



## Climate Change and Sustainable Green Growth in Nigeria: Challenges and Opportunities

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### ABSTRACT

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*There is an increasing awareness that climate change is a threat to agricultural and socioeconomic development, but agricultural production activities are generally more vulnerable to risks of climate change than other sectors. However, what have not been emphasized are the opportunities that are emerging with climate change. This review was therefore undertaken to x-ray the magnitude and trend of these threats and opportunities presented for investment and livelihood development for a green growth in Nigeria and Africa. It also analyzed the challenges compounding the impact of climate change on agriculture in Nigeria. It was observed that there are ample challenges than opportunities associated with climate change in Nigeria, however, the opportunities presented, if well harnessed could fast track the green growth tempo in Nigeria while boosting job opportunities and inflow of both foreign and local investment. Therefore, it was recommended that financial institutions in Nigeria should begin to set up initiatives for leveraging into the climate finance and carbon trading; government should forge public-private partnerships that will promote green investments and create more jobs for the youths and more profits for the farmers.*

## Introduction

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (United Nations Framework Convention on Climate Change, UNFCCC). On the other hand, the Intergovernmental Panel on Climate Change, IPCC (IPCC 2001a; 2001b) defined it as a “change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural variability observed over comparable time periods”. According to the World Bank (2016) the Paris climate conference warned that climate change, if left unchecked would be a “fundamental threat to economic development in our lifetime and ... could push 100 million people into poverty by 2030.” This will undermine all progress the world had made in fighting poverty for 15 years

gone by, the report added. Though climate change is a threat to agricultural and socioeconomic development, agricultural production activities are generally more vulnerable to risks of climate change than other sectors (IPCC 1996, Derresa et.al. 2005 and Morton, 2007).

Kofi Annan expressed optimism that Africa, which is hardest hit by climate change and food insecurity, can be part of a global solution to combat climate change. The role of small holder farmers in attaining these was stressed by him (Global Conference on Agriculture, Food Security and Climate Change, 2010). Climate exerts a profound influence on the lives of rural populations, particularly the rural poor, who depend on agriculture for livelihood and sustenance, who are unprotected against climate-



related diseases, who lack secure access to water and food, and who are vulnerable to hydro-meteorological hazard. The dangers of climate change highlighted above pose threat to attainment of the Sustainable Development Goals 1 and 2 (aimed at eliminating poverty and reducing hunger to zero level by 2030 respectively). Climate shocks such as drought and flooding lead not only to loss of life, but also long-term loss of livelihood through loss of productive assets, impaired health and destroyed infrastructure. The uncertainty associated with climate variability is a disincentive to investment and adoption of agricultural technologies and market opportunities, prompting the risk-averse farmer to favor precautionary strategies that buffer against climatic extremes over activities that are more profitable on average (Barrett et al., 2007). The adverse consequences of climate change (which includes damage on arable lands, water and biodiversity resources) will take an irreplaceable toll on food production and food security especially in developing countries which have a low capacity to cope and adapt to these challenges.

According to FAO (2018) "even though agriculture still remains the largest sector of the Nigerian economy and employs two-thirds of the entire labour force, the production hurdles have significantly stifled the performance of the sector." FAO estimated that the country had lost USD 10 billion in annual export opportunity from groundnut, palm oil, cocoa and cotton alone due to continuous decline in the production of those commodities. These yield decline may have some links with the vulnerability of Nigerian agriculture sector to climate change. The vulnerability of Nigerian agricultural sector to climate change is of particular interest to policy makers because agriculture is a key sector in the economy accounting for between 60 -70% of the labour force and contributing between 30-40% of the nations GDP (Ajetomobi, Abiodun; and Hassan, 2010). The sector is also the source of raw materials used in several processing industries as well as a source of foreign exchange earnings for the country.

Though there is evidence of increase in food crop production generally in Nigeria, the nation is not self sufficient in production of any food crop except cassava, noted Ajetomobi, Abiodun and Hassan (2010). They further stressed that the production of major export crops in the country such as groundnut, rubber, coffee, cocoa and palm produce in the country declined in magnitude since the drought of 1972/73 which is the first real evidence of climate change in Nigeria.

In Nigeria reports have shown that between 1901-1935 and 1936-1970 climatic periods, temperatures were below the 1970-2005 normal, but 22 years (63%) out of the 35 years studied were above the normal between 1971 and 2005 (NEST, 2003 and Ojuogo, 2010). The temperature anomalies showed the facts that global warming is unequivocal and climate change signal is stronger as from the 1970s. Within the 105 years, temperatures increased by 1.2°C in the coastal cities of the Niger Delta and 2°C in the northern extreme of Nigeria, the reports stressed. A mean air temperature increase of 1.7°C was observed in Nigeria for the past 105 years (since 2010). The available evidence shows that Nigeria, like most parts of the world, is experiencing the basic features of climate change (Seo and Mendelsohn, 2008; Mall et al 2006; and Cline, 2007). The challenge of climate change and global warming is enormous in Nigeria owing to widespread poverty, prevailing slash and burn agriculture, erosion and burning of firewood and farm residues from the livestock sector (Ajetomobi, Abiodun and Hassan, 2010). Most climate change studies have focused on risks and adaptation to climate change by farmers in the agricultural sectors (Onyeneke and Madukwe, 2010, Deressa et al. 2008, Umoh and Eketekpe, 2010, Nwajiuba, Onyeneke and Munonye, 2008; Ajetomobi, Abiodun and Hassan, 2010; Onyeneke and Madukwe, 2010; Amos and Adeleke, 2010). These and other climate change related studies in Nigeria, to the best knowledge of these researcher made attempts to expose the inherent opportunities found in climate change. As a result a huge void in research is left to be filled prompting the need of a study that will, in



addition to discussing the challenges of climate change, expose the opportunities presented by climate change for growing a greener economy in Nigeria. This review aims at closing this research gap and also bringing new insights into the adaptive responses of crop farmers in Nigeria and other climate change investors globally are doing to tap from the opportunities inherent in climate change toll. Specifically the study was conducted to: analyze the challenges posed by climate change on Nigerian food security drive and social wellbeing; identify the major factors compounding the effects of climate change on Nigerian agriculture and review the opportunities posed by climate change in Nigeria and for Africa.

## **2.1 Climate Change Challenges Facing Nigerian Agriculture and Food Security**

A study by CitiGroup as cited in World Bank (2016) found that rampant warming could shave up to \$72 trillion off the world's gross domestic product, while another report could reduce average global incomes by nearly a quarter. A four-degree Celsius rise would also adversely affect sectors like agriculture, real estate, timber, and emerging market equities. In all, that would create a disincentive and hostile environment for both large and small businesses in agriculture sector more so as even the investors will also be affected. Harvard Business Review as cited in World Bank (2016) observed that "Climate change threatens (our) supply chain, our customers' businesses, and the communities we're part of. If we want to stay in business for the long term, contributing to the fight against climate change is just smart strategy."

Nigerian agriculture had registered some sensitivity to climate change in agriculture over time now. According to National Bureau of Statistics, NBS (2010), during the second quarter (April—June) of 2010, like other years, the major agricultural activities were planting activities in the Northern part of the country and harvesting of matured crops in the southern part of the country. Crop production which dominated agricultural activities in country is largely driven by the rainfall level across the

country. With the practice of rain-fed agriculture by farmers in Nigeria, the pattern in rainfall is expected to affect crop production in the country. In terms of agricultural output, the real agricultural GDP growth in the second quarter of 2010 stood at 5.84 percent as against 5.94 percent in the corresponding period of 2009. The drop in growth recorded by the sector in the second quarter of 2010 relative to the corresponding period in 2009 may be attributable to the slight delay of rainfall due probably to the effect of climate change (National Bureau of Statistics, 2010).

Eboh et al (2006) showed that economic cost of degradation and poor management of renewable natural resources was at least 6.4% of GDP in Nigeria. They found that the annual cost of yield decline as a result of environmental degradation from 1995 - 2004 to Nigeria was estimated at N 210 billion. More than 60 percent of this cost was attributed to roots and tubers. The annual cost of yield decline from peak year to 2004 was estimated at N 500 billion. Almost 50 percent of this cost was from cereals and 40 percent was from roots and tubers. These losses were highly significant, they noted.

Moreover, yields of major crops peaked in the 1980s (cereals) and early 1990s (pulses, roots and tubers) and have since then declined (Eboh et al 2006). Crop yields vary widely across states. The variations are a product of interplay of several factors including agro-ecological, socio-economic, institutional and farm-level management conditions. Appreciating these variations is important for agricultural planning and policy. Even differences in regional averages were pronounced. Yield index was computed for these major crops including cassava, maize, rice, millet and sorghum based on grain equivalent ratios. While the index is similar in the North-Central, South-West and South-South, regional average yield index in the South-East is almost twice as high as in North-West and North-East (Eboh et al, 2006). Eboh et al also noted that Rainfall and literacy both have significant positive effects on yield. The positive effects of rainfall underscore the critical importance of water for



increased crop productivity, hence the need to improve water management and irrigated cultivation in parts of the country, especially in water-short or drier areas. The dummy for the northern region was statistically insignificant. This implies that the lower yield in the north was largely associated with lower rainfall and the lower literacy rates generally observed in the north. Water is critical to crop yields in rain-fed agriculture. The northern parts of Nigeria receive substantially less rain than the south. Rainfall is particularly low in the North-West, which receives only a third of the annual average in the South-East and South-South, they noted. The above scenario threatens sustainable agricultural production. Sustainable agricultural production aims at maintaining productivity and incomes while ensuring benefits to the society without depleting the natural resource base (Ifejika, 2010). Sustainability implies sustaining farm production across time against many odds, including climate change. The threat is amplified by Fischer et al. (2002) who noted that of the total additional people at risk of hunger due to climate change, although already a large proportion, Africa may well account for the majority by the 2080s. Many areas including Nigeria in Africa are recognized as having climates that are among the most variable in the world on seasonal and decadal time scales.

A regional study acknowledged that food crop farmers in South Western Nigeria provide the bulk of arable crops that are consumed locally as well as major food crop supplies to other regions in the country (Apata, Samuel and Adeola, 2009). The local farmers in this region were reportedly experiencing climate change even though they have not considered its deeper implications. This is evidenced in the late arrival of rain, the drying-up of stream and small rivers that usually flows year-round, the seasonal shifting of the “Mango rains” and of the fruiting period in the Southern part of Oyo State (Ogbomoso), and the gradual disappearance of flood-recession cropping in riverine areas of Ondo state are among the effects of climate disturbances in some communities of South-

Western Nigeria (Building Nigeria’s Response to Climate Change, BNRCC, 2008).

Much of the Niger-delta wetlands areas of Nigeria are now endangered due to climate variability, as witnessed by the significant reduction of their size in recent years. The maximum flooded area of the inner Niger Delta, which is the second largest wetland area in Africa, has dropped from approximately 37,000 km<sup>2</sup> in the early 1950s to 15,000 km<sup>2</sup> in 1990, coupled with the environmental degradation of crude-oil exploration has done to Niger-delta wetlands areas (Building Nigerian Resilience to Climate Change, BNRCC, 2008).

Evidence in literature indicated that the intrusion of salt water in the water table of coastal zones of Ayetoro Community in Ilaje LG of Ondo State, Nigeria, and thus, led to increased salinity in soils. Already, the encroaching water is making life very hard. It is “extremely difficult now for food crops to grow on the island”. Salt water sweeps through the land, making it impossible for food to grow (Apata, 2006). Residents lamented that “although they have always lived in harmony with the sea, they are now frightened and scared of living on these atolls”. The atolls are sinking and despite not knowing the sciences people can see with their naked eyes the impact of the rising sea levels (BNRCC, 2008). The community now has the feeling that the waves will just come one day and swept them over; the community is now feeling restiveness. This area and the people are victims of climate change and rising sea levels, noted Apata et al (2009). Besides, there are frequent cases of floods as witnessed in Benue, Kogi, and other Niger Delta areas from 2012 to 2018. These may not be unconnected with global impact of climate change.

## **2.2 Challenges Compounding the Impact of Climate Change on Agriculture in Nigeria**

Nigeria, just like many other African countries face strong challenges that tend to compound the problem of climate change in the country. In fact many factors contribute and compound the impacts of current climate variability in Africa and will have





negative effects on the continent's ability to cope with climate change. These, according to UNDP (2006) include poverty, illiteracy and lack of skills, weak institutions, limited infrastructure, lack of technology and information, low levels of primary education and health care, poor access to resources, low management capabilities and armed conflicts. The overexploitation of land resources including forests, increases in population, desertification and land degradation pose additional threats. In the Sahara and Sahel, dust and sand storms have negative impacts on agriculture, infrastructure and health.

It was observed that education level of the country compounds the impact of climate change. It would be therefore timely to improve education of Nigerians who make up about 65 percent of Nigerian population. Data from National Bureau of Statistics (2009) indicated that the total number of primary schools in 2008 was 54,434, the point it was since 2006. Pupils enrolment dropped by 1.56 percent in 2008 from the 2007 figure. This situation could be responsible for a drop of 21.74 percent in teacher/pupil ratio within the same period which amounted to a healthier development. Total number of classrooms also remained the same (319,590) in 2008 as it was 2 years back (2006). The percentage of adult literacy was 66.0 compared to 80.0 for the youth in 2008.

The indices on unemployment too from the National Bureau of Statistics (2009) were not quite comforting. The National unemployment rate in 2005 was 11.90. Nassarawa State had the highest rate with 12.8 for 15 years and above of their populations who were eligible and ready for employment this was followed by Rivers State with 10.2 as shown in table 5.1. Zamfara State however recorded the lowest rate with 0.3. It was evident that males were more in unemployment record than their female counterparts. The same thing was also the case in underemployment situation. Sokoto State had

the largest underemployed of their population with 38.6, followed by Edo State with 30.9.

Energy is one of the main sources of social and economic development in the country. Every other sector depend on it for growth. The growth from the other sectors depends on the amount and quality of energy generated and distributed. Energy generate in 2007 and 2008 amounted to 22,978,128.66 MWH and 20,980,778.96 respectively nationwide. 2008 shows a drop of 1,997,349.7 over 2007 energy generated. In 2008 the energy distributed decreased by 4.49 per cent as against the distribution of 2007 nationwide. Households using wood had the highest with 74.1 and 79.6 per cent respectively. Households using kerosene decreased from 22.9 per cent in 2007 to 18.5 per cent in 2008. This may be attributed to high cost of kerosene in the market. In both years, households using electricity and gas recorded the least with 0.7 per cent each in 2007, 0.2 per cent for electricity and 0.6 per cent for gas in 2008. Lagos State recorded the highest usage of kerosene in years, 89.7 per cent in 2007 and 91.1 per cent in 2008, while Bauchi and Jigawa recorded the least with 1.6 per cent each.

It is a well known fact that expanding fossil fuel use to meet Africa's survival and developmental needs will lead to an increase in air pollution and greenhouses gas emissions; and even though energy supply forms the bed rock of economic development over the years, more than 40.0 per cent of the households were without electricity in the country, 41.4 per cent in 2007 and 48.0 per cent in 2008. This situation could be responsible for the huge dependence of Nigerian households on fuelwood with attendant problem of deforestation in the country. In 2007, about 47.3 per cent of the households used electricity from Power Holding Company of Nigeria (PHCN), and this figure decreased to 40.4 per cent in 2008. It was observed that Taraba State recorded the highest percentage of households without electricity in 2008, about 88.8



per cent, while Lagos with 0.3 per cent recorded the least conversely; Ogun State recorded the highest percentage of households using PHCN with 69.8 per cent, while Taraba State had the least with 2.8 per cent (National Bureau of Statistics, 2009).

The reports of the National Bureau of Statistics (2009) further showed that in terms of health, the figures were not encouraging too. HIV/AIDS prevalence rate in Nigeria increased from 4.6% to 4.8% while between 2003 to 2005 it rose from 4.8% to 11.4%. However, between 2005 and 2008 the prevalence rate decreased from 11.4% to 4.6%. Malaria was the highest among the selected diseases with 2,755,733 and was followed by Diarrhoea which was recorded 188,868 in 2008. According to the World Bank (2018) without urgent action, climate impacts could push an additional 100 million people into poverty by 2030. By 2050, it could imply that "as many as 143 million people across three developing regions will become climate migrants, with individuals, families and even whole communities forced to seek more viable and less vulnerable places to live." Air pollution was also reported as being responsible for more than 7 million premature deaths each year. Direct costs to health could be as high as \$4 billion per year by 2030, observed the World Bank. With regards to agriculture, the World Bank (2018) noted that climate change will not only make it more difficult to feed the projected 10 billion people by 2050 but its impact was already being felt "in the form of reduced yields and more frequent extreme weather events that affect crops and livestock.

### **2.3 Opportunities in Climate Change for Green Economic Growth**

Even though climate change portends a lot of challenges for food security and rural livelihoods, there are some opportunities that can be harnessed from effects of climate change too. Ifejika (2010) noted that climate change also holds some opportunities, for example, areas that were hitherto not conducive to agriculture, like higher altitudes, become so due to increases in temperature. At the

21st Session of the Conference of the Parties to United Nations Framework Convention on Climate Change (COP21) in Paris the World Bank (2016) noted that the developing countries would require an estimated \$100 billion of new investments per year over the next 40 years to build resilience to the effects of climate change. Mitigation costs were projected to be in the range of \$140–\$175 billion per year by 2030. This huge burden cannot be carried out by national governments, many of which are already struggling to make ends meet: they will need the buy-in and participation of the private sector. If global temperatures jump four degrees by 2100 – the path we are on now – droughts, flooding and ferocious storms are imminent, sowing financial chaos and upending small shops and international conglomerates alike (World Bank, 2016).

Globally investment opportunities are springing up rapidly in the renewable or clean energy sector. The World Bank reported that countries from Honduras to India have already established ambitious targets for wind, solar, and hydro-power generation and they'll need private sector investment to get there. The clean energy investments is going to spread across all nations of the world including Nigeria. If Nigeria thinks, being among the largest producers of crude oil is a threat, they should take note that even Saudi Arabia, home to one of the world's biggest oil reserves in the world, is looking to generate the bulk of its electricity from renewables and nuclear power by 2040.

In Nigeria for instance increasing climate change's effect leads to consideration of alternative energy sources such as gas and solar energy development as alternatives to fuel wood and its attendant problem of deforestation in Nigerian agro-ecosystems. Nigeria is richly blessed with abundant sunshine hours and gas reserve which are not being properly harnessed. Rather gas is being flared when Nigeria, according to the Minister of Petroleum Resources, Mrs Dezia Allison-Madueke in 2014 noted that Nigeria had the potential of becoming the sixth largest producer of cooking energy gas in the world. Nigeria can take advantage of this opportunity by developing its gas producing capacity for domestic



use and exports. This will also help in development of electricity generation which has almost become dysfunctional in Nigeria.

There are huge opportunities to be tapped from investing in Climate Smart Agriculture (CSA) under a changing climate in Nigeria. The Savannah belts of Nigeria is grappling with desert encroachment yet the land there is the base for cultivation of most of the arable crops that serve as staples for Nigerian huge population of over 193 million. For instance, irrigation, water catchment systems or drought resistant seeds investments can provide solutions as do rainwater harvesting or conservation agriculture for improved soil moisture storage capacities present feasible option for adapting to climate change risks. In fact as noted by African Agriculture and Trade Investment Funds (AATIF, 2016), in Africa, and indeed in Nigeria, agricultural sector can make a significant contribution to the mitigation of climate change. The sector is attributed to 14 % of global greenhouse gas (GHG) emissions, including land use changes – most importantly deforestation – the number rises to 25 % and even higher if the entire food system is factored in (food processing, storage and distribution). They also noted that Africa's agricultural sector is the third largest contributor to GHG emissions from agriculture globally and has seen the highest average annual growth rate globally between 1990 – 2014. Hence further growth is expected going forward, driven by shifts in diet and a fast growing population. Nigerian youths and investors can increase their opportunities by investing in subsectors that provide supportive services which are geared towards adaptation of farmers to climate change and mitigation. These could be through investments in irrigation facilities, design and marketing of equipments and machines for mechanization of agriculture, development of apps for building resilience in agricultural productivity, supporting farmers with climate information, production and marketing of high yielding and drought resistant seeds as well as stocks in the livestock sector. The livestock sector, according to IAATF (2016) account for a significant share of human-induced GHG emissions and

represent half of all emissions from agriculture and land use change. Investing in methods to limit emissions such as rotational grazing, innovative feeding and manure management present yet more opportunities for investment in the agriculture sector. Development of ranches where cattle owners can rent is another opportunity in a changing climate. Rotational grazing, a system that allows vegetation to regenerate after grazing, protects the soil from erosion and helps maintain its organic matter and carbon. Development of this technology in Northern Nigeria can also help reduce the menace of nomadic cattle herdsmen and farmers clashes in Nigeria as they move around running away from drought in the north to the southern Nigeria. Development of innovative feed mixes with increased starch content can make digestion easier and reduce methane emissions from the livestock sector too. Composting solid manure and using it as organic fertiliser can reduce emissions and simultaneously improve soil fertility. Hence investment in fertilizer plants, both organic and inorganic is another opportunity that can help provide income, job and Foreign Direct Investment in Nigeria.

Carbon trading is another untapped opportunity in climate change regime. The World Bank (2016) noted that as at September 2014, over 1,000 companies united to speak out in support of carbon pricing, joining the Carbon Pricing Leadership Coalition, which was formed from a groundswell of support for carbon pricing at the UN Climate Summit. The coalition was formally launched at the 21st Session of the Conference of the Parties to United Nations Framework Convention on Climate Change (COP21) in Paris, with the goal to expand the use of effective carbon pricing policies that can maintain competitiveness, create jobs, encourage innovation, and deliver meaningful emissions.

At the COP21 in Paris, the private sector, with its financial clout and penchant for innovation, was expected to play a leading role in the struggle for a greener future (World Bank, 2016). These are enormous opportunities for investment. Climate change financing is an area that is attracting lenders



and other players in finance industry. These run the arrays which includes green bonds issued by governments and international institutions to micro-loans for entrepreneurs. This is a huge opportunity given the fact that the potential the industry has is yet to be determined. The World Bank predicted that borrowers will need to invest at least \$700 billion annually in infrastructure, clean energy, resource efficiency, and green construction between now and 2030, according to estimates. One lender that had taken advantage of this opportunity in Africa is gravitated Sasfin Bank in South Africa.

This bank has created a credit line to expand lending in projects that will help small businesses in South Africa become more energy efficient and sustainable. (World Bank, 2016).

In the past many companies globally muted the idea of going green but were scared of it due to possible cost of going green. However, according to World Bank (2016) with the dramatic drop in prices of eco-friendly technologies, a lot of opportunities are now springing up. Many companies are now rushing into climate-smart investments, not only because it's the moral thing to do, but because it's profitable. In a study of 1,700 leading international firms they found that the money they put into reducing greenhouse gas emissions saw an internal rate of return (IRR) of 27 percent – an indication that those investments were paying off. Findings from Harvard University as noted in that report also indicated that firms with interest for environmental and social sustainability outperformed firms that treated those issues less seriously.

Examples from other countries can also provide earning points. According to the World Bank (2016), in Panama companies were building what will be Central America's biggest wind farm. The 215-megawatt Penonome plant is expected to prevent the release of 400,000 tonnes of carbon dioxide emissions per year, the same as taking 84,000 cars off the road. Meanwhile, the private sector is playing a key role in the construction of a

massive 510-megawatt solar plant in the Moroccan desert that will provide power to 1.1 million people. The project, worth \$2.6 billion, could help turn the North African kingdom into a renewable energy powerhouse and serve as a model for future public-private partnerships. And in Nepal, Kabeli, the first project-financed hydropower plant in the country is expected to generate about 200 GWh of electricity, helping address the debilitating power shortages and lack of industrial progress there.

Besides renewable energy firms can also find opportunities in eco-friendly construction and in helping cities prepare for changes in climate. By 2050, more than 6 billion people will live in urban areas, creating a pressing need for a host of infrastructure services, like water and sanitation. As well, 400 million homes are expected to be built by 2020, a potential boon for construction companies that can incorporate green technology into their builds (World Bank, 2016).

### 3. Policy Implications

This study has reviewed the challenges as well as the moderating factors to those challenges after which opportunities inherent in climate change were also exposed. It was observed that there are many challenges as well as opportunities associated with climate change in Nigeria. but it was shown that there are many emerging areas that present opportunities for investment in climate change related interventions and products/services that can help in adaptation to climate change as well as climate change mitigation. Therefore, planning and financing adaptation as well as adapting to climate change is a needful exercise to grow Nigerian green economy. This will also require an understanding of current conditions – in social (including economic, political and cultural) and ecological as well as sector-related dimensions to be able to see where new investments and profits can be made. It requires an understanding of the adaptive capacities, resilience and livelihood strategies of the local population who are directly affected by the impacts





of climate change and who must cope with the realities of multiple pressures (e. g. climate variability and change, market and institutional failures, environmental degradation, poverty and diseases to mention just a few). It also requires an understanding of how the various levels of governance can enable or hinder local actors to improve their wellbeing. There are ample rooms for investments that will favour the private sector and public sector as well thus creating a win-win situation. Following Ifejika( 2010), it is the opinion of these researchers that knowing the what, how, when and where of climate change and the options for adaptation will allow for well-informed decision-making by farmers, policymakers and practitioners. Such spatio-temporal (where and when) dimensions and multi-actor perspectives promise relevant insights for achieving green growth in Nigerian economy, improving sustainability in adaptation and reducing poverty and vulnerability to climate change.

Based on the challenges and opportunities posed by climate change observed in this review, the following policy implications are hereby presented:

i. Poverty is one of the major factors accountable for the vulnerability and limited adaptive capacity of sub-Saharan Africa (World Bank 2007). It is also the poor who first bear the brunt of climate change impacts and at the same time have little or no capacity to withstand or adapt to climate change. Thus, climate change will worsen the situation for the poor. This constellation has implications for development cooperation – meaning that in the context of climate change, development cooperation must orient itself *inter alia* towards adaptation to climate change. Climate change adaptation strategies must be development oriented to achieve the SDGs 1 and 2 come 2030, and while emphasis must be placed on building resilience in agriculture despite the increasing growth of off-farm incomes and rural-urban migration (Powell , Pearson, and Hiernaux 2004).

ii. Nigerian Federal and State Governments need to coordinate adaptation strategies and

programmes using a multi-stakeholders approach thus coordinating between their organs, research institutes, the extension services, private sector actors, other government bodies, NGOs, civil society and not the least the farmers to promote adaptation practices.

iii. Governments should improve climate monitoring and early warning systems. Early warning systems still struggle with collecting data of adequate quantity and quality for monitoring climate and for early warning.

iv. Governments and climate policy, with support from development policy and cooperation need to guide the development pathway of Nigerian agriculture towards a low-carbon intensification path. This can be achieved through promoting smallholders' access to new and affordable farm technologies that are environmentally-friendly and which also allow them to practice integrated nutrient management. Research needs to develop and modify technologies to the smallholder contexts and needs. It also needs to examine and show how adopting a low carbon path can still maintain and increase agricultural production in Nigeria. Nigerian Government needs to increase the capacity of extension in organic and conservation agriculture: although organic and conservation agriculture are promising development paths for smallholder agriculture, this arena is dominated by private commercial farms, pesticide companies, private NGOs and foreign certification bodies in other parts of the world. In Nigeria, extension services for the sub-sectors are generally lacking. Thus, development cooperation and the research community need to first make deciding actors in governments aware of the potentials of these farming approaches to maintain agricultural production and their contributions to climate and environmental protection. With awareness raised, governments and development cooperation can direct resources to building up extension capacity in these spheres.

v. Governments (extension services), with the support of climate and development policy, should



establish programmes that promote farm resource use efficiency.

vi. Governments should promote agro-forestry by developing small-scale afforestation and reforestation whereby the district, local governments, state or national government (or even private entities) offer farmers incentives through a programme to promote agro-forestry.

vii. Banks and other financial institutions should begin to leverage into opportunities that abound in climate change adaptation financing by increasing lending to the agricultural and agribusiness sector in Nigeria. This is where most investments are going in the future.

viii. Public-private partnership with the aim of developing clean energy infrastructure and investment should be forged in Nigeria to promote inflow of foreign capital into the Nigeria green economy. In Nigeria, with increasing cost of kerosene, most households are shifting towards use of cleaner energy sources like gas. This creates opportunity for the country to stop flaring her gas and invest in gas plants for domestic and export markets. Such investments can also help mitigate climate change as it will reduce emissions from the fossil energy sector.

ix. Insurance companies should begin to design frameworks and modalities to tap into the growing clean energy and other investments aimed at promoting innovations in climate change financing.

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