention on Climate Change
- Paris Agreement.
- United Nations Renewable Energy Resolution 73/236. Ensuring access to affordable, reliable, sustainable and modern 2018.
- AGENDA 2030 Sustainable Development Goals.

Renewable energies are cleaner and cheaper, which is the roadmap to ensure access to affordable, reliable, sustainable and modern energy for all (Goal 7). Access to affordable, reliable, sustainable and modern energy will achieve the dual purpose of ending poverty in all its forms everywhere (Goal 1), Sustainable Cities and Communities (Goal 11), Positive Climate Action (Goal 13) Renewable energy is essential to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (Goal 9) and will promote gender equality (Goal 5). Regional Treaties: ECOWAS Renewable Energy Plan.

B. National Laws

➢ *The Constitution of the Federal Republic of Nigeria*

The constitution restates the fundamental objectives and directive principles of State policy to be that in pursuit of economic objective, the State shall harness the resources of the nation and promote national prosperity and an efficient, dynamic and self-reliant economy (Section 16(a) 1999 constitution). This provision constitutes the foundation upon which every other national resource management policy stands for resource harnessing.

➢ *Electricity Act 2023:*

Electricity Act 2023 (EA2023), provides a comprehensive legal and institutional framework to guide the operation of a privatised, contract and rule-based competitive electricity market in Nigeria and attract through transformative policy and regulatory measures, private sector investments in the entire power value chain of the Nigerian Electricity Supply Industry. EA 2023 is a consolidation of numerous policies and statutes that make up the legal and institutional architecture albeit fragmented, of the Nigerian electricity supply industry. Significantly, EA2023 liberalized Nigeria's electricity generation, transmission, and distribution at the National level, empowering States, companies and individuals to generate, transmit and distribute electricity. Its broad objectives are: to provide an ideal legal and institutional framework to leverage on the modest gains of the privatisation phase of electric power sector in Nigeria to accelerate growth in power generation capacity and improve utilisation of generated power through increased investments in new and efficient power generation technology and revamping existing power plants; promote policy and regulatory measures to ensure the expansion of power transmission networks in Nigeria to address any imbalance in the existing transmission infrastructure; stimulate policy and regulatory measures to generally scale up efficient power generation, transmission, and distribution capabilities of the power sector in Nigeria with a view to

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achieve a national electricity access targets and attaining the highest per capita power consumption in Africa within a reasonable time frame; eliminate through policy and regulatory measures, barriers to investments in generation, transmission, distribution, and related sub-sectors in the electricity industry in Nigeria (Electricity Act 2023).

EA2023 is a major stimulant and framework for action to drive the transition into the era of renewable energy-based electricity in Nigeria. From the articulated goals and objectives on renewable energy, EA2023 with a strong government commitment, is a veritable vehicle to move Nigeria away from fossil fuel-based energy to clean and renewable energy, with the attendant socio-economic benefits, with respect to: (i) provide a framework to stimulate the development and utilisation of renewable energy sources and create an enabling environment to attract investment in renewable energy sources to increase the contribution of renewable energy to the energy mix; (ii) provide a framework for improvement of access to electricity in rural, unserved, underserved, peri-urban and urban areas through the use of conventional sources and renewable energy off-grid and mini-grid solutions; (iii) promote indigenous capacity in technology for renewable energy sources through a framework for local content in the Nigerian electricity supply industry; (iv) promote public education on renewable energy production and consumption to increase the generation and consumption of electricity from renewable sources.

C. National Policies

- National Energy Policy (Revised 2022), which Articulates Nigeria's broad policy on renewable energy, bio-energy, electricity policy, energy utilization, efficiency, and conservation, energy financing, environment and climate issues, amongst other things.
- The Renewable Energy and Energy Efficiency Policy (NREEEP), whose broad objectives are to enhance energy security in the nation through diversifying the energy supply mix; increase energy access especially in the rural and semi-urban areas; facilitate employment creation and empowerment; protect the environment; and mitigate climate change.
- National Policy on The Environment 2016, which affirms the centrality of energy to life and sustainable development, and government efforts to provide power to all Nigerians in order to spur development and improve livelihoods, expresses government's commitment to: implement the National Policy on Renewable Energy; develop and promote an integrated national strategy for sustainable utilization of renewable energy; promote adaptation of the cleaner production concept in all energy production and consumption activities; promote the use of energy forms that are environmentally safe and sustainable; and support capacity building to enhance sustainable use and monitoring of energy resources (National Policy on the Environment {Revised}2016}).

IV. MATERIALS AND METHODS

A. Secondary Data

➢ *Population and Manure Values*

Current available data for the population of cattle, sheep and goat were obtained from the Federal Ministry of Agriculture and Rural Development (FMARD, 2017). Estimated manure values for cattle, sheep, and goat were calculated from the work of Garba (2010) through least-square regression equation, while values for pig, poultry, abattoir, were obtained from the work of Ngumah *et al.* (2013). Agricultural residues based on Nigeria's 2018 crop production was obtained from Okafor *et al*. (2022).

➢ *Estimation of Biogas*

The amount of biogas was obtained from reported work of Ngumah *et al.* (2013) as follows:

- 33 m^3 ton^{-1} for cattle excreta;
- 58 m^3 ton^{-1} for sheep and goat excreta;
- 60 m^3 ton^{-1} for pig excreta;
- 78 m^3 ton^{-1} for poultry excreta;
- 53 m^3 ton^{-1} for abattoir waste and;
- 60 m^3 ton^{-1} for crop residue (waste).

➢ *Estimation of Biochemical Methane Potential (BMP)*

Estimation of the biochemical methane potential (BMP) were calculated based on the reported work of Ngumah *et al.* (2013) as follows:

- 56% for cattle excreta;
- 70% for sheep and goat excreta;
- 60% for pig excreta;
- 66% for poultry excreta;
- 60% for abattoir waste and;
- 60% for crop residue.

V. RESULTS

The population of livestock in 1997 from Federal Ministry of Agriculture (FMA) as reported by Garba (2010), showed cattle 18.1 million and manure produced was 170.4 million tons; sheep was 33.2 million and manure produced was 13.0 tons while goat was 53.5 million and manure produced 21.1 tons. The calculated manure values for the 2001 for cattle, sheep and goat were 197.6 tons, 15.1 tons and 24.5 tons respectively as shown in Table 1. Using trend equation from manure produced in 1997 and 2001, the estimated manure produced from 18.4 million cattle, 76 million goat, 43 million sheep are 578.4 million tons $year^{-1}$ for cattle, 44.5 million tons $year^{-1}$ for sheep, and 72.1 million tons $year^{-1}$ for goat as shown in Table 2.

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Table 1: Population of Livestock and Manure Production in Nigeria (Garba, 2010)

Livestock	FMA (1997) Population (million)	Manure produced (calculated figures) (million tons)	Population based on FMA (1997) figures (millions	2001 (calculated figures) (million tons)
Cattle	18.1	170.4	21.0	197.6
Sheep	33.2	13.0	38.5	15.1
Goat	53.8	21.1	62.4	24.5
Pig	8.3	13.2	9.6	15.3
Poultry	97.3	28.1	112.9	32.6

Source: https://docplayer.net/81086935-Overview-of-biomass-energy-resources-technologies-and-programmes-in-nigeria-serc-udus-sokoto-nigeria.html

Table 2: Estimated Manure from Livestock Population

Livestock	FMARD (2017) Population (million)	Estimated manure (tons year^{-1})
Cattle	18.4	578.4
Sheep	43	44.5
Goat	76	72.1

➢ *Desk Research Estimation*

Crop residue which includes, oil palm, maize, cassava, rice, yam, sugarcane, plantain, sorghum, cocoa, wheat, millet, groundnut, cocoyam, coconut, cowpea, sweet potato, soybean was provided in metric tons (Mt). For convenience, the total value was converted to tons on Table 3, which shows that maize, cassava, rice, sorghum represents 16.4%, 22.3%, 12.1% and 19.3% respectively. Aside from millet which is 7.2% and cowpea 4.9%, other crop residue wastes ranged from 0.1% for wheat to 3.0% for yam.

Table 3: Crop Residue from 2018 Crop Production in Nigeria

CROP	RESIDUE (Mt)	% Value
oil palm	1950000	2.095
maize	15300000	16.435
cassava	20825000	22.370
rice	11288000	12.125
yam	2850000	3.061
sugarcane	426000	0.458
plantain	1545000	1.660
sorghum	17973200	19.306
cocoa	306900	0.330
wheat	99900	0.107
millet	6720000	7.218
groundnut	3612500	3.880
cocoyam	1650000	1.772
coconut	71250	0.077
cowpea	4567500	4.906
sweet potato	2015000	2.164
soybean	1895000	2.036
Total (Mt)	93095250	100.000
Total (tons)	102590965.5	
Total biogas potential	6155457930	

Source: Modified from the Work of Okafor *et al.* (2022).

The estimated biogas potential in billion cubic metres per year on Table 4 revealed that cattle manure represents 47.9%, followed by crop residue of 15.5%. Abattoir waste represents 11.1% while goat manure represents 10.5%. Others are sheep 6.48%, poultry 6.28% and pig 2.3%.

Table 4: Estimated Biogas Potential

Biomass (Agric Waste)	Estimated biomass (million tons year-1)	Estimated biogas potential billion m3 year-1	% Value
cattle	578.4	19.08	47.89
sheep	44.5	2.58	6.48
goat	72.1	4.18	10.49
pig	15.3	0.92	2.31

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poultry	32.6	2.5	6.28
abattoir	83.3	4.42	11.09
Crop residue	102.6	6.16	15.46
	928.8	39.84	100.00

Source: Desk Research estimation based on the calculation from Okafor *et al.* (2022), Ngumah, *et al.* (2013) and (Garba, 2010)

The biomass resources when utilized to provide energy can provide the needed energy mix for this country. For instance, about 19.1 billion cubic meters of biogas can be derived from our current cattle production 18.4 million cattle (Table 5). This can save the country about 30.8 billion Litres of kerosene, about 5.5 billion kg of firewood and add about 10 billion kwh of electricity from only cattle manure to our nation. The energy situation in Nigeria as at 2021 indicated that an average household required 150 kwh of electricity per day for various energy needs. From this study analysis, about 18.8 million kwh of electricity would have been added to our national grid. This implies that the 18,768,421,053 kwh of electricity would have taken care of 125,122,807 households. In addition, 64,258,064,516 liters of kerosine and 11,468,048,359 kg of firewood would have been saved. Besides, Nigeria has the highest rate of deforestation in the world with 55.7% (9,587,577 hectares) of her primary forest were lost between 2000 and 2005 (FAO, 2010).

Table 5: Biogas Equivalent of 1 m^3 in Kerosene, Firewood, Coal and Electricity (https://planet-biogas.com/en/biogas-calculator/)

Fuel	**1 m^3 equivalent**	**1.612903226**	**0.287852619**	**0.526315789**
		Kerosene (Litre)	Firewood (kg)	Electricity (kwh)
Cattle manure	19,080,000,000	30,774,193,548	5,492,227,979	10,042,105,263
Sheep	2,580,000,000	4,161,290,323	742,659,758.2	135,7894,737
Goat	4,180,000,000	6,741,935,484	1,203,223,949	2,200,000,000
Pig manure	920,000,000	1,483,870,968	264,824,409.9	484,210,526.3
Abattoir waste	4,420,000,000	7,129,032,258	1,272,308,578	2,326,315,789
Crop residue	6,160,000,000	9,935,483,871	1,773,172,136	3,242,105,263
Poultry	2.500,000,000	4,032,258,065	719,631,548.6	1,315,789,474
		64,258,064,516	11,468,048,359	1,876,8421,053
Total		64,258,064,516	11,468,048,359	18,768,421,053

Desk Research

VI. OVERVIEW

There has been a steady growth in the production of agricultural waste. This study reported 578.4 million tons $year^{-1}$ from cattle manure, 44.5 million tons $year^{-1}$ from sheep manure, 72.1 million tons $year^{-1}$ from goat manure. Values reported in this study are much higher than 61 Mt $year^{-1}$ of animal waste (Agba *et al*., 2010) and 83,037,500 tons of animal manure (Okey *et al.*, 2014). In terms of crop residues, this study reported a waste of about 6.2 billion tons $year^{-1}$ in total. Previous studies have reported 83 Mt $year^{-1}$ of crop residues which is equivalent of 91.466 tons $year^{-1}$ (Agba *et al*., 2010), 145 Mt $year^{-1}$ (Simonyan & Fasina, 2013). On the other hand, Ngumah *et al.* (2013) reported a total of 542.5 million tons of organic waste with inclusion of municipal solid waste. The value of biogas potential from this study revealed about 19.1 billion m^3 from cattle manure alone, about 2.6 billion m^3 from sheep and about 4.2 billion m^3 from goat. In terms of potential electricity generation from these wastes, this study found about 18.7 billion kwh of electricity will be available for utilization. Previous studies had reported 2,850.4 kWh and 4560.70 kWh of electricity from daily generation of biogas produced from cow wastes at a low-end efficiency of 25% and at the high-end conversion efficiency of 40% respectively which on annual basis, yields 1040 MWh and 1665 MWh respectively (Odekanle *et al*., 2020). In addition, Ngumah *et al.* (2013) estimated 169,541 MWh of electricity from their study.

VII. CONCLUSION

The world is tending towards reduction in the use of fossil fuel which is not only a wasting asset, but pollutes and degrades the environment resulting in reduction in life expectancy and promoting underdevelopment. Besides, with The Hubert Peak theory (Tushar k. Ghosh and Mark A., 2009), becoming a reality, we need to find alternative sources of energy that are renewable and green. Agricultural wastes provide one of such alternatives. Though other sources of renewable energy like solar, wind, and geothermal are available, biomass (agricultural wastes) should be given special attention because of the numerous Energy, Environmental, Economic, Green job opportunities as well as the Agricultural benefits it portends. The technology is simple and can be purpose built, even for households, which makes it affordable. It needs very little maintenance, and Nigeria has enough substrate for the biogas generation. In addition, Nigerians are apprehensive with the current increase in tariff from sixty-six Naira (N66) per kwh to two hundred and twenty-five Naira (N225) per kwh for those enjoying minimum of 20 hours per day (B and A consumers) from the national grid. This makes it imperative for urgent need to utilize biomass as energy source in the country.

Currently 18.7 billion kwh of electricity would have been available for utilization. Besides 64,258,064,516 liters of kerosene and 11,468,048,359 kg of firewood that would have been saved, Nigeria would have equally saved about 2 trillion Naira based on reported saving of 2013 (Ngumah *et*

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al., 2013). Since Nigeria is grossly deficient in energy supply, availability of adequate, reliable, sustainable and cost-effective energy will enhance her socio-economic development. Biogas technology will equally make it possible for Nigeria to utilize her mountains of biodegradable wastes which are drowning the environment to recondition her environment for sustainable livelihood. An opportunity she must leverage on to surmount her current environmental, food, health and unemployment crises which the green initiative (waste to energy) aims to address. The anaerobic digestion of biodegradable wastes, should of a necessity be given the attention it deserves. Increased renewable uptake scenario, otherwise known as the Transforming Energy Scenario (TES), sees future capacity expansion of Nigeria's electricity supply system provided largely by renewables, which reduces primary energy requirements (because most of the renewables deployed are more efficiently converted to useful energy than fossil fuels) and greenhouse gas emissions in tandem with increased electrification. In the TES, the share of primary energy requirements met with renewable energy reaches 47% by 2030 and 57% by 2050. Investment in renewables is more cost-effective than the conventional pathway. Total installed power generation capacity needs in the TES reach 62 gigawatts (GW) in 2030 and 178 GW in 2050, of which 77% is renewable in 2030 and 92% is renewable in 2050 (IRENA, 2023). Sustainable energy is the driver of modern development. Zero waste strategies are enablers of a circular economy, which aims to prevent waste by keeping products and materials in use for as long as possible, and to protect human health and the environment by the elimination of harmful chemicals Global Waste Management Outlook 2024).One cannot agree less with Francesco La Camera, the Director General of Internation al Renewable Energy Agency when he stated that: "Nigeria has therefore reached a vital juncture at which it must decide whether to maintain its reliance on fossil fuels – accepting the inevitable environmental and economic risks that path entails – or capitalise on its ample indigenous renewable energy resources to drive economic development, decrease energy costs and significantly reduce its greenhouse gas emissions." (IRENA, 2023).

RECOMMENDATIONS

This age long simple technology that will make a difference in Nigeria's development journey should be embraced for full scale implementation. This could be achieved through:

- The intensification in creating awareness among the political class about the enormous potential of bio-energy.
- The provision/grant of incentives to individuals and organizations interested in implementing bio-energy.
- The establishment of an implementation plan for National bio-energy programme.
- Making biogas production from Agricultural wastes as part of the National Agricultural program.
- The teaching of Integrated agricultural system with the intention of producing Energy from Agricultural Wastes in all Faculties of Agriculture in Nigerian Universities
- The provision of more information on proper handling and management of biodegradable wastes for bio-energy among the general public.

Education is a key driver in the transition to renewable energies There is a need for more comprehensive training and capacity-building programs. This challenge underscores the need to review and consequently overhaul the entire education sector and its architectural design so as to ensure that the entire education system from policy to delivery, is such that is in consonance with the tenents of education for development. Florence's statement on the essence of education, is indeed apposite as one reflects on the setbacks the CCI encounters as a result of paucity of knowledge and skills. According to Akaakar (2023), *"Put simply, the very essence of education, the purpose it must achieve, its measurable usefulness, is that it drives, it accomplishes, knowledge, skill, innovations, it stimulates talents, potentials, ability to address all manner of issues embedded in nature, and discovery of dynamics of exploitation of natural resources to meet human needs, Education must serve a purpose. Education must meet a need. Education must have a goal to achieve, education must be purpose-driven."*

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