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Sustainable energy for national climate change, food security and employment opportunities: Implications for Nigeria

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ABSTRACT

This paper looks into the issues around renewable energy with a view to identify the opportunities for Nigeria and critically review the nation's renewable energy policy vis-à-vis the efforts and achievement of governments and indigenous practitioners. It identified the inherent opportunities of renewable energy resources at ameliorating the incidents of climate change and global warming and also surveyed international statistics on the relationships between energy and renewable energy adoption, national development, population explosion, job creation and rural-urban integration. It found out that for Nigeria to sustain economic growth especially as it relates to agriculture and food security, renewable energy for power generation must be included in the nation's rural development plan. It also demonstrated that renewable energy poses an opportunity for mitigating the nation's contributions to anthropogenic climate change.

1. Introduction

Energy has been variously described as a means through which raw materials can be converted to useful products. Its consumption and utilization has been linked to population variation around the different regions of the world. High rate of energy use is linked to population stagnation while the more the availability and consumption of energy, the better the gross domestic product (GDP) [1–3]. Regions with low energy availability have been reported to experience high rate of migration leading to overpopulated cities and underpopulated rural communities. The reasons have been partly adduced to the fact that energy poor citizens have either developed unsustainable means of meeting their energy requirement or have had to migrate to areas with better energy supply [3,4].

Virtually all sectors of an economy require one form of energy or the other. For instance, transportation, power generation, manufacturing, thermal comfort, information technology, and agriculture are areas and sectors that depend strongly on availability of modern energy resources. The different agenda of the sustainable development goals is tied to access to modern energy resources, thereby bringing about a link between sustainability and human development. The interrelationship between energy access and human development therefore has a direct impact on the enhancement of rural-urban integration. According to literature, the task of improving energy services for the poor citizens of developing countries remains a pressing challenge if the efforts of sustainable development and rural transformation are to be successful [5–7]. amenities and service delivery becomes a mirage. Such responsibility of government which A report by the Independent Evaluation Group (IEG) of the World Bank stated that more than one-seventh of the world's population and mostly poor, lack access to electricity and equally another set of the same population though have access, "*but receive electricity services that do not meet standards for the quantity and reliability of services that an efficiently performing sector should provide*" [8]. Njiru and Letema [9] also reported that, a lack of electricity access impairs progress in human welfare and quality of life. Thus the expected progress in the provision of social include healthcare provision, education, provision of clean water services, creation of opportunities for income earnings, and opportunities for information and communication technology enhancement becomes a tough task to achieve, if the attendant challenges of giving access to modern energy are not succumbed.

Further to this, inadequate power supply services, especially from the grid-system, in cities and industrial areas creates the situation of low productivity, increased unemployment, poor economic growth profile,

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high costs of living, escalating cost of products, and underperforming industrial sector. Some studies have demonstrated the relationship between energy consumption, economic growth, and population variation [10–12]. Bhattacharya, et al. [13] and Eren et al. [14] showed that there is a positive relationship between energy availability and economic growth, with renewable energy as the major driver of the economy. Destek et al. [15] and Li et al. [16] demonstrated that modern energy consumption positively influences economic growth. They showed a causality run between electricity consumption and economic growth. On a country or regionalized assessment, several studies have reported direct relationships. For instance, Khan, et al. [17], Liu et al. [18], Zhu, et al. [19], Grabara et al. [20], Xiong and Xu [21], and Akinyemi [22] reported for China, Beijing, Organization for Economic Cooperation and Development (OECD) countries, Malaysia and Nigeria, respectively. Each of the reports shows direct relationships between energy consumption and economic growth. Also, Omitogun et al. [23] discussed various studies establishing the link between economic growth and energy production and consumption and reported that a positive relationship exists between population, energy consumption, and economic growth in Malaysia. Bakirtas and Akpolat [24] opined that a sustainable economy must experience high level of energy and resource efficiency and argued that there is the growing need to develop the economy without necessarily degrading the environment. Nsafon et al. [25] on the other hand stated that, to establish the role of energy consumption in economic development, there is the need to understand the interplay between energy consumption and production, and added that the strong relationship that exist between energy utilisation and economic growth should be extended to include pollution. The study therefore proposed that such relationship be driven towards sustainability. In which case low carbon technologies should be encouraged for production by adopting mitigating factors such as the use of cleaner fuels and technological change that encourages pollution free production.

2. Progress in universal modern energy access

The western countries of Europe, North America, New Zealand and Australia have made significant progress to ensure adequate access to electricity. Almost 100% of the countries have achieved 100% access [26]. Despite this achievement, the global electricity access was put at about 90.1% in the year 2019. This means there are still over 700 million people without access to electricity globally. Analysis by the IEG of the World Bank [27] gave a picture of the level of achievement in some regions of the world at ensuring electricity access for their citizens. Of the population without access to electricity, are people in the Sub-Saharan Africa (SSA), South Asia (SA), and East Asia (EA) (see Fig. 1). While the Asian countries are making significant progress to ensure nationwide access in each of their countries, those of the SSA are lagging behind. Despite the fact that, the SA and EA regions are reported to be putting efforts at closing the gap by 2030, the SSA region seems to be slow. Worst still is the fact that as at 2017, the region was home to forty out of the world's fifty-one low-access countries [28,29].

Also, further analysis reveals that 9 of the SSA countries have less than 25% access while 2 have less than 10% access. On a regional basis, the entire SSA region has less than 48% access, while those of SA and EA & Pacific have 94% and 98% access, respectively [30,31]. This is a far cry and suggests that substantial efforts are required for the SSA region to measure up in the race towards energy enhanced development. However, the countries within the North African region have done well with electricity access of 99%. Looking at Nigeria and benchmarking electricity access in the country against some other African countries (Fig. 2), shows that the nation has more to do to achieve a stimulated socio-economic development. Electricity access in the country in 2019 was put at 62%, comparatively lower than some of the other African countries with similar economic growth indices [32].

Going back to 2010, Nigeria was ranked second behind India on the list of the top 20 countries with electricity access-deficit. The statistics shows that about 82.4 million Nigerians endured non-electrified communities or grossly inadequate supply of electricity [31]. Majority of this population are in the rural areas and cut off from the national grid system. Statistics show that 66.6% Nigerians live in the rural areas [33]. Today, all of these statistics only fared better by a margin, and suggests concerted efforts are required. The tradeoff to this has been the utilisation of unsustainable and environmentally benign means of meeting rural communities' energy needs. In addition to this, the prevalence of rural energy poverty has brought about several issues of migration and underdevelopment experienced in such communities. This invariably also bring with it underpopulated rural communities and may lead to a reduction in agriculture practices and thereby point to a projection of food shortage if the trend is not arrested. A report states that by 2030, the rural dwellers will be fewer than current statistics as the world settlements increasingly tends towards urban [34]. Furthermore, most of the efforts of governments at alleviating the electricity situation of Nigeria are focused on urban areas. This may be due to the necessity to boost industrialization and improve the manufacturing sector, and consequently enhance the GDP of the nation. Nonetheless, disregarding the nation's rural communities in the national electrification plan initiates an imbalance into the energy demand and supply system. Another implication is the incessant depopulation of rural areas. World Bank

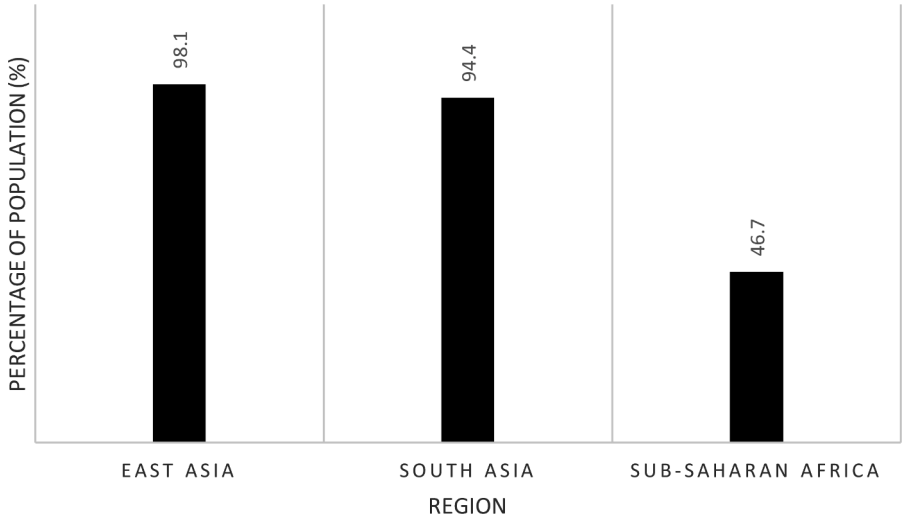

Fig. 1. % Of Population with access to electricity [31].

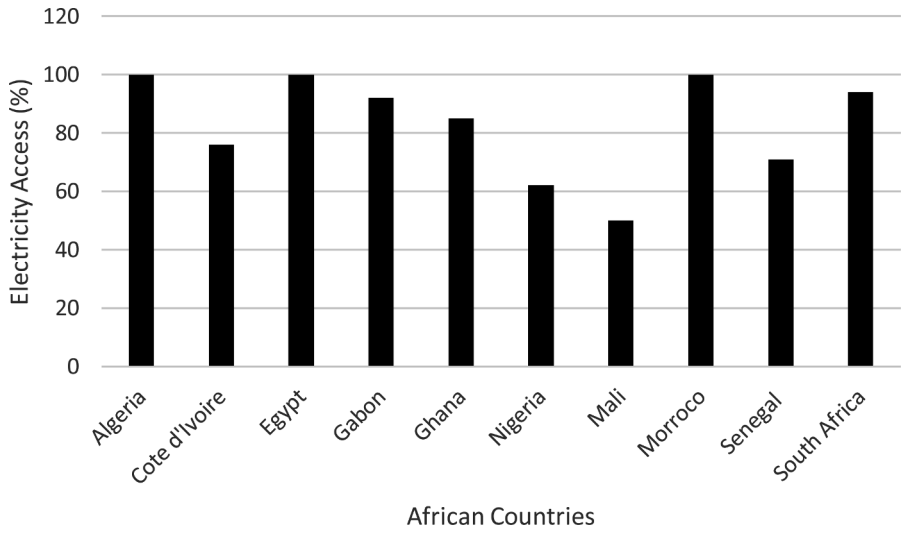

Fig. 2. Comparative analysis of the Nigeria electricity access in the year 2020 [30] (IEA, 2020).

[31] and Moyei et al. [32] stated that only about 10% of rural households are connected to national electric grid-system, while on state by state analysis, 14 and 6 states have respectively, 40 to 60% and 60 to 80% of their households connected to the electricity grid.

Worthy of note is the fact that, not more than 20% of households in Yobe, Borno, Taraba, Plateau and Ebonyi states are connected to the nation's electricity grid system [31]. Meaning that over 80% of the population from these states meet their energy requirement through various means which may include self-generation via fossil fuelled generators and unsustainable biomass burning. In addition, these states and some other states are very rich in agriculture products which include rice, groundnut, banana, citrus, soybean, cashew, sorghum, pepper, maize and yam. Hence, the unavailability of modern energy supply may affect farm product processing, leading to expensive farm products and poor postharvest management and control practices.

3. Challenges of lack of access to modern energy resources or its inadequacies

In 2008, Sambo [33] reported that the national electricity projection of vision 2020 was based on 13% GDP growth rate. The basis of this projection was due to the fact that, the nation hopes to become one of the leading industrialised nations in the year 2020 [34]. The report stated that the energy demand should increase from 5.7 GW in 2005 to about 298 GW in 2030, while the supply should correspondingly increase from 6.4 GW to above 300 GW over the same period [35,36]. 12 years after the start of this projections, total electricity generation stood in the neighbourhood of 5 GW (in 2017), which is 0.7 GW lower than 2005 demand figure. Moreover, the report stated that, in order to achieve the projected target, new installed capacity should be about 11.69 GW yearly. This means that in 2017, total installed electricity capacity ought to be about 146 GW. This points to a deficit of about 141 GW of electricity. In 2020, this figure ought to be about 181 GW.

The demand for energy is determined by the total population and income growth which are the two strongest steering forces. 80% of the population generates around 35% of global GDP and uses 54% of global energy in the nations we live in today[37-40]. Khan et al. demonstrated a ce in Nigeria's energy demand and supply chain brings to the fore the urgent need for concerted efforts at ensuring that the desired stimulated growth is achieved at stated target period. Worst hit however, are those of rural areas. Aside the fact that, there is insufficient supply of modern energy to cities and development regions of the nation, people of rural communities are either not connected to the national grid or are under blackout for most parts of the year. This leads to engaging in unsustainable and environmentally malignant means of meeting the energy needs. Consequently, several companies in the cities rely on fossil based generators for production and daily needs while those in the rural areas depends on traditional biomass burning. Effluents from this sources have been attributed to cause global warming and climate change. Where modern energy resources have been absent or insufficient, fossil fuels and biomass resources have been the mainstay. Various argument and debates against these energy n inverse relationship between population growth and per capital energy supply. This imbalance resources exist, including the different climate change protocols, conventions and declarations [41]. Such protocols, conventions and declarations include the United Nations Framework Convention on Climate Change (UNFCCC, 1992), Rio Declarations (1992) and Kyoto protocol (1997).

Other climate change negotiations and debates include the Paris Agreement (2015). All of these international efforts on climate change issues agreed that there is the urgent need to cut the emission of greenhouse gases of which carbon dioxide (CO_2) is a major causative agent of climate change and global warming due to its long term atmospheric stability [42–44]. Sources of atmospheric greenhouse gases however, have been variously traced to anthropogenic emissions derived from activities that include power generation, transportation, industrialization, agriculture, and domestic use [,[45,46]]. Of these activities, that relating to power generation and transportation have been described as the main source with highest anthropogenic emission of CO_2. Anthropogenic climate change evidences exist all around us today. From the increasing drought in the north to alterations in the amount and periods of rainfall in the south, climate change phenomenon in Nigeria have cause for concern.

The changing climate pattern in Nigeria and across the globe, the alteration in global ecosystem, failing crop yields, desert encroachment, warmer nights, and rising sea levels are a few examples of climate change incidents. Global warming which is a direct effect of the greenhouse gases on the atmosphere, brings with it increased infectious diseases that thrives during hot weather conditions. Such diseases include malaria from mosquitoes, fever, and diseases from rodents. The impact of energy shortage on anthropogenic climate change has been the basis of the World Bank discourse on ameliorating the energy poverty of sub-Saharan Africa and other energy poor countries. Several statistics and suggestions exist pointing to the fact that, if the energy poor states are not assisted, the progress of climate change agreement may be hampered in the near future [,[47–49]].

4. What can be the solution to the lack of/or poor access to modern energy supply in Nigeria and other sub-Saharan African countries?

Going by all the aforementioned, one of the ways suggested globally for energy poor nations to increase access to modern energy resources is the adoption and utilisation of renewable energy resources for power generation and other energy needs. Renewable energy resources are environmentally friendly, sustainable, abundant, non-toxic, able to be operated as a standalone facility and in modular form, non-depleting, naturally applicable, easily adaptable, and also it is easily accessible [50]. It contains sustained opportunities for meeting the direct energy needs of rural communities without access to electricity. Various climate change discourse has favoured the adoption of renewable energy resources for power generation and countries like the United States of America, China, India, and some European nations have constantly increased their annual installed wind power capacities [51]. Africa is lagging behind in the adoption of renewable energy for power generation. Across the continent of Africa, very few countries which include Kenya, South Africa, Egypt, Morocco, and Algeria are growing in installed wind power capacity. Some others are slow and either in policy development stages or in the process of discussions. Moreover, according to the United Nations Environment Programme (UNEP), the West African region has abundant renewable energy resources, especially solar and wind energy, in sufficient capacity to serve the rest of the sub-Saharan region and also able to meet the current and projected energy demand of west Africa [52].

With these resources, Africa can take care of her energy needs, if concerted efforts are put in place and geared towards regional cooperation aimed at energy development. The Nigeria's Renewable Energy Master Plan (REMP) developed in 2005 by a team of national energy practitioners and consultants at the instance of the joint Energy Commission of Nigeria and United Nations Development Programme, contains road maps and vivid government statements on the adoption of renewable and clean energy resources into the national energy mix [53]. Today, the country is yet to attain 10 GW generation, neither is there grid-connected renewable electricity. Also in 2005, the national renewable energy and energy efficiency policy (NREEP) was approved by the federal executive council (FEC) for the electricity sector of Nigeria [54].

The policy statements agreed that the *national grid is limited in reach with limited extension capacities to remote communities*. It also agreed that citizens in remote communities lack access to electricity and that the existing power network can only serve less than 40% of Nigerians. To this end, the policy statement acknowledged that there is the need to seek alternative means of generation to compliment the limited national generation and supply. Majority of the industrialized countries have introduced legal structure to consolidate the consumption of renewable energy (RE) sources in agreement with environmental goals [55]. It therefore proposed and affirmed that adoption of renewable energy resources is a veritable policy option for national energy development. Globally, renewable energy resources have become a major opportunity for meeting nationwide electrification programmes and to combat the issues of energy related anthropogenic climate change.

Renewable Energy resources in Nigeria include the vast large and small rivers and natural falls for hydropower generation at both large and small scale levels, well distributed solar irradiation with annual average of around 5.5 $kW/m^2.day^{-1}$, wind power capacities with average wind speeds range of between 4.0 to 8.5 m/s in the north and 2.9 to 4.0 m/s in the south, and biomass resources of over 200 MWh [56]. The combined hydropower potential is estimated to be above 13 GW [56]. Thus, for Nigeria to enjoy sustained energy future and also embrace a well-developed energy stimulated economy, adoption and utilisation of renewable energy is a must. The use of renewable energy resources for power generation should be included in the nation's rural development plan. Also, adequate focus on complimenting the present energy mix with renewable energy will ensure an improvement in the nation's carbon footprint.

5. Alternative energy resources & employment: any relationship

The impact of adequate access to modern energy on an economy cannot be overemphasized. The link between economic development and energy access have been variously established [57]. Countries with high energy access sits on the ladder of global development indices and continue to have sustained industrilisation, well developed information and communication technology industry, quality and enhanced healthcare and education sectors and robust rural-urban integration. Based on a recent report by the International Renewable Energy Agency [,[58,59]], about 9.8 million people were employed globally through various renewable energy businesses in the year 2016, amounting to 11% increase over 2015. Excluding jobs from large hydropower, the report stated that renewable energy jobs in 2016 reached 8.3 million with 2.8% increase. Asian countries like China, Japan and India, the United States of America, and European countries with Germany as the leading nation accounted for most jobs in renewable energy. In 2015, solar power created 3.1 million jobs, while 1.2 million jobs were created by wind power investments. Biologically related energy resources cumulatively created 2.7 million jobs while large hydropower continue to create over a million jobs yearly.

Nigeria is not left out in the renewable energy job markets. Although, no common statistics have pictured the growing markets in Nigeria, it is however noteworthy to say that large hydropower has been a major employer of labour. Several Small and Medium scale Enterprises (SME) have majorly relied on the nation's grid system which is a combined hydro and gas power system. Today, the adoption of solar power for SME is growing. Citizens now deploy solar power for solar charging and other cottage businesses. The capacity of rural applications of solar and wind power systems is enormous. This is based on the advantages of renewable energy technologies which include, the ability to operate as standalone facility, its modular format, ease of application and minimal operation and maintenance costs. With renewable energy fixed into Nigeria's rural development plan, the nation will improve employment generation in rural areas, improve healthcare facility, education services, boost information and communication technology and also move a step forward in achieving the sustainable development goals.

6. Conclusion

- Nigeria's energy demand is on the rise with increasing population.
- The nation's energy supply has repeatedly suffered setbacks owing to issues that surround the present grid system, energy-mix and poor infrastructural development.
- It is reported that less than 40% Nigeria's enjoy grid supply of electricity while several others have their communities not connected to the national grid. Those with grid connections also suffer from repeated power outages and are overburdened by estimated billing. The nation's grid system is weak with over 40% power losses in transmission. While the government has made concerted efforts at improving power supply in Nigeria, the concentration has only been on generation.
- The transmission and distribution system is grossly imperfect and require urgent action. Due to the challenging national energy demand and supply chain, policy statements of government have favoured the adoption of renewable energy resources for power generation. However, a decade after the policy, there is still no grid connected renewable power.
- The enormous renewable energy potential across the geopolitical zones of the nation have largely been untapped. While they represent sustained opportunity at making the nation energy sufficient, renewable energy resources require funding for development. Such funds are huge and can only be achieved by public-private

partnership in the face of dwindling national resources. Also, the policy and decision-makers should abate ecological degradation as well as make transport sector ecologically sustainable.

- The policy statements of government, though very clear and unambiguous, require action from the part of government to convince investors for partnership and engage in developmental strides. More so, the role of science at localizing the technology of renewable energy cannot be overemphasized.
- The high cost of renewable energy technologies can be traced to the fact that indigenous scientists have not done enough at ensuring localisation of the technology.

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