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Nigeria - Land, climate, energy, agriculture and development

A study in the Sudano-Sahel Initiative for Regional Development, Jobs, and Food Security

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Nigeria – Land, climate, energy, agriculture and development

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Abstract

This review report involves the analysis and synthesis of literatures on climate change, land use, energy, livelihoods and sustainable development in Nigeria. The methodology employed in the review involves searching keywords related to the study objectives on relevant literature search engines and platforms, including Google Scholar and Cross Referencing through triangulation of search results. The articles were screened and validated for inclusion or exclusion based on relevance, content and context. The review process follows the sustainable livelihoods framework. The search returns are complimented with published reports. The report provides information on the current status and guidance on appropriate interventions and innovative investments in Nigeria. Specifically, this report provides a systematic literature review on: 1) situation and trends in energy and land use changes, 2) observed and projected impacts of climate change, 3) technological, socioeconomic and policy actions for sustainable land management and climate change adaptation and mitigation, 4) evaluation of existing major policies and investments, and 5) conclusion and policy implications.

Based on the assessment of literature in this study, the key trends and problems include inadequate attention to the agricultural sector over the years, which has caused a major setback in food security and productivity. Climate change has further exacerbated the problem through desertification, drought and flooding across the country. The literature further revealed inadequate energy supply, distribution and low per capita consumption in Nigeria. The use of fuel wood for heating and cooking has significantly contributed to deforestation by worsening land degradation. Resulting implications are that food security is threatened and economic growth is hampered. Land degradation negatively impacts the environment and the rural poor whose livelihoods depend on it. Opportunities in agriculture and renewable energy should be further harnessed and forest and land use policies should be enforced to ensure sustainable livelihoods. In Nigeria, policies and investment plans on land use, energy/electricity and agricultural livelihoods are not coherent and lack consistency in implementation. Thus, lack of strong institutions has resulted in the weak performance witnessed in programme and policy implementation on climate change mitigation, land use, energy and sustainable development in Nigeria. Therefore, there is a need for productive, viable, sustainable policy and programmes that support climate change mitigation, land use, energy and sustainable development in Nigeria. Another important suggestion is the need for provision of renewable energy mix (off-grid) in forms that are easily accessible and affordable by households. Adequate attention should be paid to the provision of bio-energy and the wider bio-economy framework, including the transformation of solid waste, wood waste and agricultural waste into bio-gas and energy. Overall, the investment landscape in Nigeria is improving, and various opportunities for investment in agricultural livelihoods and value chains, renewable energy, carbon trading and green bonds should be harnessed through public-private partnerships.

Keywords: Sahel, energy, climate change, land degradation, innovation, policy

JEL codes: O30, Q24, Q25, Q42, Q54, Q55, Q58

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Contents

1 Introduction

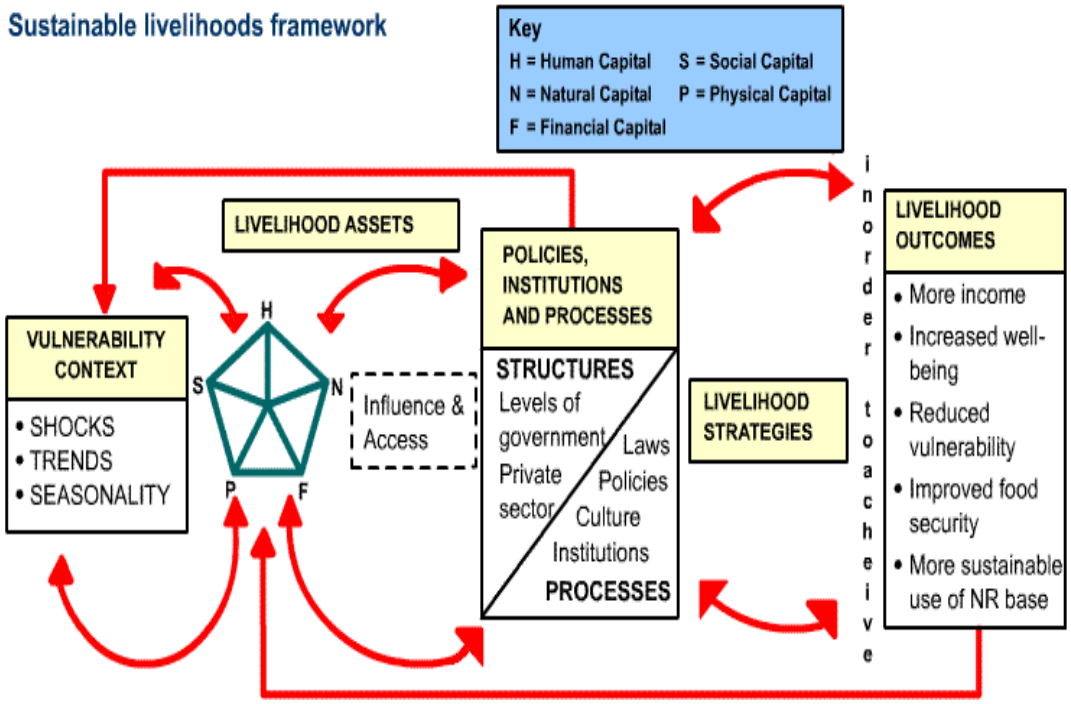
This research report provides a systematic literature review on: 1) situation and trends in energy and land use changes, 2) observed and projected impacts of climate change, 3) technological, socioeconomic and policy actions for sustainable land management and climate change adaptation and mitigation, 4) evaluation of existing major policies and investments, and 5) conclusion and policy implications for Nigeria.

Nigeria is the most populous nation in Africa. It has been governed by democratic rule since 1999. It has a growing population of about 186 million people and a GDP per capita of USD 2,178, a World Bank ease of doing business ranking of 169, and an improving corruption perception index (NBS, 2019; USAID, 2019). The mainstay of Nigeria's economy before the discovery of crude oil was agriculture. The agricultural sector provides employment for 56% of the population out of which 70% reside in the rural areas (FGN, 2012). Small-scale, resource-poor farmers dominate this population. They operate on 0.1 to 5 hectares of farmland, rely on low-level, traditional technologies and primitive production techniques, and focus on fisheries, animal husbandry and crop production (Idowu et al., 2011; Izuchukwu, 2011; Amaechi, 2018; Matemilola et al., 2017; Muhammad-Lawal et al., 2015). After independence in 1960, the country moved towards self-sufficiency and thrived in global markets as the world's largest producer of groundnuts, palm oil, cotton and cocoa. Up to the 1980s, the export of cash crops was responsible for 62.2% of foreign exchange and 66.4% of GDP (Olomola and Nwafor, 2018), with agricultural production largely practiced on subsistent and scattered plots (Matemilola et al., 2017; Muhammad-Lawal et al., 2015).

The population of Nigeria faces an energy deficit, while the natural resource (land) for the main livelihood (agriculture) is simultaneously being degraded by the impacts of climate change (Roche et al., 2019; FMP, 2020). Hence, this study assesses the nexus of climate change, energy, land use, livelihoods and sustainable development. It involves a systematic review of relevant literature to identify and triangulate key trends, problems, solutions and their implications for sustainable development in Nigeria. The methodology employed in the review involves searching keywords related to the study objectives on relevant literature search engines and platforms, including Google Scholar and Cross Referenced. The articles were screened and validated for inclusion or exclusion based on relevancy, content and context. The search returns are complimented with published reports. Further, the review study was conceptualized within the sustainable livelihoods framework (Figure 1), and underpins the various factors of vulnerability context (including climate change) which interacts with livelihood assets and policies to transform livelihood strategies into livelihood outcomes, such as reduced vulnerability and sustainable use of natural and land resource (DFID, 2001; Olayide and Ikpi, 2013).

The economy of Nigeria is undoubtedly agriculture-based (World Bank, 2008). The agriculture sector (including crops, forestry, fisheries and livestock) is practiced under interconnected systems based on natural resources (including water, land and energy). However, these resources are exposed to the impact of climate change and land degradation. Agriculture currently contributes about 22% to real GDP (NBS, 2019). The decline of the agriculture sector's contribution to Nigeria's GDP is largely attributed to the discovery of crude oil and fossil fuels in commercial quantities in Nigeria. Although the foreign exchange to the country is dominated by earnings from crude oil (NBS, 2019), agriculture is still the major driver of the economy in terms of employment and domestic food production. Thus, it is the largest non-oil contributor to the GDP (NBS, 2019). However, the country loses about USD 10 billion annually in export opportunity from crops of comparative advantage like groundnut, palm oil, cocoa and cotton due to a continuous decline in the production of these commodities (FAO, 2020). The decline in production is often attributed to climate change, lack of technological advancement, economic milieu and unfavourable policies (Olayide and Alabi, 2018).

Figure 1: The adapted sustainable livelihoods framework



Source: DFID (2001).

Climate change has had serious and unprecedented impacts in Nigeria as the most populous nation in the continent of Africa. The challenges of climate change range from economic impacts to social impacts with obvious environmental repercussions. These challenges are characterised by environmental pollution, floods, ocean surge and rapid decrease of forest resources, all of which have consequences for the environment. Literature finds that the agricultural sector is vulnerable to the impacts of climate change (Adeoti et al., 2010; Ebele and Emodi, 2016; Odunuga et al., 2014).

An adequate food production system is connected with functional energy systems. Unavailability and inaccessibility of energy/electricity has resulted into diverse constraints and complaints associated with the generation of power supply in rural Nigeria (Borok et al., 2013). This situation has led rural dwellers to improvise energy sources, including use of fuel wood as the main source for cooking and heating energy, which is predominant in the country, because only about 40% of the population has access to electricity supply with largely untapped sources of renewable energy. The national grid is also limited in reach (Energypedia, 2019; FMP, 2015). The unbridled use of fuel wood for cooking and other domestic and construction activity is resulting in a loss of different species of forest trees to deforestation as felled trees are not replaced by new ones. This has led to an increase in the bare land (otherwise meant for trees and cultivation) and constructed lands in urban areas. Hence, the use of renewable resources such as biomass as sources of electricity has been advocated (Adaramola et al., 2011).

2 Situation and trends in rural energy and land use change

2.1 Energy use, associated challenges and opportunities

Energy is an important factor contributing to economic growth and development in Nigeria (Oyedepo et al., 2019). Biomass is used to produce bio-energy which can be used in rural and urban areas. Biomass can come in various forms such as solid waste, wood and wood waste and agricultural products and waste (Adaramola et al., 2011). Biomass and bio-fuels are potential innovative green energy sources capable of producing 2.01EJ (47.97MTOE) of energy from 168.49 million tons of agricultural residues and waste in Nigeria (Simonyan and Fasina, 2013). Furthermore, the current policy direction of the Nigerian government is to significantly increase the share of small hydro power sources as well as solar power generation to achieve energy sector goals of the sustainable development goals by 2030 (see Table 1). Hence, there is opportunity for investments in the energy sector in Nigeria.

Tab 1: Summary of renewable electricity sources and targets

Energy resource	Short-term (2015) in MW	Medium-term (2020) in MW	Long-term (2030) in MW
Hydro (LHP)	2,121.00	4,549.00	4,626.9
Hydro (SHP)	140.00	1,607.22	8,173.81
Solar	117.00	1,343.17	6,830.97
Biomass	55.00	631.41	3,211.14
Wind	50.00	57.40	291.92
% of RE plus LHP	10%	18%	20%
% of RE less LHP	1.3%	8%	16%

(FMP, 2015)

Nigeria plans to achieve energy security and to maintain its National Determined Contributions (NDC) by 2030 through the overhaul of current dysfunctional energy systems, including a transition into a low carbon energy system. Borok et al. (2013) opine that energy security could be achieved through diversification of energy supply and distribution. Thus, the policy of promoting an energy mix through renewable resources will ensure seamless transition into a low carbon energy economy while enhancing climate change mitigation, livelihood improvement, poverty reduction and sustainable development.

Due to Nigeria's over-dependence on hydro-electric power generation, the availability of sufficient water for the power plants affects power availability, especially in the dry season. Climatic variables of high temperatures coupled with low rainfall have been associated with a reduction in hydro-electric power generation and transmission (Idowu et al., 2011). Drought leads to evapotranspiration, which results in reduced water volume and reduction in hydroelectric power generating capacities. Hence, there is a need to explore alternative sources of renewable energies like solar and wind-powered energy systems. The different energy sources used in Nigeria include non-renewable resources such as coal and crude oil while renewable resources include hydro, wind, biomass, wave or tidal, geo-thermal and solar energy. However, inadequate legal and financing have hindered the progress in the energy sector in Nigeria (Elum and Momodu, 2017).

According to USAID (2019), the electricity capacity installed in Nigeria is 12,522MW which is divided into thermal (10,142MW) and hydro (2,380 MW). The current electricity access rate is 45% in rural and 55% in urban areas. In order to bridge the energy deficit in the country, the Federal Government of Nigeria has put some measures in place to promote investments in the energy sector. One of the

incentive schemes is the "pioneer project" which gives seven-year tax holidays to eligible industries e.g. solar energy powered equipment, cable and other electrical related equipment located in an economically disadvantaged local government area anywhere in the country (GIZ, 2015). Tariffs are developed by the Nigerian Energy Regulatory Commission (NERC) using appropriate methodology agreed upon by the project developers and consumers (FMP, 2015). The feed-in tariffs for the current medium-term Multi-Year Tariff Order (MYTO) reflect the cost and benefit of energy provision and investment in Nigeria (see Table 2). The tariffs are designed to ensure full cost recovery for investors as well as to bolster confidence in financing and investment opportunities in the energy/electricity sector.

Tab 2: Electricity feed-in tariffs – wholesale contract prices (Nigeria Naira/MWh)

Energy infrastructure type	2014	2015	2016
Hydropower plants, small up to 30 MW	27,456 (173)	29,643 (154)	32,006 (126)
Land-mounted wind power plants	28,641 (181)	30,943 (161)	33,433 (132)
Solar PV plants, ground mounted, fixed	79,116 (499)	85,401 (444)	92,195 (364)
Biomass power plants	32,000 (202)	34,572 (180)	37,357 (147)

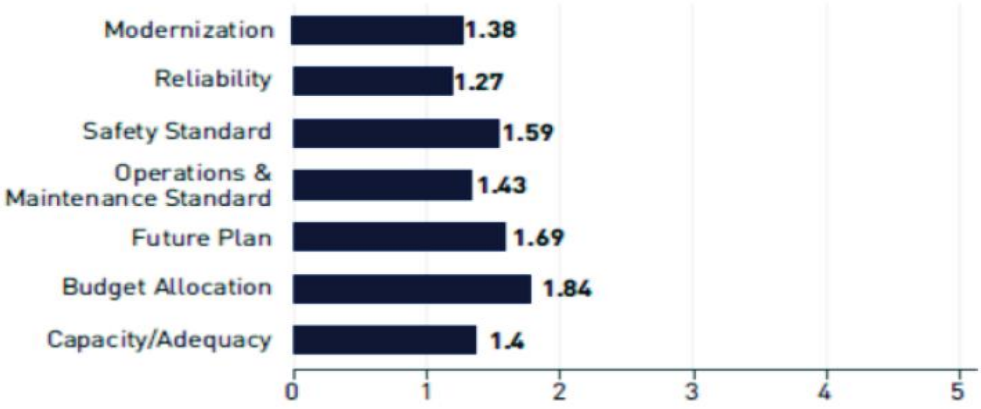
Note: Figures in parentheses are US dollar equivalent rates as adjusted by exchange rates.
(GIZ, 2015)

Further, the United States Agency for International Development's (USAID) Power Africa Project has invested in on-grid and off-grid projects in Nigeria (USAID, 2019). The project promotes energy mix systems including hydro and solar projects. For instance, the first independent power project (IPP), the Azura Project, reached financial close in 2015, and became operational in 2018. An additional USD 50 million investment was provided by the Overseas Private Investment Corporation (OPIC). The power project became operational in 2018. Rooftop solar panel kits are also being deployed to 70,000 residential and small commercial customers in Nigeria with a USD 15 million OPIC loan by Lumos Incorporated using a lease-to-own business model. General Electric, the U.S. African Development Foundation (USADF) and others under the auspices of the Power Africa initiative also awarded USD 900,000 grants to off-grid energy projects. However, the challenge of corruption often resulted in inefficiencies and unaccountability of government counterpart funds in the electricity sector (USAID, 2019).

2.2 Projected need and per capita energy consumption

The per capita electricity consumption for Nigeria in 2015 was 140 kWh, approximately 12 kWh per capita per month (World Bank and IEA, 2017; Olaniyan et al., 2018). With increasing population, the expected energy demand for lifestyle changes is also expected to increase. The low per capita electricity consumption in Nigeria is attributable to two processes – energy generation and distribution. Various factors are undermining development in energy generation and distribution in Nigeria (Okoye, 2019). For instance, on a scale of 1-5, Nigeria scored less than 2 on almost all the parameters of assessment (modernisation, reliability, safety standard, operation and maintenance standard, future plan, budget allocation, and capacity/adequacy) on power generation (see Figure 2). Hence, significant opportunities for investment would require institutional reform in the area of power generation in the energy sector in Nigeria.

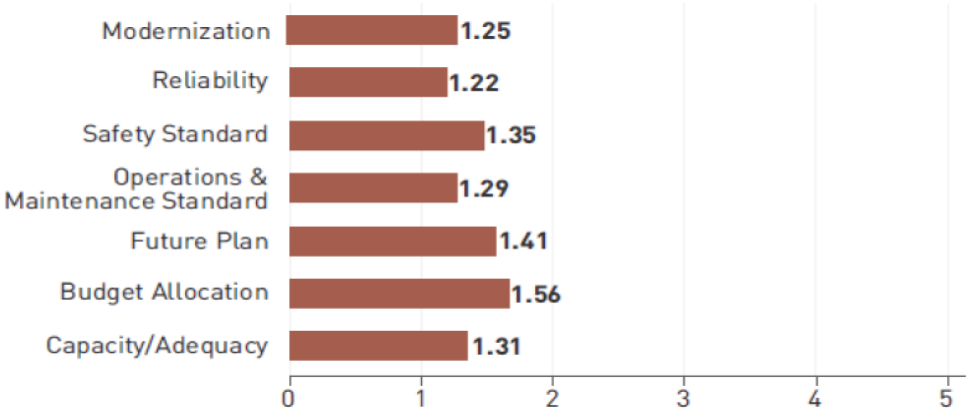
Figure 2: Electricity power generation infrastructure in Nigeria



Source: Okoye (2019).

Similarly, the parameters of modernisation, reliability, safety standard, operation and maintenance standard, future plan, budget allocation, and capacity/adequacy for power distribution in Nigeria are sub-optimal (see Figure 3). The low scores indicate specific areas for appropriate interventions and opportunities for investments and partnerships in Nigeria.

Figure 3: Electric power distribution infrastructure



Source: Okoye (2019).

2.3 Opportunities for investment in the energy sector

There is undoubtedly a huge gap in energy generation and distribution in Nigeria. For instance, average peak in energy/electricity generated in the country in the last five years ranged from 2,687.2 MW – 5,074.7 MW (FMP, 2020). However, the peak electricity demand stood at 12,800 MW. This situation leaves the country with a huge demand gap of 7,000 MW to 10,000 MW. This huge insufficiency in energy portends significant opportunities for investment in renewable energy sources at all levels of value chains, and would provide the impetus for the achievement of universal access to electricity in Nigeria. Hence, this huge energy gap carries potentials for transformative strategies to accelerate electricity coverage through on-grid and off-grid systems (Scott and Miller, 2016).

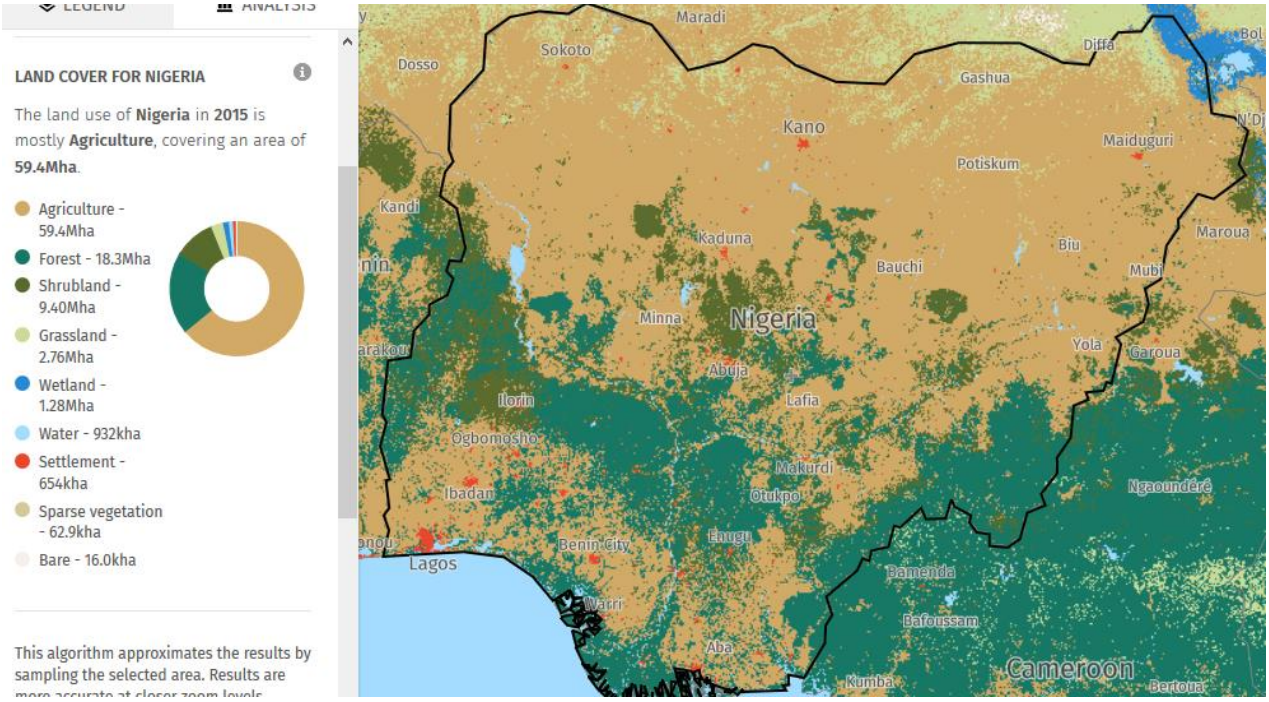
The potential for energy mix in Nigeria is waiting to be harnessed. There are opportunities to expand generation beyond the 30,000 MW from the various energy sources, including renewables and off-grid

supplies. Renewable sources include hydro, solar, wind and biomass. For instance, the country's potential to produce approximately 6.8 million m^3 of biogas every day from an estimated 227,500 tons of fresh animal waste (GIZ, 2015) offers opportunities for investment. The country's potential for a renewable and sustainable energy mix should be vigorously harnessed for the multiple benefits of energy security, sustainable land use management, livelihood generation and sustainable development. Similarly, the Regional Off-Grid Electrification Project (ROGEP) supports Nigeria's acceleration of electricity access through the use of Standalone Solar Photovoltaic systems. ROGEP aims to provide Nigeria the opportunity to realize its universal electricity access goals, and is in tandem with the aspirations of the Federal Government as outlined in its 30:30:30 plan to achieve 30% renewable energy contribution to the country's energy mix by the year 2030. The 3050 MW Mambila Hydro Electric Power Project is also being executed by China Gezhouba Group Corporation and the Federal Government of Nigeria.

2.4 Land degradation and land cover/use

Land degradation is a damaging trend in land condition that is induced by human processes (ELD Initiative, 2013; Olsson et al., 2019). Land degradation has negative impacts on agricultural livelihoods and the food security of millions of Nigerians. A land cover/land use map of Nigeria (see Figure 4) reveals differential gradation from south to north in the country (Global Forest Watch, 2019). Generally, the southern part of Nigeria has a higher density of tree cover than the northern part of the country. The density of tree cover is noticeable along the River Niger and the River Benue to the Delta region. The northern part has a unimodal (one peak) rainfall regime while the southern part has a bi-modal (two peaks with a break in August) rainfall distribution. This pattern is predicted by the length of growing season which affects agricultural livelihood activities, with implications and impacts on agricultural value chains, food security and sustainable development in Nigeria (Olayide et al., 2009). The ecological challenges of the northern part of Nigeria (droughts, sand dunes and sand storms) would require greater investment in afforestation and reforestation programmes. The land cover map also correlates with the land productivity dynamics with the southern part of the country being denser and more productive than those in the northern part (LDNST, 2018). The northern part needs regular soil amendments (including fertilizer application) to enhance land productivity. The Dangote Group has recently invested two billion US dollars in fertilizer production in Lagos, Nigeria. The fertilizer firm has a production capacity of three million tons per annum of granular fertilizer.

Figure 4: Land cover in Nigeria



Source: Global Forest Watch (2019).

Further, in 2015, land use in Nigeria was mostly agriculture, which covered an area of 59.4 million ha (see Table 3). Agriculture had the largest share of the total land cover with 64% in 2019 (FAO, 2020; Global Forest Watch, 2019). Hence, this attests to the dominance of agriculture as a major livelihood enterprise in Nigeria. The share of forest cover was 19.7% in the same period. Shrub and grass land have a total share of 13%. However, recent data (LDNTS, 2018) reports that the share of forest has declined to 11% of the total land cover of the country. This decline further aggravates the level of productivity with attendant implications for climate change, energy, poverty, food insecurity and sustainable development in the country.

Tab 3: Status of land cover type in Nigeria

Land cover type	Area (Million ha)	Share (%)
Agriculture	59.40	64.1
Forest	18.30	19.7
Shrub land	9.40	10.1
Grass land	2.76	3.0
Wetland	1.28	1.4
Water body	0.93	1.0
Settlement	0.65	0.7
Bare land	0.001	0.001

(computed based on Global Forest Watch, 2019)

Furthermore, from 2001 to 2018, Nigeria lost 858,000 ha of tree cover, equivalent to an 8.5% decrease in tree cover since 2000, and 201 million tons of CO_2 emissions (Global Forest Watch, 2019). Generally, the rate of loss in tree cover is faster than the rate of recovery of tree cover on annual basis. Similarly, a total soil organic carbon loss of 1,307,187 tons is the estimated result of changes from forest land to other land use, representing 0.04% of the national soil carbon stock (LDNST, 2018; UNCCD, 2016).

Considering the multi-faceted nature of climate change impacts, halting and reversing land degradation is imperative, as is transforming land from being a source of greenhouse gas emissions to a sink by increasing carbon stocks in soils and vegetation through reforestation and afforestation programmes.

2.5 Causes and impacts of land degradation

Land degradation is a multi-impact phenomenon in Nigeria. The impact of land degradation affects the entire country, both the northern and southern parts. Sand dunes and storms, droughts, and desertification are prominent impacts of land degradation in the northern parts while soil erosion is a recurrent experience in the southern part. Flash flooding occurs in the whole country while coastal flooding occurs mostly near the coastlines in the southern part of the country (Adeoti et al., 2010; LDNTSP, 2018). According to LDNTSP (2018), land degradation results in loss of forest lands, and conversion of forest lands into shrubs and grasslands as well as an increase in bare lands. In the last decade, 463,360 ha of forestland has been lost, including, 344,710 ha that has been converted to shrubs, grasslands and sparsely vegetated areas, and 118,570 ha that has been converted to cropland. Similarly, bare lands and other areas increased by 80 ha in the same period. It was also reported that 360,340 ha of forestland was already showing declining productivity while 178,620 ha of forestland showed early signs of declining productivity.

The causes of land degradation are both direct and indirect (Geist and Lambin, 2001; Kissinger et al., 2012; LDNTSP, 2018; Millennium Ecosystem Assessment, 2005). Livelihood activities, including agriculture expansion, infrastructure development and wood extraction are the direct causes of land degradation in Nigeria. The indirect causes include changes in political governance and commodity price changes (Geist and Lambin, 2002; Obersteiner et al., 2009). Population increases, unemployment, inconsistent agricultural practices, mining, quarrying, infrastructure, transportation and energy have also aggravated land degradation in Nigeria. The resultant effects of land degradation in Nigeria include unemployment, conflict over resources (crop farmers-herdsmen conflict), food insecurity, desertification, drought, flood and erosion (LDNTSP, 2018). Most of the rural poverty experienced in Nigeria is as a result of land degradation induced by human activities. Examples of this are bush burning, deforestation and over-grazing which have led to soil erosion in the south and desert encroachment in the north. Low productivity from subsistence farming has been associated with degradation of farmland; this has also brought about the conversions of lands to marginal agricultural lands with fragile soils (Ogunlela and Ogungbile, 2006). Increasing marginal lands and soils have great tendency to increase poverty, especially in rural area. A study conducted by Ezeaku and Davidson (2008) found that land degradation has generally reduced food, water, fuel, and climate regulation with consequences such as food insecurity, increase in poverty and slow economic development. Thus, the importance of the challenge of land degradation to the nexus of food, energy and water cannot be over-emphasized. Access to energy is important for sustainable livelihoods in Nigeria. This is critical for social, economic and environmental development. Oyedepo (2012) stressed the promotion of renewable energy resources in meeting the energy needs of Nigeria. This is because energy demand is already high and is increasing without adequate and regular supply. Hence, access to clean and renewable energy would promote employment, female empowerment, economic growth, environmental sustainability and the general wellbeing of Nigerians.

3 Observed and projected impacts of climate change in Nigeria

3.1 Observed and projected trends in extreme weather events

About two-thirds of Nigeria's land mass in the northern parts of the country is prone to drought and desertification which puts its energy resources, fishing and farming culture at risk. Evidence from Lake Chad, the largest lake in the Chad Basin and an economically important water source that provides water to over 30 million people in four countries (including Nigeria), shows that the lake has shrunk by over 90% due to climate change and water withdrawals (UNEP, 2013). In 1960, Lake Chad was the fourth largest lake in Africa and the second largest endorheic lake in the world. In 1950, it covered over 37,000 km^2, by 1960 it dropped to cover 26,000 km^2, and by the mid-1990s it was further depleted, covering only 15,000 km^2. By the turn of the century, the lake had lost about 96% of its waters, shrinking to about 1,350 km^2. In fact, the lake has completely receded beyond the Nigerian border (Onuoha 2008).

The persistence of drought in the northern part of Nigeria is caused by low rainfall, which in turn led to the low water levels in streams and rivers witnessed in some communities, and ultimately lead to water scarcity that brought about economic and environmental hardships (Ozor, 2009). Olayemi (2016) noted that this situation worsened the living conditions of many people as drought affects the quantity of water available, which triggers distributional conflicts and poses major challenge of water handling and management. Anyadike (2009) reported that drought-related conflicts have resulted in the death of over 200,000 and displacement of more than two million people in Nigeria.

Similarly, the southern part of Nigeria is also confronted with the challenge of climate change. This is specifically linked to its expansive 800 km coastline, which is prone to ocean surges, heavy storms and floods (Kunlere et al., 2018). Over the period of 1985 to 2014, the country has been exposed to floods that have negatively impacted over 11 million people, causing 1,100 deaths alongside property damaged amounting to USD 17 billion (Nkwunonwo et al., 2015). The country has suffered degrees of flooding (coastal and flash flooding) and climate related disasters with extremely high externalities due to diverse factors (Adeoti et al., 2010; Ajayi et al., 2012). The frequency and intensity of flooding has been increasing in the country. For instance, 32 of the 36 states in Nigeria experienced flooding incidences with catastrophic outcomes in 2018 (Ikpefan and Okeke, 2018) along with increased inundation (Odunuga et al., 2014).

3.2 Climate change, agricultural productivity, livelihoods and food security

There is increasing evidence of the impacts of climate change on agricultural productivity, agricultural livelihoods and food security. Idowu et al. (2011) and Olayide et al. (2016a) noted that due to the over-dependence of the Nigerian cropping system on rainfall, agricultural productivity and livelihoods have been significantly impacted. As a response to changing climatic variables, farmers from the southern parts of the country are now adapting to the change in weather through cultivation of crops that require heavy rains. Farmers in the northern part of the country consider rain scarcity before crops are planted, and seasonal migration of herders has been more frequent. Moreover, decline in cereal crop (including millet and maize) yields is linked to variability in rainfall and drought conditions (Adejuwon, 2005, 2006; El-Tantanwi et al., 2018; Lebel and Ali, 2009; Odekunle, 2004).

Further, Mereu et al. (2018) showed through a simulation model that a 70% decrease in crop yields is expected by 2050 due to climate change under a business as usual scenario. The study substantiated

the case for rice as the most affected crop with a yield decline of 7% in 2020 and 25% in 2050. Rainfall variability and increased temperature has reduced the quantity of pastoral lands, resulting in annual variability of livestock flocks caused by diseases and pests (e.g. foot rot and mange), thereby impacting accruable profits and necessitating cuts to investment by over 20% per annum (Idowu et al., 2009).

Climate change impacts food security, however food insecurity implies unavailability, inaccessibility and poor utilisation of food (Dutse and Ibrahim, 2013). Food insecurity results from increased crop failure and loss of livestock. In some areas diminishing returns are already setting in with a loss in the length of growing days of 20%. Growth rates of major staples like maize, guinea corn, millet and rice are suppressed by a rise in temperature. In addition, infestation by pests and diseases is affected by variability in climate, thus hampering food storage. Further, Onyia et al. (2015) identified the link between change in climate and conflict in the country. According to the report, the migration of herdsmen and their animals to the southern part of the country in search for water and greener pastures has resulted in conflicts. Rural-urban migration has been said to be the main cause of conflict in northern Nigeria. These are the new realities induced by climate change. Drought, desertification and deforestation are recurrent and now occur at alarming rates in northern Nigeria as a result of water scarcity and pasture inadequacy. This situation has made cattle herders begin their annual migration to the south earlier and forces them to stay in the southern fields for longer periods in the hope that the fields in the north would have had enough time to be fully regenerated.

4 Technological, socio-economic and policy actions for sustainable land management and climate change adaption and mitigation

4.1 Technological aspects of sustainable land management, climate change and mitigation

Nigeria has a low level of agro-technological advancement in land management and climate change response, including irrigation systems for adapting to climate change and enhancing climate smart agriculture since only 1% of irrigated arable lands are under irrigation (Olayide et al. 2016a). The National Adaptation Strategy and Plan of Action policy underscores climate-specific and climate-sensitive variables (Olayide et al., 2016b). The strategies promoted for climate change adaption and mitigation in Nigeria include the expansion of irrigated area, flood plain agriculture (Fadama), water harvesting, crop diversification, adoption of drought tolerant crop and planting materials, organic farming, agro-forestry, afforestation and reforestation as well as development of water catchments, rangeland and cattle ranges (Ruga settlements). The impact of climate change is also considered in technologies' electrical infrastructure. For instance, solar-powered irrigation systems are advocated for as a form of renewable energy mix. Although agricultural and energy policies are often not in tandem with environmental policy in terms of how specific numbers and projections are made (FMARD, 2015; FMP, 2015, 2020), it is noteworthy that renewable sources of energy are specified as a source of energy for promoting climate-smart agriculture in Nigeria (Olayide et al., 2016b).

4.2 Socioeconomic aspects of sustainable land management and livelihoods

Various sustainable land management (SLM) and livelihood strategies are practiced at the farm and community levels in Nigeria. Farmers diversify into various production systems, including cereal-legume systems, crop-livestock systems, agroforestry, planting of indigenous climate-resilient crops, seasonal migration from drought-affected or flood-affected areas and off-farm activities (Adeoti et al., 2010; Olayide et al., 2009; Olayide et al., 2019; Sanz et al., 2017). These sustainable land management and livelihood strategies reduce uncertainties and risk associated with agricultural livelihood activities in the face of climate change (Pender et al., 2009). The strategies also reveal underlying social and economic responses to climate change impacts in Nigeria. The sustainable livelihoods framework adapted for this study incorporates social and financial capitals for enhancing livelihood outcomes, including more sustainable management of the natural (land) resource base, as well as social justice and principles of equity, especially among people who are economically and environmentally vulnerable (Odunze, 2019).

4.3 Policy actions for sustainable land management, climate change and mitigation

Climate smart agriculture is gaining momentum as a strategy for handling climate impacts while at the same time promoting climate change mitigation, climate change adaptation, climate resilience, and increasing productivity of livelihoods (Olayide et al., 2016a). Specifically, climate smart agriculture enhances and equips farmers and others with agricultural livelihoods with the strategies, trainings and

tools necessary for enhancing food systems. A general summary of the Nigerian government's National Adaption Strategy and Plan of Action on Climate Change (NASPA-CCN) envisions integrating climate adaptation with sustainable development while also seeking to reduce vulnerability and enhance resilience and capacity of all economic sectors and people, especially women, children, the resource-poor and people with disabilities. It also seeks to reduce or minimize risks by improving adaptive capacities to deal with land degradation, drought, flooding and erosion (Olayide et al., 2016a).

Land degradation and drought are strongly correlated (Reichhuber et al., 2019), and sustainable land management has been proven to be a holistic approach for achieving land restoration and regeneration (Sanz et al., 2017; Pender et al., 2009). Nigeria's strategies for promoting sustainable land management are focused on combating desertification, land degradation, drought and erosion while promoting climate change mitigation, climate change adaptation and renewable energy (see Table 4). The proportional allocation of the investment needs of the strategies and technological responses/practices reveal that the use of agroforestry practices and animal waste management to improve cropland productivity has the highest financial need. The investment outlay reveals that the use of agroforestry practices to improve cropland productivity receives the largest share. The use of agroforestry practices and animal waste management are consistent with sustainable land management and resource conservation with high potential for bio-gas generation for electricity, livelihood activities, green enterprises, and climate change mitigation. Similarly, the investment plans include the introduction of financially viable alternative options for the prevention of bush/forest encroachment. The strategies have the potential to enhance carbon trading, secure land tenure and land rights and empower women in forest-based and non-forest-based product utilisation.

Tab 4: Strategies and investment plan for reversing land degradation in Nigeria (to be achieved by 2030)

Strategies and technological responses/practices[a]	**Area (Ha)**	**Investments required (USD)[b]**	***Share (%) of total investment required**
Reforestation with local species, expanding irrigation, rainwater harvesting, conservation agriculture, agroforestry	528,000	47,520,000	0.02
Community-based forest management, livelihood diversification	3,776,000	339,840,000	0.18
Avoiding further decline of forest through economic incentives (rehabilitation), conservation agriculture, agroforestry	214,654,000	19,318,860,000	9.96
SLM practices to avoid overgrazing, SLM practices to avoid soil erosion, rotational grazing, addressing invasive bush encroachment, afforestation and enforcing compensation	188,240,000	16,941,600,000	8.73
Use of agroforestry practices to improve cropland productivity, animal waste management	1,228,770,000	110,589,300,000	56.99
Introduce financially viable alternative options for the prevention of bush encroachment	5,202,640	46,823,760,000	24.13
Total		194,060,880,000	100

Note: *Computed. a Sustainable land management practices based on Sanz et al., 2017; b Cost estimations: Reforestation to USD 9,000/ha or USD 900,000/sq km, 1 sq km = 100 ha). Based on Summers et al. (2015). (LDNST, 2018)

5 Evaluation of existing major policies and investments

There are various policies and strategic plans that are related to land degradation, climate change, energy, livelihoods, and sustainable development in Nigeria. However, of the specific policies that directly focus on land degradation, climate change, energy, livelihoods, and sustainable development, the National Economic Recovery Growth Plan (NERGP) and the National Policy on Environment are overarching. The National Economic Recovery Growth Plan (2017-2020) specifies the path for economic growth and recovery after the 2016 recession while the National Policy on Environment covers most areas of the environment, including agriculture, energy, natural resources, and climate change. For empirical review purposes, the National Renewable Energy and Energy Efficiency Policy; Policies on Drought, Desertification, Erosion, Climate Change and Biodiversity; Agriculture Transformation Agenda; and Agriculture Promotion Policy are presented in this report. The identified policies and programmes have direct implications on the themes of land degradation, climate change, energy, livelihoods, and sustainable development.

5.1 National renewable energy and energy efficiency policy

The National Renewable Energy and Energy Efficiency Policy (NREEEP) is consistent with the adoption and ratification of the United Nations Sustainable Development Goals (SDGs), especially the goals on affordable and clean energy (SDG 7) and climate action (SDG 13). Similarly, the NREEP envisions that 30% of the electricity mix will be renewable energy by 2030. This vision statement on renewable energy mix is popularly referred to as EV: 30:2030. The investment plan for the energy mix agenda is coordinated by the Nigerian Energy Regulatory Commission (NERC) and uses appropriate methodology agreed upon by the project stakeholders (developers and consumers) to compute feed-in tariffs that reflect the cost and benefit of energy provision and investment. Nigeria has also witnessed improvement in the ease of doing business index and corruption perception index (USAID, 2019) which have influenced the level of confidence that investors have in the Nigerian business environment. Similarly, the potential for expansion of energy reach in the country has also spurred more investment in the electricity section (off-grid and on-grid).

5.2 Policies on drought, desertification, erosion, climate change and biodiversity

The policies include the National Drought and Desertification Policy, National Policy on Drought Preparedness, National Policy on Climate Change, National Adaptation Strategy and Action Plan, National Erosion and Flood Control Policy, National Forestry Policy and the National Biodiversity Strategy and Action Plan. The Federal Ministry of Environment and the relevant ministries, departments and agencies are charged with the responsibility of implementing these policies with specific programmes and projects including the Land Degradation Neutrality Target Setting (LDNTS), Reducing Emission from Deforestation and Forest Degradation (REDD+), and the Great Green Wall Programme (GGWP).

The land degradation neutrality target setting programme (LDNTS, 2018) is benchmarked with the sustainable development goals (SDGs) with a baseline of 2015. The specific targets of land degradation neutrality are to improve land productivity, rehabilitate land with low productivity, retard further degradation and reduce soil sealing. The operational frameworks are implemented at national,

regional and continental levels. The programme activities are in form of afforestation, reforestation and soil reclamation. There are various engagements in the schemes like the Africa Forest Landscape Restoration Initiative, Reducing Emissions from Deforestation and forest Degradation (REDD+), and the green belt Sahelian projects. Similarly, the Great Green Wall Programme (GGWP) promotes alternative livelihoods through the establishment of 1,280 ha of community vegetable gardens and procurement and distribution of over 100,000 improved woodstoves, solar cookers, and solar lanterns as well as a pilot project on bio-gas production (UNCCD, 2016). The domestic funding sources are national budgets, ecological funds and other sources. The international and regional funding sources include the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), African Union Commission and the Economic Community of West African States (ECOWAS).

5.3 Agriculture Transformation Agenda and Agriculture Promotion Policy

The Agriculture Transformation Agenda was implemented from 2011-2014 (FMARD, 2015). The policy succeeded in creating a database of reported farmers even though it is grossly inadequate for identifying genuine farmers and their locations. Similarly, the creation of special funds to support farmers did not lead to improvement in the backlog of unpaid Growth Enhancement Scheme funds. The increase in rice paddy production from 2.0 to 2.5 million tons has not bridged the demand gap as the import of rice has increased and exceeded USD 1 billion/annum. Market access is critical for food security. The re-establishment of some commodity marketing boards might have created illegal food imports which undermined the efforts of farmers and deprived them of market opportunities

On the other hand, the current agricultural policy is termed the Agriculture Promotion Policy (FMARD, 2015). The policy document has three thematic areas: (i) productivity enhancements; (ii) crowding in private sector investment; and (iii) Ministry of Agriculture and Rural Development institutional realignment. The sub-themes of productivity enhancements include measures for accessing land for agricultural enterprises; soil amendment and fertility; accessing information and knowledge; accessing inputs; production systems management; storage facilities; processing facilities; and marketing and trade facilities and infrastructure. The sub-themes on crowding in private sector investment are access to finance and agribusiness investment development. Table 5 highlights the constraints and expected policy impact of agriculture promotion. It can be deduced that the policy, which is expected to be revised by 2020, is currently under-performing in the areas of facilitating access to agricultural land and finance, improvement of soil fertility and irrigation for agricultural productivity, and empowerment of women and youth.

Tab 5: Summary of Constraints and Expected Policy Impact of Agriculture Promotion Policy (2016 – 2020)

Theme	Item	Constraints	Expected policy response	Remarks
Productivity enhancements	Access to land and land management	Unconducive land use rights for agricultural activities, including access to loans due to request for collateral assets	Incentivize land use rights to raise investment and productivity	Situation is changing. There is improvement in land rights and agri-preneurship
	Soil fertility	Soil fertility and desertification	Erosion control and tree planting	Situation is expected to change. Plan underway to plant 25 million trees
	Irrigation	Inadequate investment in equipment and facilities	Promote water conservation by harvesting	Changing. Plan underway to plant 25 million trees
Crowding in private sector investment	Access to finance	Inadequate access to credit and insurance	Increase public sector funding of agriculture to 10% of the national budget	Situation is not changed. Current allocation is still less than 3%
Ministry of Agriculture and Rural Development institutional realignment	Youth and women	Inadequate entrepreneurship capacity of women and youth	Increase and build entrepreneurship capacity for women and youth	Situation is changing. More women and youth are engaging in agri-preneurship
	Climate smart agriculture	Mismanagement of agricultural land, water and genetic resources	Use of appropriate technologies in the management of agricultural land, water and genetic resources	Situation is changing. Climate smart agriculture is increasingly being promoted.

(Agricultural Promotion Policy according to FMARD, 2015)

6 Conclusion and policy implications

This report contains a systematic review of literature on the nexus of climate change, land use, energy, livelihoods and sustainable development in Nigeria. The review process follows the sustainable livelihoods framework and specifically provides information on: 1) situation and trends in energy and land use change, 2) observed and projected impacts of climate change, 3) technological, socioeconomic and policy actions for sustainable land management and climate change adaptation and mitigation, 4) evaluation of existing major policies and investments, and 5) conclusion and policy implications.

Based on the assessment of literature in this study, the key trends and problems include inadequate attention to the agricultural sector over the years, which has caused a major setback in food security and productivity. Climate change has further worsened the problem through desertification, drought and flooding across the country. There is inadequate energy supply, distribution and low per capita consumption in Nigeria. The use of fuel wood for heating and cooking has significantly contributed to deforestation and has worsened land degradation. The implications of these factors are that food security is threatened and economic growth is hampered. Land degradation negatively impacts the environment and the rural poor whose livelihoods depend on it. Adequate attention should be paid to the agricultural sector through sustainable land management. Additionally, opportunities in the renewable energy sector should be further harnessed and forests and land use policies should be enforced to ensure sustainable livelihoods. Policies and investment plans on land use, energy/electricity and agricultural livelihoods in Nigeria are not coherent and lack consistency in implementation. Therefore, there is a need for productive, viable and sustainable policies and programmes that support climate change mitigation, land use, energy and sustainable development in Nigeria. Another important suggestion is the need for the provision of a renewable energy mix (off-grid) in forms that are easily accessible and affordable by households. Adequate attention should be paid to the provision of bio-energy in the wider bio-economy and the sustainable livelihoods framework, including the transformation of solid waste, wood waste and agricultural waste into bio-gas and energy.

Overall, the investment landscape in Nigeria is improving, and various opportunities for investment in agricultural livelihoods, renewable energies, carbon trading and green bonds should be harnessed through public-private partnerships for overall sustainable development in Nigeria. There are favourable policies and incentives, especially in the agricultural and renewable energy sectors in Nigeria. Investment opportunities in agriculture and energy/electricity offers concessionary interest rates and tax holidays, including through build, operate and transfer business models. The country's potential for renewables and a sustainable energy mix should be vigorously harnessed for the multiple benefits of energy security, sustainable land use management, livelihood generation and overall sustainable development of the country. The country should also ensure policy consistency, legal frameworks and adequate financing of projects and programmes.

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