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Abstract. Climate change is a global phenomenon with multifarious unique regional consequences. Contemporary studies have established Climate change as a product of anthropogenic activities. Studies have linked extreme weather events, heat waves, increase pollution, crop failure as some of the many discernable effects of climate change. Hence, the spatial temporal effects of Climate change are of concern to policy makers, researchers, innovators and the entire public to develop veritable mitigation strategies. This paper examines climate change in Nigeria as a case study; the research adopted desk research method to collect secondary data from literature about hazards caused by climate change and potential adaptation strategies in Nigeria. The findings revealed that a potential environmental hazard caused by climate change in Nigeria includes that of biological, chemical, physical, mechanical and psycho-social. Moreover, this review further showed adaptation technologies that can be used in adapting and mitigating climate change in Nigeria.

1. Introduction

Climate change is the most important global phenomenon of our time with discernable consequences both on the global and regional scale. Its consequential effects on infrastructure, agricultural production system, technology, local culture are important highlights of contemporary researches. While a zoologist may consider the influences of rising sea level, consequential of climate change on the migration behavior of sea animals, the economist may be burden with its effect on socio-economic budgetary policies designed by government to combat activities of extreme weather events. None the less, observations on existing impacts of climate change and scientifically informed future strategies on areas of design and development of adaptive technology, infrastructure, and policy formulation must be the concern of the Engineer.

Earth's climate has been documented to change quite a number of times in the billions of years of its existence varying from the period of warmth to the ice ages. However, while several of such changes can be attributed to natural process such as volcanic eruptions, changes in ocean circulation etc. The current climate change observed is mainly motivated by anthropogenic activities such as increased

emissions from burning fossil fuels and deforestation. Global warming is a closely related terminology to Climate change. Global warming refers to the exponential increase in earth's temperature over the last century. Global Climatic indices averaged over the last 100 years display a warming of an average of 0.5 degree Celsius temperature with a resounding 1.1^{o}C increase for Nigeria. Several climate models forecast the Earth to warm up between a range of another 1.4 to 5.8 ^{o}C over the next century in the continuations of the existing trends [1]. This shifting change in earth's weather has been documented to coincide with the birth of the world industrial revolution however discernable impacts of greenhouse gas (GHG) became apparent in the mid-twentieth century.

The World Metrological Organization (WMO) became the first to propose the terminology "climatic change" and begun studies of climatic variability regardless of the causes. Thereafter the terminology "climate change" was birthed referring to climatic variability linked specifically to anthropogenic activities. The Intergovernmental Panel on Climate Change (IPCC) was subsequently formed by the WMO and the United Nations (UN) Environment. This collaborating effort also birthed the UN Framework Convention on Climate Change (UNFCCC) in the early 1990s. Pivotal in the submission of the IPCC is its fifth assessment report (2013) which made conclusive arguments on the reality of climate change and the correlation with anthropogenic activities[2,3]. The report made three key submissions and proffers budgetary CO_2 emission to stem current tide of events. Key findings includes:

i. Earth's temperature increased by 0.85°C between the years of 1880 till 2012.

ii. Global sea levels rose by an average of 19 cm between the years 1901 to 2010 due to warming and consequential melting of ice caps.

iii. Average sea levels to rise by 24-30 cm by the year 2065 in continuance of current trends and this change may be irreversible

2. Current trends in GHG Accumulation and Climate Change in Nigeria

Earth's climate and temperature balance revolves principally around energy absorption from the Sun and the rate at which it is lost. However, several intrinsic and extrinsic factors help shape the climate and are referred to as "climate forcing" or "forcing mechanisms". Anthropogenic activities leading to increase levels of CO_2 constitute the chief of such extrinsic factor. Aside from CO_2 several other heat-trapping GHG such as methane, Nitrous-oxide, hydrofluorocarbons and perfluorocarbons may also prevent heat from escaping to space and significantly alter earth climate [4]. The industrialized countries of the world remain the chief producers of GHG contributing up to 97% of the world total GHG. However, the consequential effects of Climate change have an overreaching global effect. Hence, a global effort is required both in the reduction of GHG and in proffering efforts to the consequential effects of climate change [5].

The USAID GHG emissions factsheet pegged Nigeria's emission of CO_2 in the year 2014 alone at 492.44 million metric tons with the larger part of this, 38.2%, being a product of land use changes such as deforestation and land cultivation [5] Closely followed emitters include the energy and industrial sectors. While Nigeria currently has a very small GHG footprint its urgent need to meet the energy requirement and the drive for industrialisation is beginning to constitute a source of worry to environmental sustainability enthusiasts. This is also coupled with poor policy formulation over the spectrum of energy and energy related sub-sector[6]. Some notable threats includes:

i. Fossil fuel combustion in oil and gas exploitation and refinery in the southern parts of the country is imperative to Nigeria economy but continues to leave an undesired footprint on our environment (figure 1). Prominent are emissions from gas flaring releasing methane and other GHG gases. [7] reported an alarming value of 518.84 million metric tons of CO_2 gas released from the fossil fuel combustion between the years of 1990-2009 reflecting its fair share of about 0.26% of global emissions within the same period.

ii. Exponential increase in solid mineral exploration and processing: The federal government continues to make concerted efforts to increase solid mineral exploration in the country, however with little known recourse to environmental monitoring policy and control in the

subsector. Primal among such is cement manufacture which has been noted to contribute significantly to Global GHG. [8] Ranked cement manufacture as the third anthropogenic activity contributing to climate change, while available data for estimation of GHG emissions are poor, global emissions was estimated as 1.45 ± 0.20 gigatonnes of equivalent CO_2.

iii. Tropical deforestation has been documented to accounts for up to 10 % of world GHG production with Nigeria's forest losses accounting for a large share of the world's tropical deforestation [9]. The reckless destruction of Nigerian forest as a result of high demand for fire woods, urbanization and increased agricultural activities unchecked will continue to complicate the issue of climate change. Climate Analysis Indicators Tool (CAIT) pegged Nigeria's GHG emission from deforestation at 43.15% by the year 1991 [10]. While there has been a steady decline in deforestations contribution to overall GHG emission as a result several other competing factors, it continues to remain a considerable threat to environmental sustainability on the long term. This agree with findings of [11] who recommended that deforestation should be discouraged through appropriate policy in the rural and urban area of Nigeria.

iv. Poor waste disposal and management account for up to 20% of world's methane emissions. CAIT estimated poor waste disposal to account for 14.0% of total GHG emissions in the country. [12] suggested that estimated methane emission from waste to have grown from 231Gg CH_4 by the year 2004 from below 100Gg CH_4 estimated for the year 1994.

v. Ruminant animals such as cows are seldomly discussed emitter of GHG, the methane gas produced after breakdown of their excreta contribute to GHG accumulation. The tropics and arid regions host a large portion of the small ruminant animals of the world with more than 50% adapted to these regions.

3. Discernable Hazards from Climate Change in Nigeria

The Climate change phenomenon has already begun to manifest discernable alteration on the physical environment both for the present and future case scenarios. While an accurate assessment may pose a challenge, several key indices are of concern to contemporary researchers.

i. Biological Environmental Hazards: The disruption on the balance of adapted native organism and their local environment may either lead to the extinction or cancerous multiplication of varying species. The African elephants for example have consistently lost range from three million in 1976 to one million in 2007 [13]

ii. Chemical Environment Hazards:-Temperature influences the toxicokinetic of chemicals that are usually released into the environment. Similarly, continued exposure to chemicals also in turn affects the temperature tolerance of organism with varying effects on health. Also, the rise in sea level may culminate in salt water intrusion on freshwater in unconfined aquifer and surface water bodies. This in twin can lead to shortage of freshwater supply for domestic purpose. Other chemical pollutants such as nitrates (NO_3), Phosphates (PO_4), pesticides and herbicides that originated from agricultural lands. Chemical contaminates either directly or indirectly affect man through domestic water sources and food.

iii. Physical Environment Hazards: The physical environmental hazards are factors that can indirectly impair the human body without necessarily being in contact with it. They may comprise problems that are related to changes in the physical aspects of the environment. The expansion of aquatic habitat area by rising ocean water level at coastal areas; flood water is most often accompanied by drowning of people and destruction of houses, house hold properties and livelihood assets, livestock and low-lying agricultural lands are submerged and obliterated. When roads are flooded, vehicular movements and transportation system of food and services

are disrupted with crop products damaged thereby depleting food security, while electricity and communication facilities are affected by windy storms destroying buildings and finally render several families homeless. High relative humidity is also associated with dampness in homes and the growth the mould inside. Climate change and the rise in sea level are the same extent responsible to river bank and coastal erosion usually occasioned by the influence of strong currents, wave energy and high tidal amplitudes. These hydraulic processes usually result in the loss of habitable lands, houses, properties and economics assets. People are usually displaced from their comfortable homes and are compelled to relocate to safer, but less comfortable locations.

iv. Mechanical Environmental Hazards: These are factors or processes that usually cause harm to man through body contact. These include several causes of injuries and trauma on individuals or the populace are exposed to as a result of the impact. During wind storms, trees fall, houses are uprooted and some even collapse, electric poles fall and their wires snap and unsuspecting persons are electrocuted; hence fire outbreak from electrical shot-circuits may results. All these factors and processes may directly or even cause premature death of people children and women. The elderly and the physically challenged people are the most vulnerable groups to these mechanical environmental hazards.

v. Psycho-social Environmental Hazards: These hazards take place when individuals or groups are subjected to uncertainty or anxiety and they lose control over their own life situation or immediate surroundings. The multifarious effects of these factors end up culminating in stress. For example, climate change induces frustration and stress when people lose their houses, properties, loved ones, live stocks, farm lands, and other means of livelihood to floods and wind storms. Stress comes in when there is no hope for shelter, relief materials, health care and rehabilitation, poor psychological health.
Status is linked to psychosomatic diseases, alcoholism, drug abuse, sexual harassment, rape etc. These behavioral attitudes may in turn culminate in diverse physical injuries, suicide and even murder.

The severe changes observed in these indices may lead to extreme weather events, heat waves, pollution, diseases, earthquake and wild fires to mention a few. In the same light, agricultural food production systems and culture are also been affected which if unchecked will derail progress towards food security in the Country. The IPCC has forecasted a prevailing negative effects of climate change on agricultural growth with global yield of crops such as wheat and maize already reduced by 5.6 and 3.8% respectively [14]. Developing countries such as Nigeria has also been pegged more vulnerable to these challenges. In Nigeria several farmers still practice rain fed agriculture and the attendant uncertainties of climate change will hamper success of adopted traditional agronomic practices of many region. In the same light, threat to food security in sub-regions within the countries already designated as vulnerable to hunger and malnutrition will only become more complicated.

4. Practical Climate change Mitigation and Adaptation Strategies for Nigeria

Africa's rich natural resources, about 65% of the world total available arable land is a ready avenue for the next generation technological innovations in the drive to ensure global food security. Despite this fact, relevant climate impact assessment tools have also shown that agriculture to be one of the most sensitive subsectors to be affected by climate change in Nigeria. The Federal Ministry of Environment, Nigeria has predicted productivity within the heavily rain-fed agriculture subsector of Nigeria to decline by up to 25% by the year 2080 [14]. Hence incorporating climate change in policy, planning and implementations becomes imperative. FAO in 2013 adopted the term Climate Smart Agriculture (CSA), defined as "an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change" [15]. While integrating economic, social and environmental considerations, it prescribes action plans to support the three main pillars of the CSA, namely:

i. Sustainable increase in agricultural productivity to promote equitable increase in incomes

ii. Technological developments and adaptations resilience to climate change.
Assessing and exploiting opportunities at reduction and removal of GHG in Agricultural production systems.

The IPCC climate-resilient transformation pathway in figure 1. describes the multi layered criterion in CSA decision making. While CSA may not be unilaterally applied, adaptors must execute a site-specific evolutions along its decision pathways.

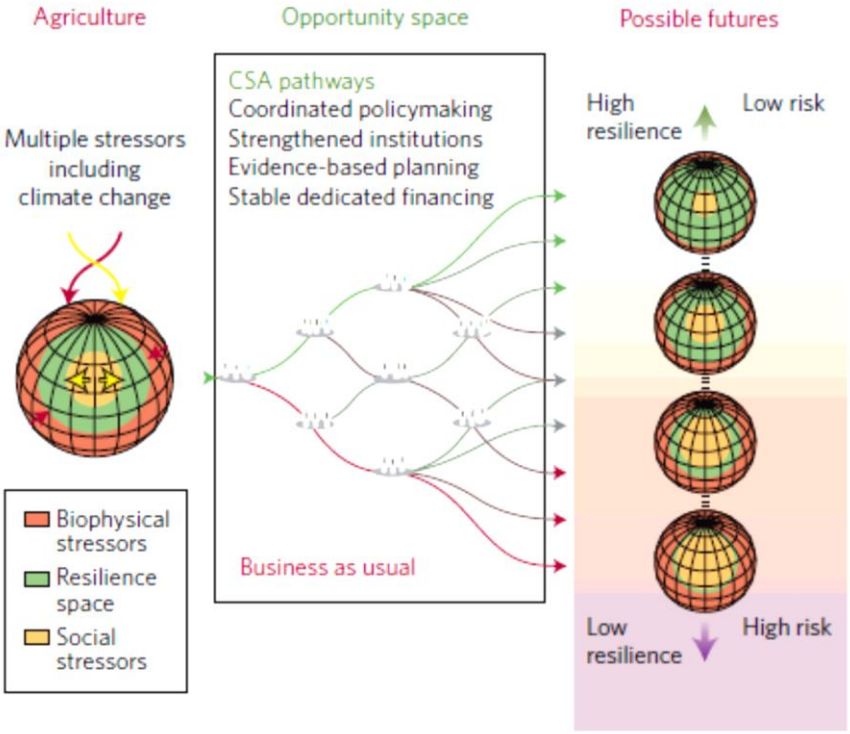

Figure 1. Climate resilient transformation pathways for agriculture [16]

In Nigeria awareness of these CSA strategies are still relatively low. [17] evaluated awareness of several CSA practices such as use of drip irrigation system in upland and dryland conditions, reincorporation of refuse form cleared farmland into the soil rather than burning etc. awareness was conclude has generally low hence, the consequentially adoption was also low [17]; [18] postulated that education and ability to assess information with relevant communication gadgets were significant in adoption rates. Farmers who did not possess formal education were severally disenfranchised in CSA practices and their tendency to adopt CSA was lowered by 33.59% [18].The Climate Department of the Federal Ministry of Environment, the policy convener on CSA in Nigeria has itemized seven key points for immediate actions [14].

i. The development of a new resilience national agricultural production framework that embraces the three pillars of CSA
ii. Initiation of pilots with CSA farm inputs such as disease, pest and draught resistant seeds.
iii. Development of large-scale water use efficiency irrigation schemes made accessible to small scale farmers.
iv. Execution of climate change insurance to ameliorate adverse effects of climate variability.
v. Strategic national policies aimed at self-sufficiency in rice and wheat production over a 3year period.

vi. Encourage of the country's largest agri-business enterprises to exploit opportunities in CSA practices.
vii. Multi-agency approach to national climate information gathering and dissemination.
viii. In the attainment of Climate resilient agricultural production system for the country, relevant stakeholders, research institutions, innovators, and farmers must hereby key in to this action plan as recommended in a research findings on the impact of climate change on cocoa and chocolate production [**19**].

In the attainment of Climate resilient agricultural production system for Nigeria, relevant stakeholders, research institutions, innovators, and farmers must hereby key in to this action plans. Several other suggested action plans to improve CSA practice include:

i. Systematic policy formulation to redress informal education especially in the rural areas with curriculum that incorporate CSA strategies.
ii. Redesign of the country's extension workers to exploit the avenue in the modern multimedia technological aids in teaching and dissemination of information.
iii. Increased efforts for sensitization of climate change realities and recommended CSA strategies directed to the small-scale farmers.
iv. Policy formulation for governmental institutions to incorporate climate change studies in their programme
v. Retraining of extension workers on CSA practices
vi. Researchers, innovators and farmers who practices CSA practices may be encouraged through provision of incentives by the government to encourage CSA incorporated outputs.

5. Conclusion and Recommendations

5.1 Conclusion

This paper identify the potential causes of climate change in Nigeria, highlights environmental hazards caused by it and perspective mitigation and adaptation technologies that will reduce the impact of climate change in Nigeria and thereby concludes that for food security to be a reality both the government at all levels, and other stake holders must work together and for an ecosystem to be sustainable, various hazards caused by climate change must be reduced through adaptation and mitigation technology. Also, Agricultural Engineers should embrace the challenges of fabricating machines that depend on renewable energy power as a strategy of reducing the accumulation of GHG at global level.

5.2 Recommendations

In the grand scheme of actions for mitigating environmental hazards associated with climate change scientists, Technologies and Engineers must also develop and or adopt strategic technologies such as the follows:-

i. Early Warning Systems: The early morning indicators are those indices that can predict the location, timing and magnitude of specific climate change related hazards. These include indices of alterations in weather climate and rise in river or sea level. The application of early warning indicators facilitates the early detection of imminent environmental hazards and equally enhances the disaster preparedness through the provision of pre-emptive information, so that high magnitude impacts can be avoided. Meteorologist can detect and forecast wind storms by the use of high precision weather radar. Satellite images and even messages from airlines operating in the area. Reliable long-term forecasting of extreme weather and flood events can provide crucial information.

ii. Emergency Service: The application of modern technologies that pertain to emergency services and life support systems is important in reducing mortality rates. This may include

rapid response in the evacuation of vulnerable and affected persons, provision of emergency water supply motor vehicles and flying boats, availability of rescue equipment and personnel and also establishment of well-equipped resuscitation and first-aid center that can support large numbers of victim.

iii. Security Services: During storms and floods, there is a tendency to increased rates in crimes like robbery, alcoholism, drug abuse, sexually harassment and rape. It is therefore important that law enforcement agents are fully around with modern Technological equipment to enable them deal with the available challenges.

iv. Unconditional Agricultural Systems: It may be necessary to adopt agricultural systems; such as wet lands farming and hydroponics which allow certain crops to be successfully grown in flooded or semi-flooded areas.

v. Water conservation and Recycling: The application of technologies for conservation and recycling of fresh water may become inevitable.

vi. Design Structure of Houses: - Design of structures for flood-prone areas may have to be changed from the existing ones to structures that can enable people to continue to dwell safely in their houses during flood occurrence.

vii. Health Care Management: Adequate preventive health care measures will be needed in order for people to cope with the outbreak of water related diseases, such as malaria, typhoid, cholera, dysentery, etc.

viii. Alternative Source of Potable Water: There is need for scientists to adopt a technology that will ensure sustainability in the supply of adequate quantity of safe potable water for domestic purposes. This may involve the application of high production capacity plants that convert soft water into freshwater using reverse mechanism, purification plants which de-contaminate raw river or reservoir water and Automatic water quality monitoring device.

ix. Information Dissemination: The inhabitants in such areas should be adequately informed of imminent dangers along with instructions or possible evacuation, relocation and other survival strategies. This can be achieved by improved and effective communication network. Information and alert on pending environmental hazards can be disseminated in several ways, including flags, photographs, posters, leaflets, newspapers, bulletins, radio and television broadcasts, internet reports, mobile telephone, messages etc.

x. Specialized Transportation Systems: Conventional road motor transportation is often disrupted in flooded areas. There will be need to introduce specialized means of transportation, which are designated to travel close to but over mud, land and water, small and medium sized ground effect vehicles to convey people out of such a place.

References

[1] Fernández-Martínez M, Sardans J, Chevallier F, Ciais P, Obersteiner M, Vicca S, … and Peñuelas J 2019 Global trends in carbon sinks and their relationships with CO_2 and temperature. *Nature Climate Change*. https://doi.org/10.1038/s41558-018-0367-7

[2] Climate Change 2014 Synthesis Report Summary Chapter for Policymakers. *Ipcc*. https://doi.org/10.1017/CBO9781107415324

[3] Climate Change 2014 Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Ipcc.

[4] Hansen J, Sato M, Kharecha P, Russell G Lea, D W and Siddall M 2007 Climate change and trace gases. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and*

Engineering Sciences. https://doi.org/10.1098/rsta.2007.2052
[5] European Environment Agency 2019 EEA greenhouse gas - data viewer. Data Viewer on Greenhouse Gas Emissions and Removals, Sent by Countries to UNFCCC and the EU Greenhouse Gas Monitoring Mechanism (EU Member States).
[6] Bala E J, Zarma I H, Gaji M M, A B G 2017 Overview of Renewable Energy Technology for Nigeria Sustainable. *24th AGM and International Conference of the Nigerian Institution for Mechanical Engineers (NIMechE)*, (November). Retrieved from https://www.researchgate.net/publication/321342662
[7] Anomohanran O 2011 Estimating the greenhouse gas emission from petroleum product combustion in Nigeria. *Journal of Applied Sciences*. https://doi.org/10.3923/jas.2011.3209.3214
[8] Andrew R M 2017 Global CO_2 emissions from cement production. *Earth System Science Data*.
[9] Butlez R A 2006 Impact of Population and Poverty on Rainforests. *A Place Out of Time: Tropical Rainforests and the Perils They Face*.
[10] WRI 2017 Climate Analysis Indicators Tool (CAIT). Climate Data Explorer. 2017.
[11] Obaniyi K. S., Kolawole A. E, Ajala A. O, Owolabi A. O, and Akangbe J A 2019 Environmental Change Impacts on Agribusiness and Food Security in Sub Sahara Africa: A Practical Way Forward. *Medwell Journal of Engineering and Applied Sciences* **14** 24 9639-44
[12] Aboyade A 2004 The potential for climate change mitigation in the Nigeria solid waste disposal sector: A case study of Lagos. *Environmental Science*. Lund University, Sweeden.
[13] Mawdsley J R, O'Malley R and Ojima D S 2009 A review of climate-change adaptation strategies for wildlife management and biodiversity conservation *Conservation Biology*. https://doi.org/10.1111/j.1523-1739.2009.01264.x
[14] Department of Climate Change, Federal Ministry of Environment, Nigeria 2015 Climate Smart Agriculture. Retrieved from http://climatechange.gov.ng/climate-smart-agriculture/
[15] Asseng S, Ewert F, Martre P, Rötter R P, Lobell, D B, Cammarano D, …and Zhu Y 2015 Rising temperatures reduce global wheat production. *Nature Climate Change* https://doi.org/10.1038/nclimate2470
[16] Lipper L, Thornton P, Campbell B M, Baedeker T, Braimoh A, Bwalya M, …and Torquebiau E F 2014 Climate-smart agriculture for food security. *Nature Climate Change*. https://doi.org/10.1038/nclimate2437
[17] Tiamiyu S A, Ugalahi U B, Eze J N and Shittu M A 2018 Adoption of Climate Smart Agricultural Practices and Farmers Willingness to Accept Incentives in Nigeria. *International Journal of Agricultural and Environmental Research* **4** 4 198–205.
[18] Ekpa D, Akinyemi M and Ibrahim H 2017 Investigating Climate Smart Agricultural Practices in Livestock Production in Sokoto State, Nigeria: An Application of Principal Component Analysis. *FUDMA Journal of Sciences* **1** 1 103–8
[19] Obaniyi K S, Aremu C, Abolusoro S, Ajiboye B, Adeyonu A and Okunola A 2019 Impacts of Climate Change on Chocolate and Cocoa Production *Medwell Journal of Engineering and Applied Sciences* **14** 24 9645-50.