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Original Paper

Creating the Healthiest Nation: Climate Change and Environmental Health Impacts in Nigeria: A Narrative Review

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Abstract

Climate change is a "threat multiplier and a prime cause of universal threat to health in the 21st century, including 4th industrial revolution. The health effects of climate change will increase dramatically over the next few years and pose a risk to human life and the well-being of billions of people. As we all know, the milieu is fundamental to our sustained earth survival and environmental changes (natural and artificial) affect it either to the benefit or detriment of humans. Climate change is one of such changes in the physical environment which has grave consequences for the existence of mankind. Climate change is interestingly, no longer a speculative subject. There is a good international scientific consensus existing to show that this phenomenon is real and if recent global warming movements continue, temperature rise, ocean levels and more frequently weather conditions that is extreme (storms, heat-waves, droughts, floods, cyclones, etc.) may perhaps cause severe food shortages, loss of shelter, water, livelihoods, extinction of flora and fauna species. In the recent past, the earth has witnessed devastating weather-related events in different portions of the globe including hurricanes (e.g., Katrina and Rita in USA), tsunamis, typhoons, flooding especially in the Asian Continent, wild fires especially in Australia, USA, etc. Currently, the on-going flood incident in Pakistan that has so far claimed about 1,600 lives and rendered another four million people homeless is a sad reminder of the ugly and devastating consequences of global warming on the environment. There is no gainsaying the

fact that humankind is paying dearly for the massive alterations in the environment that have induced changes in climate. This is because of frequent incidence of changes in climate related disasters in the world today. There is hardly any month that passes without an incident occurring in one part of the globe or another since the advent of the 21st century. Changes in climate has significant and potentially devastating health consequences, whether through direct actions (e.g., deaths resulting from heat wave and weather disasters) or disruption of complex biological methods (e.g., changes in infectious diseases patterns, supplies in fresh water and production of food).The report of the fourth assessment of the United Nations Intergovernmental Panel on Climate Change (IPCC) have globally submitted that "it is estimated that the health of millions of people is affected, for instance, malnutrition increases; deaths increase, diseases and injury; burden of increase diarrheal diseases; frequency of increased cardio-respiratory diseases caused by high levels of ground-level ozone in cities due to climate change; besides altered spatial distribution of some communicable diseases". The association amongst changes in climate, its drivers, systemic effects, health and socioeconomic growth, mitigation and adaptation has been specified.

Keywords

Environmental Health, Climate change, Global warming, Win-Win solutions, 4th industrial revolution, Threat multiplier

1. Introduction

1.1 Concept of Environment

The term environment takes account of all living and non-living things in our environment. It entails of three major characteristics viz; social (or psychosocial), physical and biological. The association between people in their surroundings is reciprocal, because the milieu has a significant impact on them and they, in turn, make extensive alterations to their environment to meet their needs and desires for survival (Ayuba & Dami, 2011; Raimi *et al.,* 2018). The environment is defined by World Health Organization as all modifiable chemical, physical and biological aspects external to the human host, as well as all the associated behaviours that are essential to creating and sustaining a healthy liveable setting (Ayuba & Dami, 2011; Raimi *et al.,* 2018). The milieu signifies an important contribution to the health of human and well-being. Substances exposure by way of pollutants include allergens, chemicals and toxins from nature, which can originate within the milieu and could have harmful effects on the health of man and animal. Diet and lifestyle can also interact with these environmental factors and alter their effects with devastating consequences on man (Onwuliri, 2009; Raimi *et al.,* 2018).

1.2 Physical Environment

The physical setting on the non-living (abiotic) nature of the milieu, i.e., shelter/habitat, radiation, gravity, air, soil, water, light, heat, pressure, climate and various other referable agent's inter-alia. The physical environment exerts an undesirable consequence through determining the organism's distribution in the biological environment. Humans alter the natural characteristics of the physical

environment, sometimes on a small scale such as clearing a small patch of bush, building a hut, digging a small canal to irrigate a vegetable garden, etc. But often times they do so on a very large scale for example by building large cities, draining of swamps, irrigation of arid zones, damming of rivers, creating large artificial lakes, etc. Many of these changes have been beneficial, nonetheless some parts have created novel risks in the milieu. Globally, there are increasing problems related to human activities that are gradually leading to a remarkable increase in earth's temperature involving predictions of complex consequences (Onwuliri, 2009; Raimi *et al.*, 2018).

1.3 Biological Environment

All biotic in an area (including plants, micro-organisms and animals) constitute the biological milieu. Humans intentionally control the biological milieu through growing valuable plants that are beneficial for fibre and food, e.g., through rearing farm animals for their milk, leather, wool and other useful products. They hunt, destroy and kill wild animal and insects, which spread infectious diseases and contend for food (Onwuliri, 2009; Raimi *et al.*, 2018).

1.4 Social Environment

This is another portion of the milieu that place emphasis entirely on human nature. Essentially, it epitomises human beings condition as it reflects the state of society, i.e.; villages, family groups and urban communities; culture (including attitudes and beliefs), the organization of society, i.e., politics and governments; judicial systems and laws; the system of education; communication and transportation; and associated social services, including healthcare and interrelated aspects, interacting to form social life, conduct and other associations (Onwuliri, 2009; Raimi *et al.*, 2018).

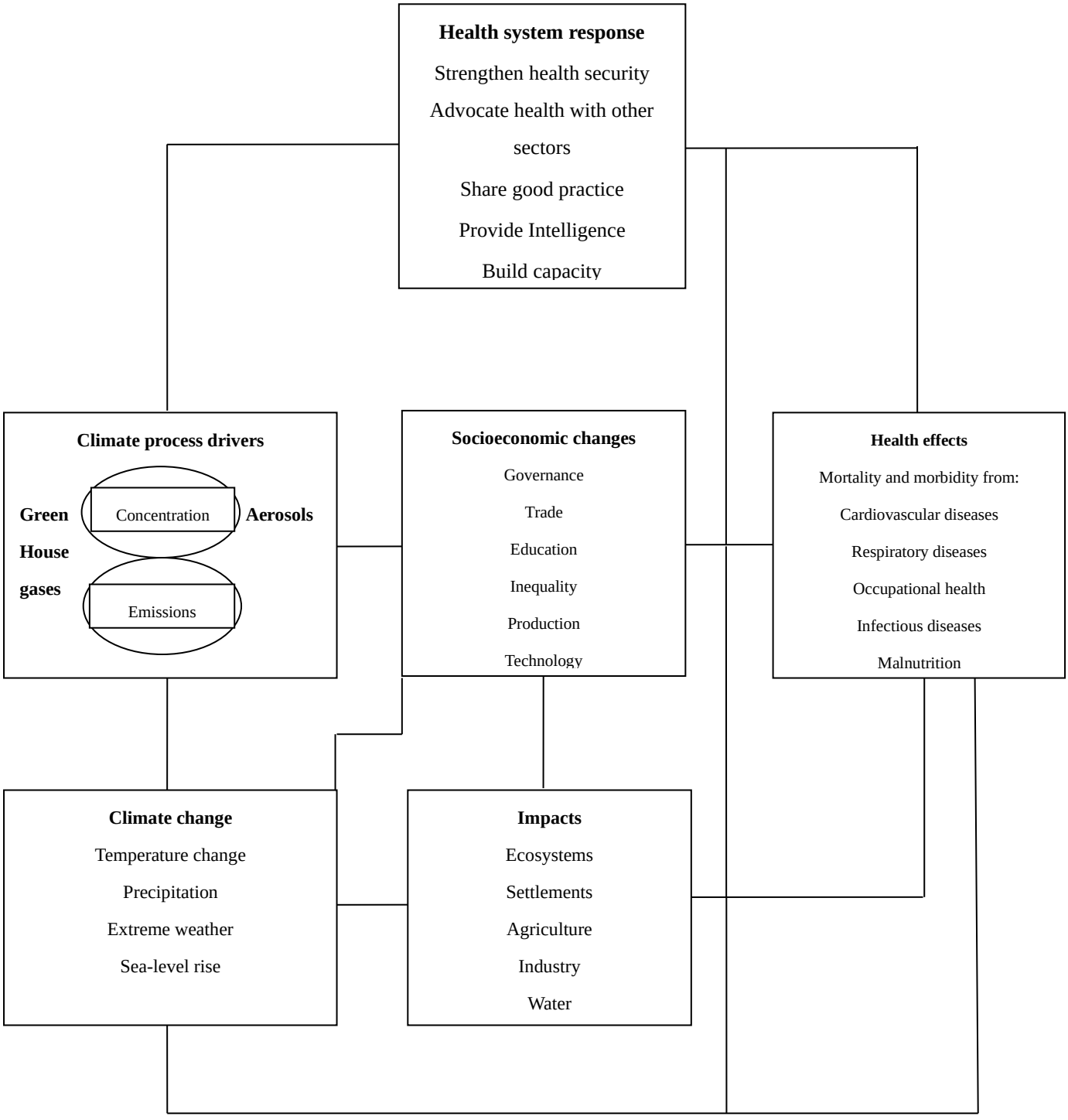


Figure 1. The Relationship between Climate Change, Its Drivers, Effects on Systems and Socioeconomic Development, Health, Mitigation and Adaptation

Source: Adapted from WHO (2008) and Raimi *et al.* (2018).

2. Environment Health

"Environmental health is the totality of all factors in man's physical environment which exercise or may exercise, a deleterious effect on his physical development, health or survival. Environmental health therefore takes account of the various aspects of public health (including quality of life) that are determined by physical, chemical, biological, social and psychological factors in the environment". It also denotes the concept and practice of evaluating, modifying, controlling and averting those factors in the environment that may possibly have a negative impact on the health of present-day and forthcoming generations (Onwuliri, 2009; Raimi *et al.,* 2018). Most diseases generally have complex etiologies that allow for multiple casual and pathogenic factors including exposure to environmental agents. Scientific and clinical evidence suggest that almost all human diseases may be caused, altered or modified through environmental agents. One of the important elements in improving public health is recognising and comprehending elementary biological processes that alter the environmental functions that lead to the outbreak of disease processes or disease course to be altered substantially. In essence, the implementation of environmental health practice aids in creating and sustaining an environment that encourage good public health in the community, including safeguarding elementary health requirements such as availability of clean drinking water, clean air and safe food for its citizenry (Onwuliri, 2009; Raimi *et al.,* 2017; Raimi *et al.,* 2018). Some environmental health components according to Environmental Health Officers Registration Council of Nigeria (2007) include "waste management; food hygiene and control; pest and vector control; environmental health control of housing and sanitation; epidemiological investigation and disease control; air quality management; occupational health and safety; water resources management and sanitation; noise control; protection of recreational environment; radiation control and health; health control of frontiers, air and sea ports and border crossing; pollution control and abatement; educational activities (health promotion and education); promotion and enforcement of environmental health quality standards; collaborative efforts to study the effects of environmental hazards (research); Environmental Health Impact Assessment (EHIA) and the management of emergency situations (disasters, flooding, disease outbreaks)" (EHORECON, 2007; Raimi *et al.,* 2019; Omidiji & Raimi, 2019; Odubo & Raimi, 2019; Raimi *et al.,* 2020; Olalekan *et al.,* 2020; Adedoyin *et al.,* 2020; Olalekan *et al.,* 2020).

3. Environment Sanitation

Environmental sanitation is an age long practice introduced during the early period of human civilization. Environmental sanitation is the principle and practice of achieving health and sanitary conditions in the surrounding to improve the health of people's and well-being, improve the life quality and safeguarding a healthy environment. The main elements of environmental sanitation are "solid waste and medical waste management, pest and vector control, food sanitation, disposal of the dead, excreta and sewage management, market and abattoir sanitation, sanitary inspection of premises, management of urban drainage, control of reared and stray animals, weed and vegetation control,

hygienic education and promotion" (EHORECON, 2007; Olalekan *et al.,* 2018; Raimi *et al.,* 2019; Olalekan *et al.,* 2019; Gift and Olalekan *et al.,* 2020; Gift *et al.,* 2020). The report of July 2011, published in Water and Sanitation Program (WSP), shows that Nigeria loses around ₦455 billion or $3 billion annually due to poor sanitation. According to the report of WSP, the loss of income is equivalent to 1.3% of Gross Domestic Product (GDP) of a nation's (WSP, 2012; Olalekan *et al.,* 2018; Raimi *et al.,* 2019). The economic impact of poor sanitation in Nigeria, according to a Water and Sanitation Program (WSP) report, is estimated at $2.5 billion annually against untimely death from diarrhoea—90% due directly ascribed to poor water, sanitation and hygiene. About $13 million a year is lost due to productivity damage arising from sickness or accessing healthcare services. Likewise, the report of WSP estimates that nearly $191 million is lost in healthcare expenditure (Raimi *et al.,* 2017; Olalekan *et al.,* 2018; Raimi *et al.,* 2019; Gift *et al.,* 2020). Globally, 64.2 million disability-adjusted life years (DALYs) are ascribed through unsafe water, poor sanitation and hygiene practices (Prüss-Üstün *et al.,* 2008; Olalekan *et al.,* 2018; Raimi *et al.,* 2019; Olalekan *et al.,* 2020), including 52.5 million (82 per cent) are among the low-income countries. The disease burden falls deeply on children and children under the age of five (5) account for 88% of DALYs in the low-income countries (over 46 million DALYs). Nationally, the disease burden due to unsafe quality of water and poor sanitation has declined heavily in sub-Saharan Africa (46% of DALYs global) and South Asia (34% of total DALYs). The disease burden falls deeply on children; diarrhoea is the second leading cause of death among children under the age of 5 worldwide (The Lancet, 2012; Raimi *et al.,* 2017; Olalekan *et al.,* 2018; Raimi *et al.,* 2019; Olalekan *et al.,* 2020). Diarrhoea episode in children contributes to malnutrition, reduce infections resistance and over time, to weakened physical and intellectual growth and progress as per readiness of school and performance. Some of the recent sanitation related studies in Nigeria include: "Nigerians crying for availability of electricity and water: a key driver to life coping measures for deepening stay at home inclusion to slow covid-19 spread by Gift *et al.* (2020); Leaving No One Behind? Drinking-Water Challenge on the Rise in Niger Delta Region of Nigeria: A Review by Olalekan *et al.* (2020); Access to electricity and water in Nigeria: a panacea to slow the spread of Covid-19 by Gift and Olalekan (2020); "Digging deeper" evidence on water crisis and its solution in Nigeria for Bayelsa state: a study of current scenario by Olalekan *et al.* (2019); Assessment of Environmental Sanitation, Food Safety Knowledge, Handling Practice among Food Handlers of Bukateria Complexes in Iju Town, Akure North of Ondo-State, Nigeria by Raimi *et al.* (2019); The sources of water supply, sanitation facilities and hygiene practices in an island community: Amassoma, Bayelsa State, Nigeria by Raimi *et al.* (2019); The sources of water supply, sanitation facilities and hygiene practice in oil producing communities in central senatorial district of Bayelsa State, Nigeria by Olalekan *et al.* (2018); A survey of hand washing behaviour and awareness among health care workers in health care facilities in Kubwa district of Bwari Area Council, F.C.T Abuja, Nigeria by Raimi *et al.* (2018); Water-related problems and health conditions in the oil producing communities in central senatorial district of Bayelsa State by Raimi *et al.* (2017); Bacteriological assessment of selected hand

dug wells in students' residential Area: A Case Study of Osun State College of Health Technology, Ilesa, Nigeria by Henry *et al.* (2019). Sanitation was also studied in different areas of the world by Admasu and Kelbesa (2018)". Interestingly, many sanitation programmes in Nigeria have been based on the assumption that improved hygiene and sanitation are fundamentals for improved health, quality of life and to social and economic development. However, these projects have not always been as successful as expected. One of the reasons may be that many individuals do not share Western conceptions of hygiene and health, another reason could be that improvement in sanitation facilities and health education do not necessarily by themselves lead to remarkable health impacts.

4. Health, Diseases and Infections

The World Health Organisation (WHO) defined "health as the complete state of physical, mental and social well-being and not merely the absence of disease or infirmity". A perfect state of health therefore is modulated through a number of aspects, essentially from social, genetic and emotional, toward the natural and man-made milieu. Subsequently, a deep reflection of such a perfect health state would have to put into consideration, factors like the purpose of development and strategies and the relationship between economic and dominant social structures, values systems in the community and beliefs (WHO, 2008). Good health is the key to overall prosperity and healthy well-being. While good health also helps reduce poverty, growth and contributes to social security, deprived health drives and contribute to poverty. Infectious microbial and diseases that are parasitic in nature are major contributors to individual's poor health status and communities all over the globe. They occur against a background of economic and social underdevelopment, changing climatic patterns, wars/migration of refugees (including non-immune populations), poverty, malnutrition, low investment in health and related sectors, insufficient recognition of the havoc being caused and the lack of know-how on the use of tools for control and prevention. It weakens the government, health care systems and the national economies. Majority of infectious microbial and parasitic diseases occur in developing countries and have been found to have the utmost impact on women who are pregnant, children as well as the elderly, where the above-mentioned factors work in synchrony to foster their prevalence and persistence in the environment (WHO, 2002; Raimi *et al.,* 2017; Raimi *et al.,* 2020). Infectious microbial and parasitic diseases result from an interaction between a host, an agent and the environment. In an ideal situation, the agent, the host and the environment maintain a dynamic state of equilibrium. A change in the environment can upset the balance leading to the multiplication and spread of the disease agents or their contact with man. For example, since vibrio bacteria causes cholera as well as other diseases, with poisoning of ciguatera fish plus shellfish poisoning as well as harmful algal blooms, warming temperatures plus more extreme rainfall possibly will favour the outbreaks of waterborne disease. Figure 2 below demonstrates in what manner climate related events, as per heavy rainfall, can contribute towards the occurrences of waterborne disease. The precipitation washes away the pathogens found in animal as well as human faeces into the sewer systems as well as eventually enters the water bodies

locally where water can remain drawn in lieu of crop irrigation or drinking. Warmer temperatures can promote pathogens growth (see Figure 2 below).

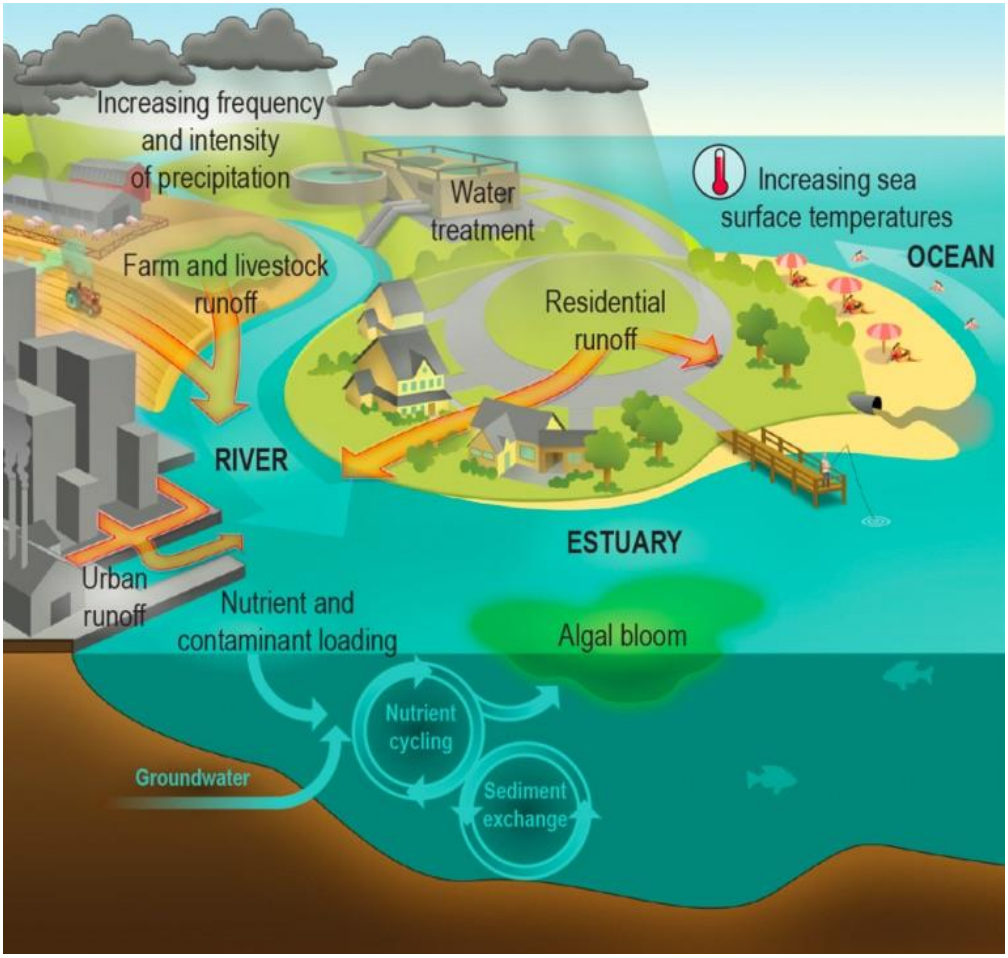


Figure 2. Pathways from Climate Change to Waterborne Disease

Source: Adapted from https://health2016.globalchallenge.gov

Alterations in the physical parameters of the environment such as temperature, humidity and air pressure are mostly responsible for the rapid proliferation of disease vectors and micro-organisms and the abundance of such diseases as malaria (It is estimated that more than 200 million people are infected with malaria each year, mostly in the tropics, and more than 400,000 people die, mostly children under the age of 5. Almost half of the world's population lives currently in areas where the malaria disease can spread.), filariasis, onchocerciasis, etc. (Onwuliri *et al*., 2005). As earlier indicated, the social environment or socio-cultural environment which is that part of the environment that creates prominent role in man mental health (and indicates all the conditions affecting man as a member of the society, e.g., the culture, beliefs and attitudes, educational system, housing, etc.) also influences his health either positively or negatively. Common examples of infectious microbial and parasitic diseases of public health significance are: AIDS, typhoid fever, cholera, tuberculosis, leprosy, malaria,

schistosomiasis, onchocerciasis (river blindness), trypanosomiasis, guinea worm (dracunculiasis), leishmaniasis, filariasis, ascarisis, hookworm, etc. (Onwuliri *et al*., 2005; Raimi *et al.*, 2017). These six (6) diseases (such as Schistosomiasis, African Trypanosomiasis, malaria, lymphatic filariasis, onchocerciasis, and leishmaniasis) have been identified as "major tropical diseases" by World Health Organization in consideration of their public health significance and grave socio-economic consequences on afflicted individuals, families and societies as shown in Tables 1 and 2 below. The devastating effects of these diseases are summarized in the words of Dr. Hiroshi Nakajima, former Director General, WHO: "beyond their toll of individual illness and death, these tropical diseases have insidious effects on society. They impede national and individual development, make fertile land unhospitable, impair intellectual and physical growth and exact a huge cost in terms of treatment and control" (Onwuliri, 2009; Raimi *et al.*, 2020). In addition, the number of people in emerging countries is expected to increase by 2·3 billion in 2005 to 4 billion by 2030, this is compounded due to growing urban sprawl, including poor housing (UN, 2005; Gift *et al.*, 2020). These changes increase inevitably the peril of heat strokes and heat waves in cities in emerging countries due to the effect of the so-called heat island.

Heat stroke could lead to lasting impairment to brains as well as nerves (among other organ systems) along with death. Of course, very few people die from heat stroke. Often, heat exposure makes existing ailments worse. The heat can promote dehydration, which in turn leads to a variety of illnesses, including heart and lung conditions, for instance chronic obstructive pulmonary disease, asthma and heart failure and diabetes. Heat can also make it difficult to think and productivity have been shown to decrease. Also, heat waves can be fatal for a number of reasons. The brains, hearts, as well as lungs are all sensitive toward heat stress as well as when they become overheated, they fail. Greater death in the course of heat waves has been ascribed mainly to organs failure. Throughout heat waves period, emergency room visits increase with many heat-related conditions for instance heat cramps, neurologic conditions, heat exhaustion plus heat stroke, electrolyte disorders and dehydration, cerebrovascular diseases and cardiovascular, acute renal failure, respiratory disorders as well as mental illnesses. Likewise, fetuses born to women with exposure to high temperatures may be at higher risk of neural tube as well as other birth defects. Of course, there are many factors that can make a person's ability to dissipate heat. Aging seems to be the biggest contributors, with older adults having markedly less energy to get heat away from their bodies. Pre-pubertal children likewise could have low capacity as compared to adults. Equally, those who work outdoors, especially in construction, could be at higher risk for years to come. The heat exposure pyramid shown on the right shows a range of health effects associated with caused heat exposure as well as the proportion of a population that may be affected by it. The wider the pyramid is at the level of certain health risks, the more likely the health problems (see Figure 3 below).

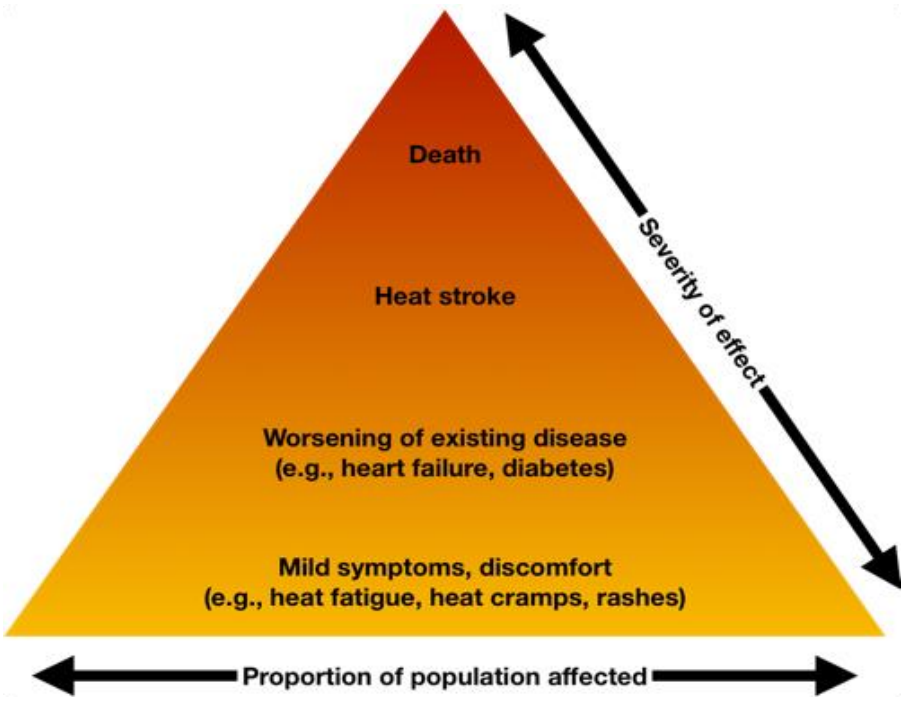


Figure 3. Heat Exposure Pyramid

Source: Adapted from https://courses.edx.org

High temperature affects diseases spread and the rates of transmission of vector-borne and rodent-borne diseases. Temperature affects pathogen maturation rate and mosquito's replication, the insect's density in a specific area, and increases infection likelihood. As a result, certain populations having little or no immunity to novel infections could be at higher risk. Reproduction of vector, parasite growth cycle, and frequency of bite commonly increase with temperature; hence, tick-borne encephalitis, malaria, including dengue fever would turn out to be increasingly widespread. For instance, the world faces multiple challenges, some new and many enduring, including pandemics, rising global temperatures, unemployment, and inequality, extreme harsh events, like heavy rains that would wash away the eggs, including the larvae and reduce populations of vector. Mosquitoes will grow, responsible for malaria, through accessing warm and high altitudes, in regions once known as disease free (Kovats *et al.*, 2005; Raimi *et al.*, 2018; Raimi, 2019). Malarial parasites are recognized to remain sensitive to temperature, particularly throughout the so-called extrinsic period of incubation for parasite lifecycle (see Figure 4 below), which happens once the parasite remains alive in the mosquitoes. For example, warmer temperatures promote faster reproductive cycles in mosquitoes that transmit malaria and in the parasite itself.

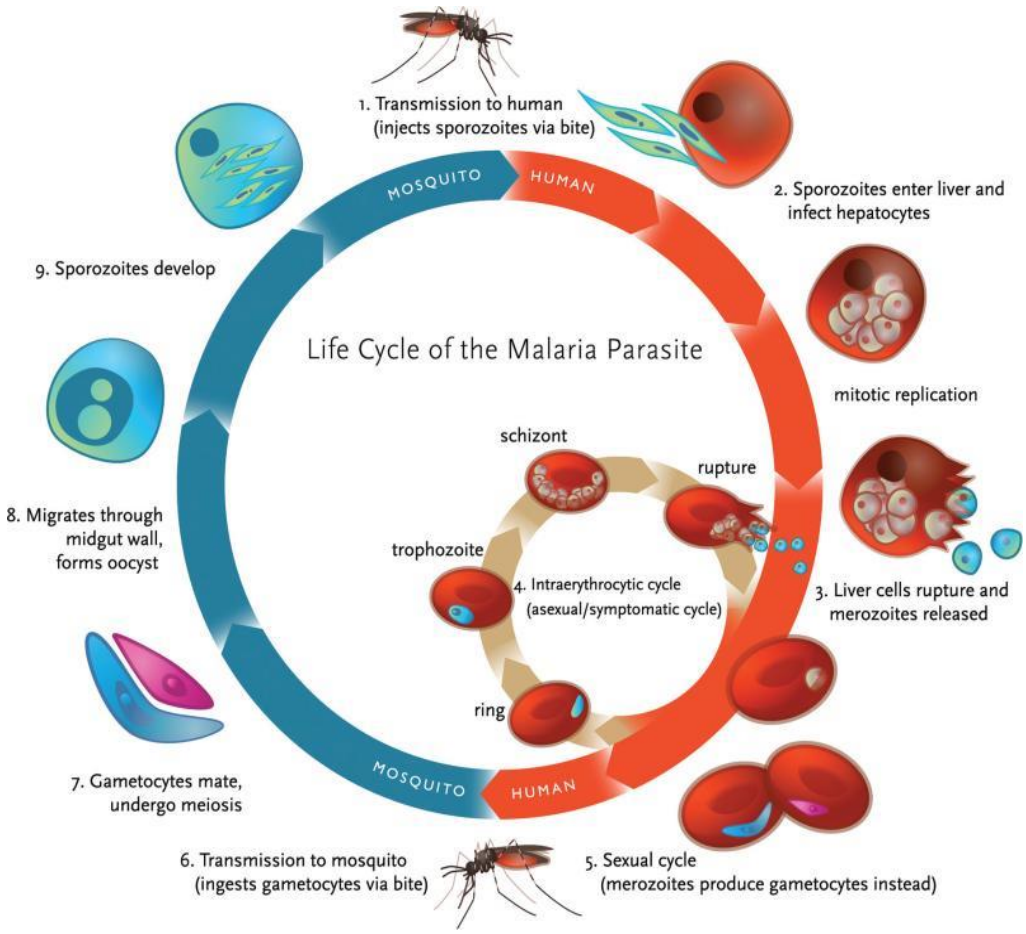
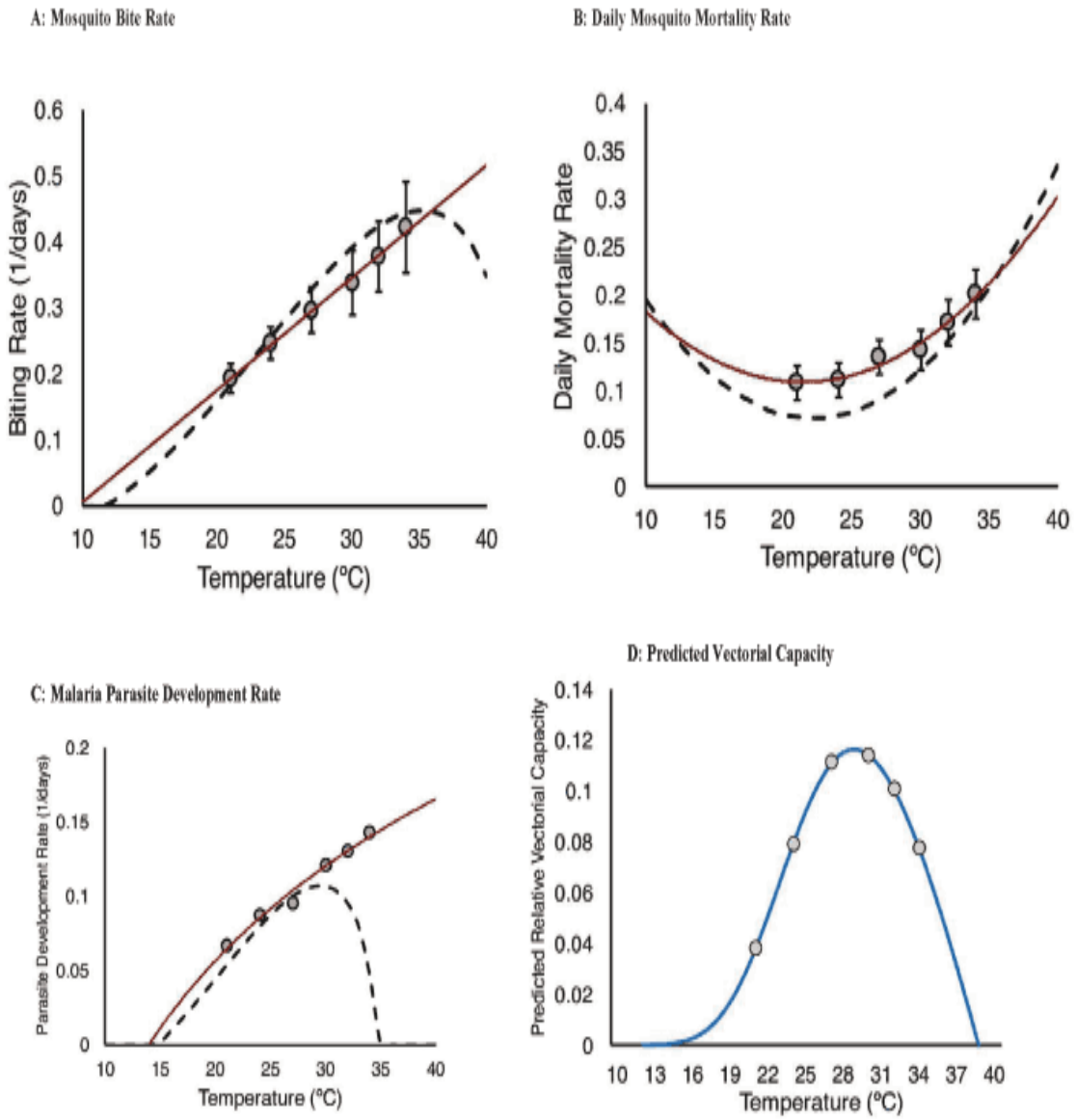


Figure 4. The Malaria Parasite Lifecycle

Source: Adapted from Klein (2013).

Research on the correlation amongst temperature plus malaria have addressed the problem of how a rise in the mean temperature can widen the disease geographic range. Recent research suggests that studying average changes in temperature possibly will exaggerate the extent to which malaria respond towards earth's changing climate. The charts beneath illustrate some temperature effects on mosquitoes which transmit malaria as well as malarial parasites (see Figure 5 A, B, C &D below).



Figures 5. A, B, C &D: Shows the Effects of Temperature on Mosquitoes That Transmit Malaria and Malarial Parasites

Source: Adapted from Shapiro *et al.,* (2017).

The solid red lines are best-fit lines, even though black line indicate predictions from an earlier study by Mordecai *et al.,* The blue line in graph D shows a prediction based on the collected data in their study. Warmer temperatures stimulate greater biting rates as well as more rapidly parasite growth rate (noting that graphs A & C demonstrate the biting as well as growth rates as reciprocals (1/days) as a result, the greater the worth the quicker the biting or development rate). Still, high temperatures likewise increase mosquito mortality (graph B). Mosquitoes live a short time at remarkably most extreme temperatures. Graph D indicate the strength of the predicted vectorial capacity (that is the rate at which mosquito bites could spread infection toward humans after ingestion of an infected blood meal) depending on how

temperature affects mosquitoes' as well as parasites' ability towards transmitting malaria as well as indicate that at low plus high temperatures, mosquitoes remain considerably less likely toward spreading disease. Dengue fever is also climate sensitive; the disease is seen in cities due to water scarcity affecting nearly 100 million people around the world. Changing climate will rise the number of areas impacted via arbovirus, like New Zealand and Australia. Heavy precipitation and an increase in temperature intensify the infection rate (Menne *et al.,* 2002; Raimi *et al.,* 2017). By 2080, an estimated 6 billion individuals could be at risk for contracting dengue fever as a big climate change implication's, compared to 3.5 billion people without earth's changing climate (IPCC, 2007; Hales *et al.,* 2002). Alveolar echinococcosis, tick-borne encephalitis, schistosomiasis, leishmaniasis, fascioliasis, lyme borreliosis, and hantavirus infections are estimated to increase due to global changing climate (Mas-coma *et al.,* 2008; Clement *et al.,* 2009; Raimi *et al.,* 2018; Raimi, 2019). However, some studies have ascribed changes in patterns of disease, like tick-borne encephalitis, towards socioeconomic rather than changing climate (Randolph, 2008; Raimi *et al.,* 2017). At present, no clear evidence on the effect of changing climate on avian flu or influenza (Gilbert *et al.,* 2008).

The prevalence of animal infections, like virus such as blue-tongue and other Orbiviruses, make available additional evidence for the possibility of climate change consequence on vector-borne diseases (Purse *et al.,* 2008; Raimi *et al.,* 2017; Olalekan *et al.,* 2020). The species extinction across the world arising from fragmentation of habitat, pollution, climate change and the swift worldwide movement of individuals and other biotic organisms have synergistically worked to reduce the function of ecosystem. Modifications of ecosystem through changing climate and human-made environmental changes that can cause catastrophic environmental disease outbreaks (Aguirre and Tabor, 2008; Raimi *et al.,* 2017). The health systems capacity to effectively respond to the health effects, resulting from direct and indirect climate change faces a global challenge, particularly in several countries in low-income and middle-income, thereby, suffering from inefficient, disorganized and under-resourced health systems.

Table 1. Examples of Neglected Tropical Diseases (NTDs) Affected by Climate Change

Neglected Tropical Diseases (NTDs)	Transmission via	Estimated % of SSA infection population	Africa country with highest prevalence	SSA disease burden of Global total	Sources
Hookworms	H_2O	29%	Nigeria	34%	WHO, 2008
Ascariasis	Vector	25%	Nigeria	21%	WHO, 2008
Schistosomiasis	H_2O	25%	Nigeria	93%	WHO, 2008
Trichuriasis	H_2O	24%	Nigeria	27%	WHO, 2008
Lymphatic filariasis	Vector	6-9%	Nigeria	37-44%	WHO, 2008
Onchocerciasis	Vector	5%	Yemen	>99%	WHO, 2008
Trachoma	H_2O	3%	Ethiopia	48%	WHO, 2008
Drancunliasis	H_2O	<0.01%	Sudan	100%	WHO, 2008
Leishmaniasis	Vector	<0.01%	Sudan	No data	WHO, 2008
Human African Trypanosomiasis	Vector	<0.01%	DR Congo	100%	WHO, 2008
Buruli ulcer	Vector	<0.01%	Cote d'Ivoire	57%	WHO, 2008
Leprosy	Vector	<0.01%	DR Congo	14%	WHO, 2008

*SSA=Sub-Sahara Africa.

Source: Adapted from Hotez & Kamath (2009).

Table 2. Examples of Vector Borne Diseases Affected by Climate Change in Decreasing Order of Affliction

Disease	Vector	Current geographical distribution
Malaria		Tropics
Dengue fever		Africa, Caribbean, Pacific, Far east
West nile		World wide
Yellow fever	Mosquito	Africa, South America
Leishmaniasis	Sand flies	Africa, Central and South America
Trypanosomiasis	Tsetse flies	Africa, Central and South America

Source: Adapted from Hay *et al.* (2009).

5. The Climate System: An Overview

The composition of the atmosphere, which is made up of aerosols (very small particles) and gases disrupts the movement of incoming planetary radiation, including outgoing infrared radiation. The

atmosphere contains natural greenhouses gases (ozone (O_3), methane (CH_4), water vapour, carbon-dioxide (CO_2) and nitrous oxide) which naturally warm the surface of the earth's through impacting the discharge of infrared (heat) energy in interplanetary. The natural greenhouse effect of these gases is called the natural greenhouses effect (World Development Report, 2010). The natural greenhouse effect warms the earth by about 33^0C and retains majority of the global water in the form of liquid and permits life existence from near the poles to the equator. The released gases from activities of human have contributed to increase in the natural greenhouse effect. As a result, the average global atmospheric carbon dioxide concentration has dramatically risen since the start of industrial revolution. Due to carbon-based fossil fuels burning, and a slowdown deforestation, including land use changes, carbon dioxide concentration has risen from approximately 280 parts per million (ppm) toward 387 ppm in the last century and are presently growing at a proportion of around 2 ppm yearly (Bello, 1998; Afiesimama, 2000; Raimi *et al.,* 2018; Raimi *et al.,* 2020; Ajayi *et al.,* 2020). Through human activities, some artificially introduced pollutants lit the earth while others have been cooled by it. There remain some pollutants that are long-lived, and others short-lived. The earth is warmed as a result of the trapping of infrared radiation, carbon dioxide, nitrous oxide and halogens. Since their increased concentrations continue for decades, their warming effect ultimately translates into long-term earth's changing climate. Conversely, the methane warming effect persists only for a few years, while the aerosols effect, could be alternately heat trapped like black carbon (soot) or could be reducing heat, for example, reflective sulphates continue only a few days to weeks (Forster *et al.,* 2007). According to the World Development Report (2010), a sharp decline in carbon dioxide emission from coal combustion controls long-term warming, while lowering the cooling impact from sulphur emission principally through combustion of coal, that will lead to a rise of around 0.5^0C. Today, as report also noted, temperatures are already 0.8^0C above preindustrial levels and the current greenhouse gases concentrations alone are almost obligating the world to a 2^0C warming, a step higher than the world is expected to experience disorderly and dangerous outcome. Scientific understanding of climate change has greatly improved over the past few years. This has enabled scientists to make available a causal explanation for the occurrence of earths changing climate and predict possible future impacts. The IPCC, in 1995 resolved that "the most complete evidence on global climate submits a discernible human influence" (IPCC, 1995). By 2001, the IPCC confirmed its expert opinion when it noted novel evidence and the veracity of warming observed over the past 50 years is attributable to the activities of human (IPCC, 2001). Also, in 2007, the IPCC said that global heating of the earth climate system is unequivocal. Majority of increase observed in world-average temperatures in the 1920s is also due to the observed anthropogenic increase of greenhouse gas contributions (IPCC, 2007a). The IPCCs assessment fourth report asserts that climate change has recently been widely and better understood now as many climatic risks which are now considered to be larger than hitherto thought, with predictions of large sea level rise and increases in extreme weather events in this current century. The physical impact of the future earth's changing climate will have different consequences on people and

communities in varying temperature and in diverse regions. Yet, there is a consensus that they will be negative. According to Parry *et al.* (2007) in the World Development Report (2010). "When temperatures rise above 2^0C pre-industrial levels, availability of water will reach 0.4 to 1.7 billion people in mid-latitudes, including semiarid low latitudes. People suffering from severe water shortages will be more common in Sub-Saharan Africa and Asia. At high temperatures, more reefs are likely to die, and other crops, especially cereals cannot be grown successfully due to altered climates predominant in low-latitude areas. Approximately a quarter of biotic and abiotic species are probable at increased extinction risk. Communities will become more and more sensitive to heat stress and coastal zones will remain more constantly flooded" (Bello, 1998; Raimi *et al.*, 2018; Odubo *et al.*, 2019). Battisti and Naylor (2009) in World Development Report (2010) also observed that: "If temperature rise to 5^0C above the pre-industrial levels, approximately 3 billion individuals could suffer from extreme water stress, only the corals could die off, nearly 50 percent of the worldwide species could in due course go into extinction, crops productivity in tropical and temperate regions will decline to approximately 30 percent of the coastal wetlands will be submerged, the world will remain dedicated to several meters of rising sea-level, and there will be a heavy burden on the health systems, beginning from increase in malnutrition, cardio-respiratory and diarrheal diseases" thereby resulting to great implications for individuals, businesses, and policy makers (Raimi *et al.*, 2018; Raimi *et al.*, 2019; Olalekan *et al.*, 2019; Olalekan *et al.*, 2020).

6. The Climate Change Phenomenon

Climate Change has become a global issue that has caught substantial prominence in the 21st century especially recently and is also, incorporated into international politics, which now receives serious attention as a primary environmental and developmental threat. This has resulted in the lower atmospheric accumulation of Green House Gases (GHG). The worldwide gas concentration is increasing, principally due to activities of human, by way of fossil fuels combustion (releasing carbon dioxide) and deforestation (since forests tend to remove atmospheric carbon). The atmospheric carbon dioxide concentration, the foremost greenhouse gas, has amplified via 30% since the start of the pre-industrial times. Worldwide GHG emissions have increased via 70% between 1970 through 2004 (Climate Change Synthesis Report, 2007). In the year 2005, the atmospheric carbon dioxide (CO_2) concentrations and methane (CH_4) significantly surpassed the preceding 650, 000 years of the natural level concentration. The prime contributors of GHG emission worldwide since the 1970 has been in the energy segment, followed via "industry, forestry, agriculture and transport" sectors (Figure 6). This global picture is not quite different when compared with the situation in Europe where the major drivers of GHG are the energy and transport sectors with forestry remarkably having little or no contributions (Figure 7). Trapping of GHGs heat directly from sun are faster than they emit, causing an earth's temperature rise, likewise called "global warming" (Ayuba & Dami, 2011; Raimi *et al.*, 2018; Raimi, 2019).

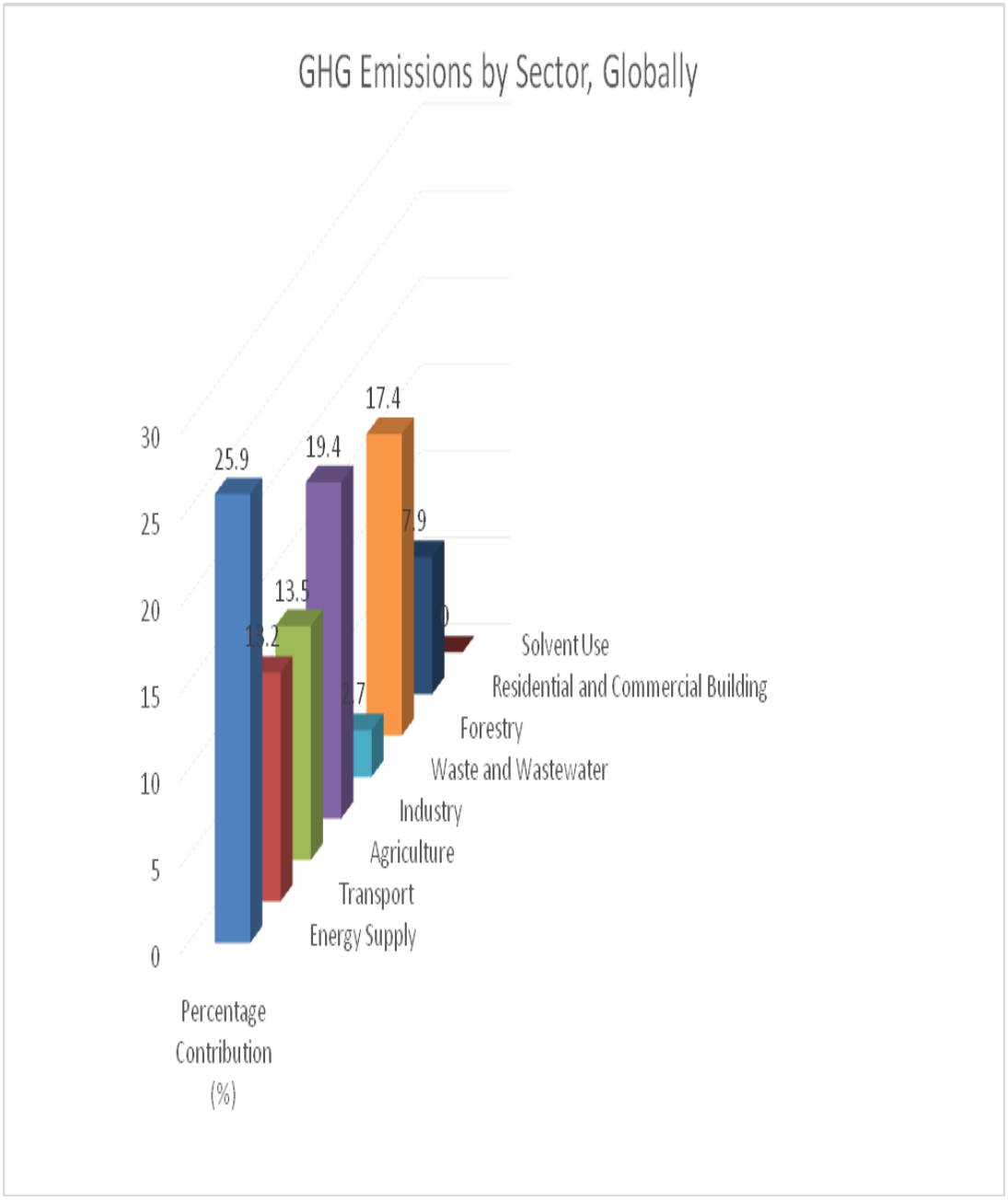


Figure 6. GHG Emissions by Sector, Globally

Sources: Adapted from Raimi *et al.*, 2019; Ebuete *et al.*, 2019 [doi.org/10.22158/ees.v2n2p18]

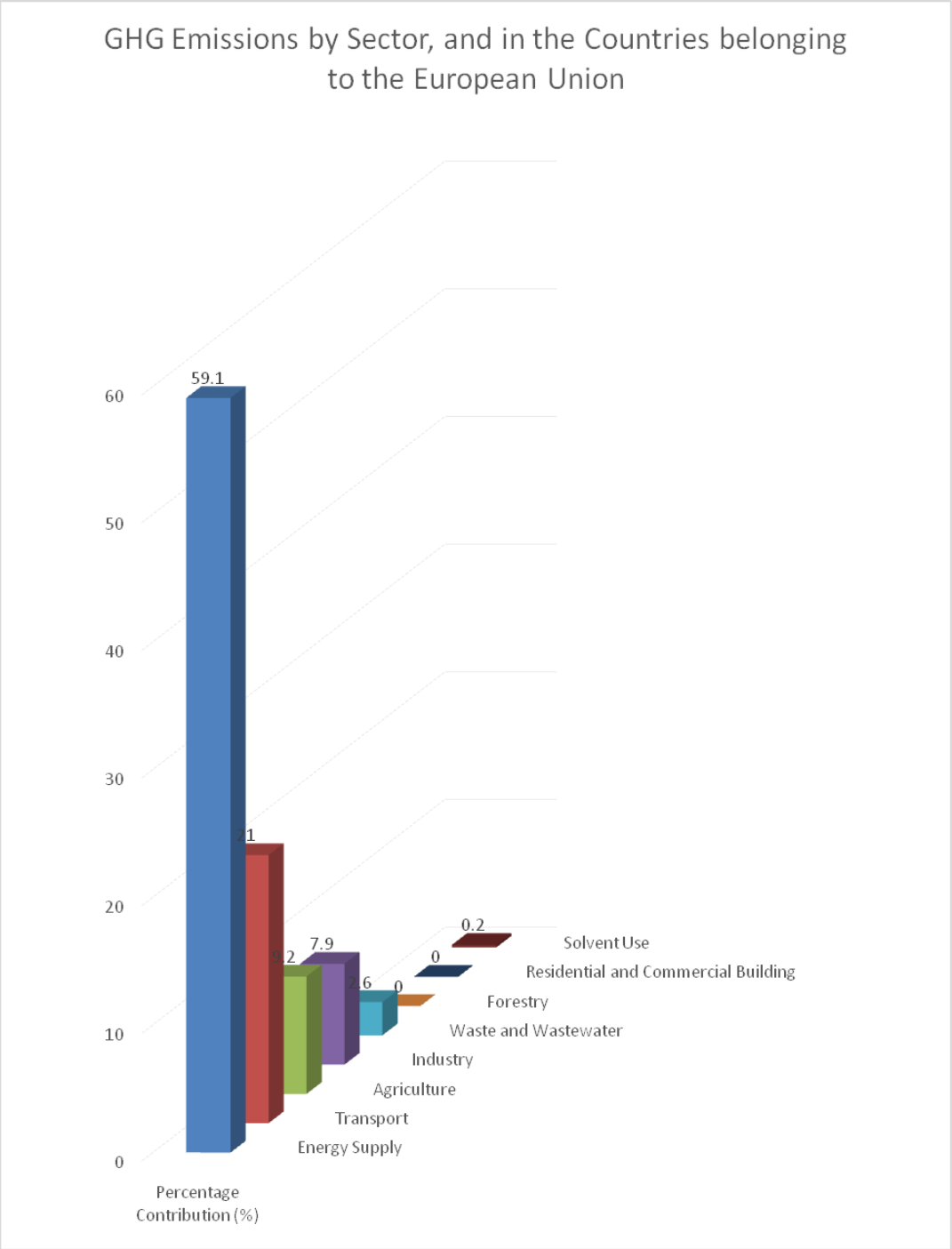


Figure 7. GHG Emissions by Sector, and in the Countries belonging to the European Union

Sources: Adapted from Raimi *et al.*, 2019; Ebuete *et al.*, 2019 [doi.org/10.22158/ees.v2n2p18]

The average worldwide surface temperature has exceeded 0.74ºC in the previous 100 years, causing widespread snow melting and global rising of the sea level. These changes already have had a conspicuous effect on several ecosystems especially in Europe, including many marines with terrestrial ecosystems for example the earlier time of spring, migration of birds and pole ward including

ascendant shifts in biotic and abiotic species (Summary for Policy Maker, 2007). Similarly, the spatial distribution changes brought about by some pathogens including pollen seasonality changes, which have also been observed (Confalonieri *et al.*, 2007). Climate change future projections by climatologists stems globally from climate model or universal circulation model experiments suggesting that worldwide surface mean temperature will increase via 1.5ºC - 3.5ºC through 2100 (Spore, 2008). This warming rate is remarkable and will result in precipitation changes, increased frequency and weather events intensity like storms with floods, including rising sea level owing to expanding oceans and mountain glaciers melting, etc. Rising sea level will in turn intensify coastal flooding vulnerability and storm surges. It is projected that the faster the changing climate, the more the damage risk to the milieu as climatic zones (and thus agricultural zones and ecosystems) may perhaps shift towards the poles from 150-550 kilometres by 2100 (Spore, 2008). The overall effects that several ecosystems can be reduced (or fragmented) and that species of individual can go into extinction. water, socioeconomic development, food production, agriculture and settlements, etc., will be affected by these changes. Table 3 shows the universal trends and direction in adverse weather events and its health impact (Onwuliri, 2009; Raimi *et al.*, 2018; Raimi, 2019).

7. Climate Change Incidence in Nigeria

Changing climate and its swift emergence in recent years have posed a key public health challenge, with poverty, inequity, and infectious and no communicable diseases together. Besides, the poorest nations will suffer the highest climate change consequences even if they have fewer emissions least. Changing climate is known to be responsible for nearly 5.5 million Disability Adjusted Life Years (DALYs) lost by 2000.While other continues around the world including Nigeria is directly visible to changing climate, through changes in the patterns of weather and through indirect changes in air, water, quality and quantity of food, agriculture, livelihoods, ecosystems and infrastructure. For example, annual precipitation has decreases in space and time through the reduction of 100-311mm depending on topography and the location (Ayuba & Dami, 2011; Raimi *et al.*, 2018). The result also shows fewer wet days and higher rainfall intensities as well as shortened crop growing periods (Ayuba & Dami, 2011). Between 1970 and 2000, many parts of Nigeria had witnessed variations in onset and retreat of rainfall relative to the period 1941-1970 (Jegede, 2010; Raimi *et al.*, 2018). Similarly, many parts of the country currently experience warmer conditions. A number of sectors have remained severely affected by changing climate in Nigeria namely; agricultural and forestry resources, as well as human, energy, water and coastal/shelf resources. In the rainforest and coastal agro-ecological zones of South-Eastern Nigeria, the common ecological problems are those affecting agriculture and forestry, water resources and energy resources especially fuel woods. For instance, erosion of soil is one of the utmost conspicuous land surface features in South-Eastern Nigeria which has negatively impacted on the general land use in the area (Ayuba & Dami, 2011; Raimi *et al.*, 2018). Floods are known to be a common and persistent phenomenon in many parts of the coastal reverie areas, where marine and

coastal erosion, including land degradation have also been observed. The Ogunpa flood disaster which occurred in the 1980s in Oyo State is a typical example of the devastating effects changing climate in Nigeria. Similarly, recent flooding events have been recorded in about 25 villages in the Ringim Local Government Area of Jigawa State located along the bank of Tiga River and in some village in Akwa Ibom State along the bank of the Cross River. Desertification is a problem in the northern fringes of Nigeria. Also increased evaporation has resulted in significant loss of surface water in Northern Nigeria as is the case with Lake Chad, which is Nigeria's major lake. Furthermore, drought is swiftly becoming a characteristic that is common in several parts of the country with reduced precipitation incidence and continued dry season. This has resulted in reduced agricultural activities with concomitant decrease in production of food and supply (Ayuba & Dami, 2011; Raimi *et al.,* 2018).

Table 3. Global Direction and Trends in Extreme Weather Events and Health

Phenomenon and trend	**Projections for the 21st century**	**Benefits or risks to human health**
Over most land areas, warmer days and nights, more hot days and nights and fewer cold days and nights	Virtually certain	Reduced mortality from decreased cold expose
Increase in frequency of warm spells/heat-waves over most land areas young and socially isolated	Very likely	Increased risk of heat-related mortality especially for the elderly, chronically ill.
Increase in frequency of heavy precipitation events over most areas health problems	Very likely	Increased risk of deaths, injuries, infectious, respiratory and skin diseases, and mental
Increase in drought areas	Likely	Increased risk of food and water shortages malnutrition and water and food-borne diseases
Increase incidence of extreme high sea levels (excluding tsunamis)	Likely	Increased risk of deaths and injuries from drowning and of negative migration-related health effects

Source: Adapted from Climate Change Synthesis Report (2007) and Raimi *et al.*, (2018)

8. Climate Change Evidence in Developed and Emerging Country

Global temperature has increased by approximately 0.6^0C. The last 142 global instrumental record have proven since 1998 that the past 100 years remained the single warmest year (Jonathan & Kerey, 2003). There is now evidence that climate change is already being experience in Nigeria and is related to activities of human that have given rise to Green House Gases (GHG) emissions (Bello, 1998). Climate models in the country submit that the future is likely to experience changes in seasonal rainfall, higher temperatures, including an intense shift toward a more extreme rainfall events, sea levels rise and more frequent storms. These variations may perhaps have a remarkable impact ranging from environmental processes to socio-economic that may perhaps be affected through weather (NIMET, 2009). The global assessment of global warming forecasts confirms this change by science photography resident in the Arctic to the Antarctica, from the glaciers to oceans, in all aspects of the climate zones. Rapid changing climate and its implication is quickly becoming a leading 21st century worst public health events, including the wrenching economic disruption stemming from COVID-19. With more than 90 per cent of confirmed cases coming from the urban centres, as cities remain the epicentres of COVID-19. This collection is real and draws together acceleration across the world. As the destabilization of this change together with weather related crises and overpopulation, disruptions of climate will affect more population than does COVID-19 pandemic and war (Oyedele, 2009). As a result, the United Nations Programmes on 'Global Environmental Outlook 2000' has cautioned that an impending global damage to the milieu is imminent by way of irreversible ecosystems damage (Owolabi, 2000). The 1992 Rio Earth Summit alerts the world clearly against the ills of mistreatment towards the environment (FEPA, 1993). While several nations have given significances toward other issues relating to the environment, whereas many countries face multiple challenges, some new and many enduring, including pandemics, rising global temperatures, unemployment, and inequality. For instance, the United States had the maximum environmental awareness issues followed by countries in Europe. Though some Mid-East, Asian and African nations are experiencing socio-political upheaval and instability, including wrenching economic disruption stemming from COVID-19 (Raimi & Raimi, 2020; Samson *et al.,* 2020; Raimi *et al.,* 2020; Gift *et al.,* 2020; Gift & Olalekan, 2020).

9. Studies of Earth's Climate of the Reality, Nature, and Conceptual Issues

Several researches have been conducted on the mechanism and perception of changing climate in Nigeria (Oje, 1987; Ayoade, 1995; Bello, 1998). Ayoade, (1995) and Oje, (1987) remained perhaps the first group of scholars to study climate change and global warming meaning, nature, and problems in Nigeria. Ayoade (1995) described climate change as a significant long-term change in the expected weather average of each situation over a period of time. Ultimately, climate change reflects irregular variations in the region expected climate. Bello (1998) submit that earth changing climate is caused through several factors which consist of the earth drying processes, the intensity of sunlight and more significantly, anthropogenic factors such as combustion of fossil fuels and ozone depletion. These

employees agreed that changing climate and its accompanying implications threaten the desire of Nigerians to attain socio-economic growth and become one of the most twenty industrialized nations in the world come 2030. Ayoade (1995) and Bello (1998) studied the wide-ranging causes and approaches for mitigating earth's changing climate. They have shown four ways to mitigate the menace of earth's changing climate. This includes lifestyle changes, novel inventions (for instance, using automobiles that are non-fuel energy), appropriate development of environmental management standards and policies and advanced initiatives in the direction of sustainable use of environmental related resources. Other authors have also studied the earth's changing climate mechanism for example Bormet *et al.* (2007) and Ayoade (2004). For example, Ayoade, (2004) reported that changing climate is triggered through greenhouse gases (see Figure 8 below). Hence, the sun rays that make it through the atmosphere are absorbed on the earth's surface. They are then radiated back into space with a wavelength longer than the incoming sunlight radiation, which in turn was visible light becomes infrared light. This wavelength lengthening is essential for the greenhouse effect: molecules of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) as well as other greenhouse gases are better able to absorb energy at any wavelengths of the radiation coming from above the earth's surface as well as heading back toward space instead of being at the wavelengths of incoming solar radiation.

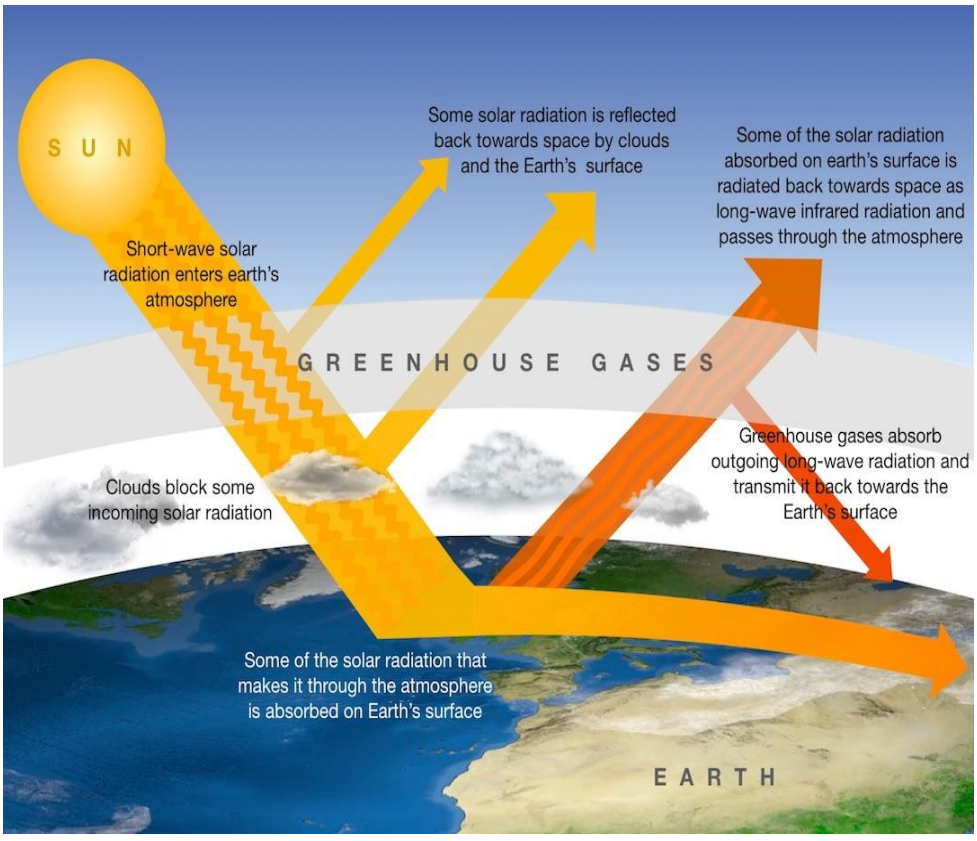


Figure 8. The Greenhouse Effect

Source: Adapted from https://courses.edx.org

Ayoade (2004) therefore noticed that earth's atmosphere works like a mirror in a greenhouse permitting considerable amount of sun's solar radiation to penetrate almost unimpeded, but absorbs most of the reflected heat escaping back to the planetary space (see Figure 8 above). This activity increases earth's temperature (as the case of a greenhouse) resulting in a measurable and significant rise in the earth's atmospheric ambient temperature, land mass and oceans. Green-house gases (GHG) improve the properties of the earth's atmospheric greenhouse. The solar radiation from the sun is allow to travel through the planetary space nonetheless avert the heat reflection from absconding to space. This causes an increase in earth's temperature (Bormet *et al.*, 2005). Onokala and Ali (2009) noted that the earth is at present experiencing a slow period of warming brought around through increasing levels of heat trapping gases (greenhouse gases) in the planetary space through a process called global warming). Involved greenhouse gases comprise methane, carbon dioxide, ozone, nitrous oxide, aerosols and synthetic chemicals. They summarized the key factors contributing to changing climate and global warming: (1) huge carbon dioxide emission (2) volcanic eruption (3) earth's variations in orbital characteristics (4) variations in solar output (see Figure 8 above). Quoting various authors, workers noticed that large quantities of volcanic eruptions inject dust, including greenhouse gaseous with substantial global warming potentials into the planetary space. Over millions of years, these materials have changed the very nature of the universal climate characteristics. Emission of carbon dioxide due to industries with other related anthropogenic activities as per the changing atmospheric configuration as refer to by these workers as most important forcing mechanisms to a changing climate in Nigeria.

10. Studies on Climate Change Impacts in Nigeria

Several practitioners (Ubachukwu, 2005; Njoku, 2006; Umah, 2009; Raimi *et al.*, 2018) examined the impact of changing climate on many Nigerian economy sectors. These researchers warned that global warming effects and Nigeria changing climate are at present a concern to individuals, institutions, businesses, governments, environmentalists, trade and policy makers. They claim that the climate change effects in the country usually reveals a shifting weather changes or patterns linking unprecedented and general variations in the patterns of weather, extremely heavy rainfall, uncommon temperature increase, propelling remarkable changes in various parts of the country, increasing the disappearance of sea levels in the coastal strips and visible upsurges in the occurrence of extreme weather events in some part of the country. They resolved through recommending that the governments could play an important role in information dissemination on the probable/concrete impacts of changing climate by way of projecting impacts on water resources, agriculture and diseases (Raimi *et al.*, 2017; Raimi *et al.*, 2018; Gift *et al.*, 2020; Gift & Olalekan, 2020). Efe (2009) highlighted the changing climate threat toward livelihoods and food security in certain states in Nigeria, although Ubachukwu (2005) on the other hand, studied the climate change effects on productivity of food in the Niger delta. They concluded that changing climate has remarkably impacts on all aspects of food

utilization, availability of food security, and access to seeds, with crop yields. They found crop yields decreases owing to temperatures decrease in the study areas and that farmer's majority had low awareness level on the peril of changing climate hazard. Efe (2007) emphasized the consequences of changing climate-induced variability's on livelihoods and security of food and suggested that issues relating to management of their work being raised can remain interpreted into policy making and decision through stakeholder's demand to ensuring security of food in Northern Nigeria. Njoku (2006) and Umah (2009) found that the descending trend in raining days' experience annually at Kano and Sokoto stations, including Kaduna decreased slightly during its rainy days yearly. It has been reported that changing climate induced variability has a negative impact on crop annual yields. Njoku (2006) stated that the presence of food crops decreases as temperatures and rainfall declined in the study areas. He suggested the prerequisite to effectively develop longitudinal policies on agriculture that are positioned within a well-defined environmental determinant. Obioha (2005), Baka *et al.* (2007), Okoli (2008) and Oluwatuyi (2009) assess the environmental implications of changing climate threat in Nigeria. Obioha (2005) found that the main environmental implications of changing climate resulting from transportation, physical changes insurance, flood defence migration, security, forest, water, and diseases spread. He found that variations in seasonal patterns of ecosystems timing, and direct impact on the economic were part of the regional and global warming effects. Baka *et al* (2007) mentioned in the case of IPCC 2007 observed and informed that the changing climate effects will be correlated across the regions. Climate change in Nigeria according to researcher will lead to severe weather events, desertification, (flooding) and famine, diseases spread and scarcity of water in some places in Nigeria. Okoli (2008) likewise agreed that the greatest environmental implications of changing climate will be seen as physical changes, such as higher local temperature, rising sea level and changes in the pattern of precipitation. Oluwatuyi and Jegede (2009) also suggest that rising sea levels are dramatically expected through the 21st century ending and coastal cities like Bayelsa, Delta, Lagos, Port Harcourt and including Calabar could be affected adversely. The studies added that Nigeria could loss an important proportion of her wetland and coastal strips. These researchers have found that changing climate will have a significant impact (increasing farming yields) in some states in Nigeria. This is due to enhance role of carbon dioxide in promoting photosynthesis, particularly in the prevention of photorespiration, that is accountable for the remarkable destruction of many Nigeria crops. Odjugo (2000), Obioha (2005) and Nnaji (2009) discuss the effects of changing climate on Nigeria socio-economic systems and growth across the various states in the next three decades had revealed that changing climate and prevailing climatic variability will have a negative impact on individuals, businesses, low-income and disadvantaged poor people in Nigeria, additionally, the procedure of poverty eradication are becoming more problematic due to the negative effects of a changing climate: (i) economic development (ii) poor standard of people's livelihoods and economic assets (upon which they depend) and (iii) the risks level to which the humanity is exposed. They recommended through observing changing climate implication and climate variability on short-term socioeconomic impacts

that could be vast nonetheless the impacts could be felt frequently by disadvantage Nigerian. Obioha (2005) noted that the economic sectors heavily depend on weather and climate sensitive sector which are affected mostly by their development. He described agricultural origin and water resources as an important sector. This, he said, could interrupt the revenues of government and undermine the government's capacity to finance vital services. Nnaji (2009) continues these deliberations through observing the poor that are adversely impacted through lessening their capacity and ability to diversify livelihoods and afford unrestricted and sustainable surviving strategies.

11. National Policies and Climate Change

Nigeria has a number of critical sector-specific policies in environment, agriculture, forestry, health, water resources, transport, ICT and communication which play a significant bearing in this response policy and changing climate strategy. Only a few policies directly deal with climate variability and climate change directly, but most have a few measures that have links with climate. Some of these policies include:

(i) **Environment Policies, strategies and plan:** To meet the challenges posed by the country's environmental problems, the Nigeria government developed the National Environment Policy in 1989 which in 1999 was revised to accommodate novel and evolving environmental problems. The aim of this policy reforms is to achieved sustainable development and, in specific to ensure(i) securing a healthy environment that promotes better health and well-being; (ii) propel and promote the sustainability of nature resource; (iii) encourage the ecosystem preservation and sustenance of ecological processes, including the preservation of biodiversity; (iv) raising public awareness with improving understanding of the relationships amongst the environment and development; and (v) collaborative partnership with government bodies, including private sectors and other developed and emerging nations and international organization on matters of the environment. In an attempt to implement environment policy, Nigeria has developed precise procedures with action plans which, if implemented properly can be adapted towards supporting national efforts to respond to climate change, especially with respects to:

a. drought and desertification — National Policy, on Drought and Desertification; Drought Preparedness Plan, (2007);

b. management of erosion, flood control and coastal zone — National and Desertification on Management of erosion, flood control and coastal zone (2005);

c. national sanitation policy

d. forestry — Draft National Forest policy, 2006;

e. protection of biodiversity — National Biodiversity Strategy and implementation Plan, 2004;

National Policy against desertification and drought recognise that changing climate can intensity desertification and drought in the northern part of Nigeria with these environmental concerns. In this context, precise strategies have to remain implemented towards moderating the adverse impact of

changing climate on desertification and drought. In particular, the specific policy with respect to changing climate is to provide equipment for relevant agencies, institution and citizens adequately concerned with the collection, analysis and use of sufficient climate data to reduce and combat desertification and drought. A major proposed implementation strategy of relevance to climate change is encouraging land use practice that enhance CO_2 sequestration, as such afforestation and agro forestry. It will likewise reduce damage to soil erosion and increase productivity of crops to climate change adaptation and economic development. Other long-term integrated strategies are elaborated in the National Action Programme (NAP) to battle desertification and reduce the effect of drought that was established in 2000 and remains one of the core implementation modalities for drought and desertification policy.

The National Forest Policy is at the process of finalization, but there is a "National Forestry Action Programme (NFAP)" which is aims to ensure the long-term sustainable and protection of forest management, while promoting collaborative and participatory development process, propelling private sector forestry development, including implementing a cohesive approach to forestry development. This encompasses three (3) sub — programmes including: forest industries, social forestry and forest management, all of which, if fully implemented will enable Nigeria to drastically increase its forest cover for the changing climate mitigation and adaptation and enable it to benefit from the REDD + global programme.

The National Biodiversity Strategy and Action Plan (NBSAP) is designed to provide a suitable framework with programme instrument for the preservation of Nigeria's ecosystem and improve its beneficial effect on changing climate adaptation and mitigation options. NBSAP aims to promote and improve the integration of biodiversity considerations into national planning, policies, development plans. The National Erosion and Flood Control Policy and its Action Plan is designed to warrant systematic and coordinated actions in hazard management and erosion control of floods to decrease both people and environmental impacts (Odubo *et al.,* 2019; Okoyen *et al.,* 2020). Some of the important measures include: (i) changing forecasting mechanism, monitoring with erosion control and floods; (ii) appraise the laws and regulations regarding land use; (iii) At all levels, promote and support education in the prevention, management and control of erosion and flooding; and (iv) encourage participation through creating public awareness. Also, the policies and strategies described above, Nigeria has a wide range of laws with regulatory measure towards the promotion of sustainable environmental performance and management in different economy sectors. Other important law that could affect the response of climate change, especially as it relates to the adaptation of ecosystem, comprise (a) the National Park Service Act promulgated by Cap N65 LFN 2004; (b) "Endangered Species (Control of International Trade and Traffic) Act-retained as Cap E9 LFN 2004".

(ii) **Agriculture policy:** Nigeria adopted a new agriculture policy in the year 2001. Some of the core purposes of the policy are: (i) the accomplishment of self-sufficiency in essential supply of food with the food security attainment; (ii) improved production of agricultural raw material for industries; (iii)

improved production with the export processing of crop, by means of increased production with processing technologies; and (iv) generating sustainable employment, the policy also seeks to lessen agricultural risks and uncertainties by decreasing the natural threat factor (including potentially changing climate) militating against agricultural production and security of investment. The framework of the policy covers a number of issues that could affect climate change including (i) agro-forestry production, livestock, fisheries and crops, (ii) control of pest (Isah *et al.,* 2020; Olalekan *et al.,* 2020; Isah *et al.,* 2020; Raimi *et al.,* 2020; Morufu, 2021), (iii) irrigation and water resources.

(iii) **Water policy:** In the year 2004, the national water policy was introduced. It aims to improve on the management of nation's water resources as well as the hydrological risks and vulnerabilities management. The assessment of water resources emphasis is to improve forecasting period of the hydrological phenomena, which will correspond to the potential of the exported changes that are likely to occur in the country's hydrological cycle over the next few decades because of the impact of changing climate.

(iv) **Coastal Marine Environment Policy:** Nigeria's coastlines which define its coastal reaches spans a distance of more than 800km and it is made up of highly varied geomorphologic characteristics that are very vulnerable to climate change. Although Nigeria is yet to have a separate policy directed at the management of the coastal zone, the country is taken part in the enactment of the UNDP/UNE/UNIDO/GEF program to combat the deterioration of the coastal area and the Guinea Current Large Marine Ecosystem (GCLME) living resource depletion through regional action. The main objective of implementing this project is to develop a strategic implementation framework to address the sustainable development of the regional environment. Part of the corrective measures to address the most pressing trans-boundary problems is that the project offers a good opportunity to provide a well-planned response to adaptation and climate-induced changes in Nigeria coastal environment.

(v) **Energy policy/plan:** The National Energy Policy sets the guideline for environmental protection as well as Nigeria's fossil exploitation. It also focused on renewable exploration with alternative sources of energy, mainly wind, solar and biomass. Nigeria foresees a stable, nonviolent and prosperous nation that is increasingly driven through renewable energy. By mid-century, affordable with sustainable renewable energy could reduce the country's total demand for energy by half, in so doing contributing towards country's effort to keeping GHGs to its barest minimum. The country's Renewable Energy Master Plan (REMP) has several pertinent specific objectives which if achieved will enable Nigeria to address changing climate risks in the energy sector, by way of ensuring that the country meets it increasing energy demands (Suleiman *et al.,* 2019; Ebuete *et al.,* 2019; Ajayi *et al.,* 2020). In particular, the country will be able to pursue an economic development path that is less dependent on fossil fuels (e.g., oil).

(vi) **Health policy:** Increase in health-related problems that are predicted for the future changing climate is directly linked to the major challenge that changing climate can pose to health management

in order to adapt directly to earth's changing climate. The main objective of National Health policy (NHP) is to expand the health situation of Nigerians and achieve the SDGs health – related goals. Supporting the implementation of the NHP are (i) National Adolescence Health Policy, (ii) National Reproductive Health Policy and (iii) The Nigeria Health Promotion Policy, which is at its draft stage and which vision is to decrease the rates of morbidity and mortality from a communication disease with a barest minimum; to reserve the prevalence increase in non-communicable diseases; achieving the global goals on disease elimination with eradication; and remarkably improves the quality of life expectancy for Nigerians (Raimi *et al.,* 2019; Omidiji & Raimi, 2019; Suleiman *et al.,* 2019; Raimi *et al.,* 2020; Adedoyin *et al.,* 2020; Olalekan *et al.,* 2020).

(vii) **Transport policy:** Nigerian's transport sector has some critical vulnerability issues which are already being amplified by increasing adverse weather conditions. This is more so because the sector is characterized by a collapsed rail system, weak civil aviation system and poorly maintained road transportation network. The Nigeria's policy in the transport sector in general focuses on addressing problems like regulating urban transport economics, enforcement of safety measures, land use with transport planning, funding, institution framework with public private partnership within the transport sector. The implementation of the policy will enhance Nigeria's preparedness for more severe weather condition in a changing climate (Suleiman *et al.,* 2019).

(viii) **Tourism and Culture Master Plan**: Culture is an important factor for climate change, but climate change is profoundly affected by it. Given the high dependence of tourism on the environment, the sector is very sensitive to earth's changing climate thus a wide-range of environment changes due to changing climate will severely have an adverse effect on it. It is the climate that determines the seasonality in tourism demand and its operating cost, for example water supply, snowmaking, heating-cooling, irrigation, food, etc. The National Tourism Plan (NTP) was developed in 2005. It emphasized sustainable tourism, including the conservation and protection of national parks and game reserves. This makes it relevant to the imperative of environment sustainability, particularly in the face of increasing earth's changing climate (Adindu & Raimi, 2018; Ihuoma & Raimi, 2019; Olalekan & Adindu, 2019; Adindu *et al.,* 2019; Suleiman *et al.,* 2019).

(ix) **Vision 2030:** A twenty-year development plan designed to support Nigeria's economic growth as well as developing the country towards a pathway of sustained development plus swift socio-economic, which has been drawn up. This is contained in the Vision 2030 blueprint which enunciates the economic growth plus development strategies of Nigeria's from 2010 to 2030, with the aim, amid others things, to mitigate the impact of earths changing climate on the socio-economic development progressions in the context of sustainability and environmental preservation for socio- economic growth. In such cases, it will (i) strengthen environmental stewardship; (ii) improve environmental education and learning; (iii) boost economic profitability owing to viable environmental management.

12. Consequences/Concerns of Climate Change in Nigeria

The satire of earth's changing climate as a worldwide problem has affected countries in the global south who contribute negligibly towards the problem source have become most susceptible to its effects. Emerging countries are already suffering the most damage from earth's changing climate since they have the minimum human and technological resources endowment to battle the problem, including their economies which are largely dependent on natural resources-including sectors which are sensitive to climate. Country like Nigeria belongs to this group. Recent studies (Onwuliri, 2009; Ayuba & Dami, 2011; Raimi *et al.*, 2018; Raimi, 2019; Raimi *et al.*, 2019; Raimi *et al.*, 2019; Odubo and Raimi, 2019; Ebuete *et al.*, 2019; Suleiman *et al.*, 2019; Raimi *et al.*, 2020; Ajayi *et al.*, 2020; Adedoyin *et al.*, 2020) show that Nigeria should be concerned about the impacts of changing climate on many reasons, including particularly the following:

1) The country is highly vulnerable because of its estimated population of 210 million, increasing at 3.2% proportion per annum, while the rate is expected to rise to 56.8% in 2020 and 63.6% by 2030 correspondingly and its location in the tropics. In addition, it has an elongated coastline (800km) that is susceptible to rising sea level especially with most of the adjoining land lying within 3 meters of the coastline. Studies show that a 0.2m sea-level increase will overwhelm 3,400km^2 of our coastland; a 10m increase will cover 18,400km^2. Incidentally, the whole Niger Delta is less than 6,000km^2, besides the mangrove total area of the country is around 8, 000km^2.

2) Threat to water resources, affecting energy source such as Shiroro and Kainji dams.

3) Fishing activities and agricultural rain–fed upon which provides about two–third (2/3rd) of Nigeria's food security, is facing a serious threat of climate change.

4) Nigeria has a very high population density of an estimated 167 million population living on physical milieu through several activities spanning 923,000 sq km.

5) There is inadequate financial and technological expertise capacity in Nigeria to address the adverse impacts of changing climate.

6) Nigeria at the moment do not have a comprehensive institutional planning, including legal framework and methodical approaches with targeted policies towards addressing the impacts of changing climate.

7) The health system at the moment is inadequate to wards dealing with the threat of vector-borne diseases and other emerging diseases of public health significance such as COVID-19, as well as the key challenge of our time, i.e., climate change.

In consideration of the above concerns, it becomes imperative that coordinated and concerted action must urgently be set in place towards addressing the issues of changing climate in Nigeria. If this is not done, the impacts of climate change may severely constrain Nigeria's continuing development priorities to reduce poverty, as expressed in such cardinal policy documents as those of the "Seven-point Agenda", "Vision 20 2030", "MDGs" and now SDGs. However, changing climate, besides extreme weather conditions is health threatening nowadays as shown in figure 9a and 9b below,

and if left unaddressed, can lead toward disease and death increases. Urgent action must be put in place to reduce changing climate and prepare the systems of environmental/public health towards protecting communities from adverse health impacts.

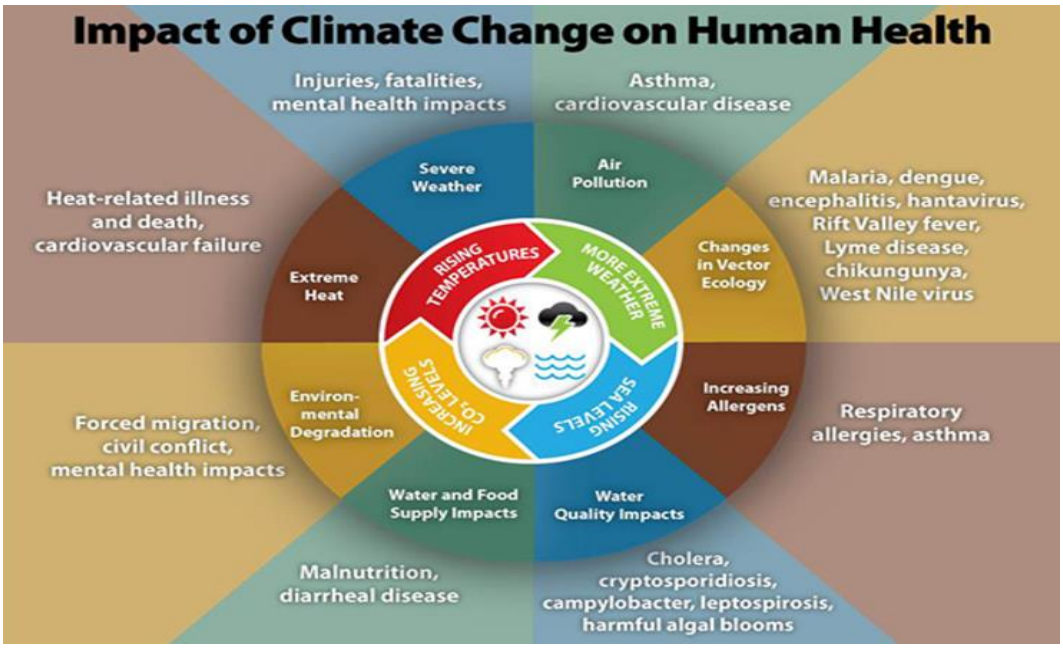


Figure 9. Impact of Climate Change on Human Health

Source: Adapted from https://www.cdc.gov/climateandhealth/effects/default.htm

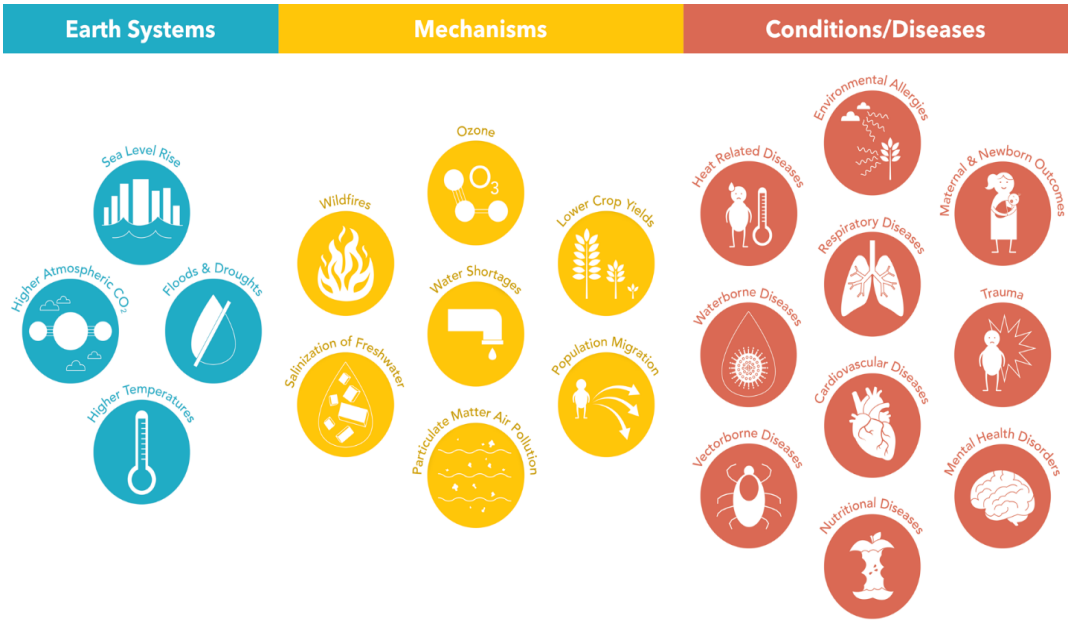


Figure 10. Climate/Health Framework

Source: Adapted from https://courses.edx.org

In addition, the climate/health implications, show a causal relationship between climate change components and impacts on major disease groups, offers a comprehensive overview of the severity of the problem.

There exist six climate change components viz: altered rainfall patterns, increase in temperature, ocean acidification, rising sea-levels, extreme weather events as well as climate-active pollutants. Each has their own unique approaches, but frequently linked pathways toward the most important health outcomes. Within each group of influence, such as infectious diseases, many wide-ranging disease entities are sensitive toward being affected by earth's changing climate, each by its own spreading mechanism. The aforementioned has projected that there remain at least hundred (100) climate-sensitive diseases. It is necessary to focus on several large groups viz: diarrhoea, malnutrition, respiratory as well as vector-borne diseases and cardiovascular. Mental disorders remain a long-term implication, a problem that is difficult to touch in recent research efforts. Toward making the plot even thicker, all diseases that are climate sensitive have remained as well as will carry on to be strongly influenced through social determinants, most of which are not involved in figure 10 above: productivity loss, poverty, habitat loss, mass migration, as well as violent conflict. In addition, when earths changing climate influences human health, the burden of disease increases. The graph below (Figure 11), which shows the burden number reached up to the year 2100 as marked "Potential total health impact," can be found on the right-hand upper part of the graph. This is the effect if we don't have a policy that limits or acknowledge earth's changing climate. The policies impacts are described in blue (mitigation) as well as black (adaptation) sections of the graph. The mitigation is aimed at reducing greenhouse gas emissions as well as increasing carbon sinks, whereas adaptation is aimed at protecting people's health against already-committed earth's changing climate. Additionally, a reduction towards baseline disease burden indicated in light green under the graph bottom. This existing improvement in our health is been achieved by *health co-benefits*. This means improvement in health through individual mitigation interventions (e.g., using a bicycle as a substitute for personal car), or through public interventions (e.g., societies changing from the use of fossils fuels to renewable in lieu of energy generation).The darker green shade in the middle of the graph place emphases on the worst-case health effects if we do not take into account policy/behavioural remodifications of human behavior as well as policies, since they remain opportunities aimed at improvement.

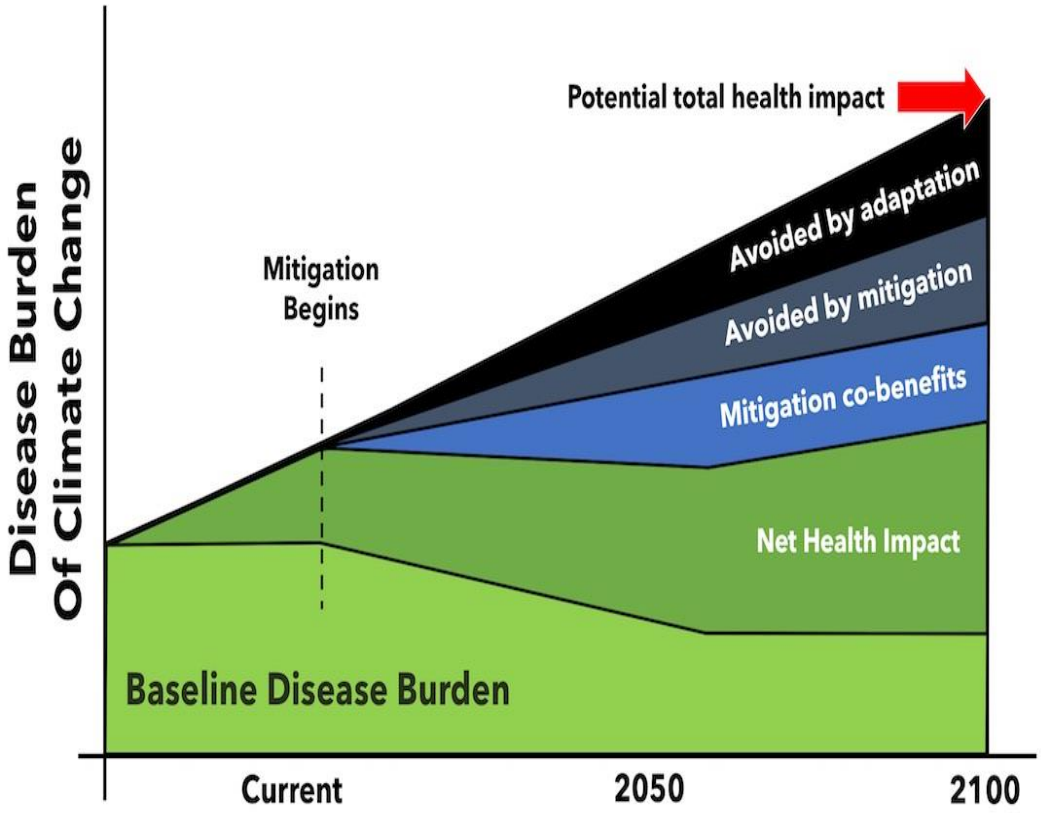


Figure 11. Net Health Impact of Climate Change

Source: Adapted from McMichael and Lindgren (2011).

13. Earth's Changing Climate and Its Direct Impacts on Environmental Health

The probable health impacts of changing climate are numerous. Tackling these health problems is a major challenge not merely for environmental health experts, but also for those responsible for climate change policy. Integration and a holistic critical response are essential for economic, social and moral reasons. Changing climate due to anthropogenic activities cannot be reversed. The change magnitude, including its intensity, as well as the willingness and ability to ease this issue, it is also a considerable subject of debate and controversy. Nevertheless, changing climate directly affects five (5) environmental components namely: weather, air, water, oceans and ecosystems (IPCC, 2007). A complicated relationship exists amongst changing climate, human health and the environment. Conversely, there is no skeptism that changing climate is at present affecting public and indeed environmental health due to myriad of environmental implications like rise in sea-level, heat waves, storms and deteriorating air quality, changes in precipitation due to drought and flooding and changes in hurricanes intensity. In a tally having only four (4) diseases (malnutrition, cardiovascular disease, diarrhoea and malaria) including floods. The World Health Organization (WHO) projected 166,000 deaths and approximately 5.5 million disability adjusted life years (Dalys, a measure of the total severity diseases burden) were attributed to changing climate in the year 2000 (Cambell-Lendrum *et al*.,

2007; Raimi *et al.,* 2018). To date, most analyses on changing climate and health have been based on diseases that principally affect individuals in emerging countries and thus are professed as less significant to more advanced countries. Though, the current pandemic of the Novel Coronavirus COVID-19 and H_1N_1 virus has revealed that such diseases have no respect for international boundaries. Thus, changing climate could be a driver for migratory diseases (Onwuliri, 2009; Gift *et al.,* 2020; Samson *et al.,* 2020; Gift & Olalekan, 2020; Raimi *et al.,* 2020; Raimi & Raimi, 2020). Examples of environmental health directly affected by climate change include, water resources management, air quality management, diseases control, control of pest and vector, protection of marine ecosystem, management of waste and sanitation, etc.

13.1 Climate Change: Effects on Water Quality and Quantity

Changes in the precipitation pattern and other rainfall, changing temperature and ice cap melting during summer are likely to have led to changes in the quantity and water availability across the world over the subsequent 30 years (IPCC, 2007). In country like United States for example water security or drinking water supply, manufacturing, agriculture, and myriad of other uses, is becoming a pressing concern. This is especially true in the Western hemisphere of the nation, where water shortages increasing due to decreasing mountain snowpack as a result of warming, and severe drought in the south have turn out to be a more recurrent incidence in recent years (Anon, 2009). The quality of water in many areas is affected by extreme weather conditions like flooding and hurricane. These same phenomena, often linked with rising sea-level and increase in storm surges, can severely affect human communities and modify complex coastal ecosystems with implication due to the supply of water and food quality. Flooding can damage health from diseases spread since no sanitation technology may be completely safe during flood water, as faecal matter could mix with the flood water and become spread with the movement of the contaminated water (Onwuliri, 2009; Morufu & Clinton, 2017; Raimi *et al.*, 2017; Raimi & Sabinus, 2017; Olalekan *et al.,* 2018; Gift *et al.,* 2020).

Generally, health and water sanitation are linked in several ways. For example:

1) Drinking contaminated water can lead to water-borne diseases like infective hepatitis, cholera, dysentery, typhoid and other diseases that cause diarrhoea.

2) Insufficient water can affect a person's personal hygiene, and can affect skin and eye infections spread for example conjunctivitis scabies and trachoma.

3) Water-related vector-borne diseases and water-based diseases can result from water supply projects (including dams and irrigation structures) that unintentionally provide shelter for mosquitoes and snails that are intermediate host of parasites that lead to Schistosomiasis, Lymphatics filariasis, malaria, Onchocerciasis and Japanese Encephalitis, etc.

4) Consumption of supplied water that comprise high quantities of certain compounds (such as arsenic) can lead to severe diseases.

More specifically poor water supply, sanitation and hygiene in particular tend to be responsible for most of the burden of disease and mortality in emerging countries. Examples include the following:

5) Approximately 4 billion diarrhoea cases occur yearly, killing an estimated 2.2 million people, with most causalities being children under five.

6) Diarrhoea accounts for about 4.3% of the total worldwide disease burden (62.5 million DALYs) and nearly 88% of this burden is linked to drinking water supply that is unsafe, insufficient sanitation and poor hygiene. These peril aspects are secondary, after malnutrition, in contributing to the overall burden of disease as a whole.

7) Intestinal worms affect approximately 10% of the population in emerging world, and can cause anaemia, retarded growth and malnutrition.

8) It is estimated that six million people are blind to trachoma and the number of people at risk is almost 500 million.

9) It is estimated that three hundred million people have malaria.

10) An estimated two hundred million people are infected with *schistosomiasis*, with about 20 million suffering severe consequences.

13.2 Climate Change and Air Pollution

The chemical composition of the atmosphere changes due to temperature, humidity, ultraviolet radiation concentration and several other factors. Changes in some of these directly decrease air quality, especially in cities, through increasing the amount of air concentration and human exposure to a range of poisonous air pollutants such as chemicals, aero-allergens and fungi (Raimi *et al.*, 2018; Raimi, 2019; Raimi *et al.*, 2020; Ajayi *et al.*, 2020). Similarly, droughts and wildfires which are consequences of climate change will decrease overall quality of air and increase human exposure due to a range of pollutants, leading to asthma increase, cardiovascular diseases and other respiratory infirmities. Climate change with changes in production of pollen can affect duration and timing of seasonal allergies (Onwuliri, 2009; Raimi *et al.*, 2018; Raimi *et al.*, 2020).

13.3 Climate Change and Pest Vector Control

Climate change may be directly related to several habitats of pest and disease vector. The impact of changing climate on vector-borne pathogenic diseases could be direct or indirect in vector biology. The direct effects according to Rueda *et al.* (1990) include temperature, humidity, precipitation and wind. For instance, an increase in heat increases vector's metabolic rates, which in turn affects the nutritional need for the vector. Although warmer temperatures allow the spread of plant diseases as well as pests toward higher levels plus poleward as well as some have done so based on observations in recent years, as shown in Figure 12 below

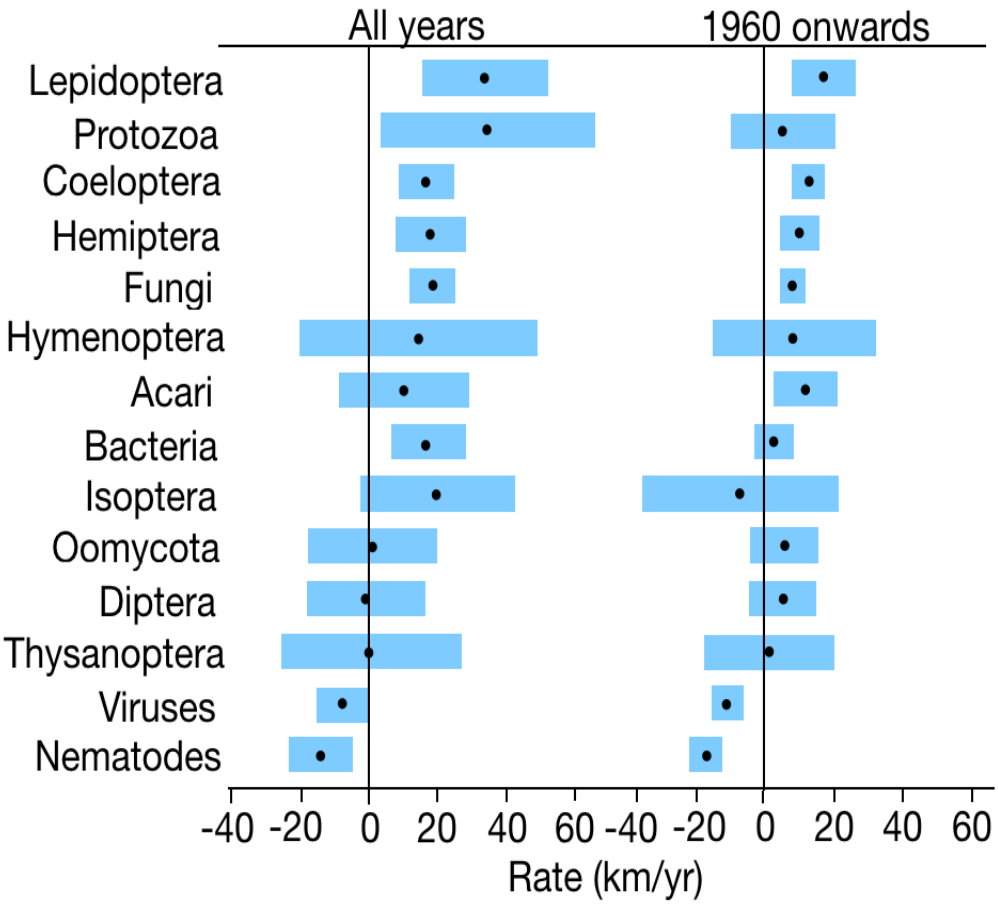


Figure 12. Yearly Latitude Shift for Pests and Pathogens

Source: Adapted from Daniel *et al.*, (2013)

Even when pests plus pathogens are active, plants can protect themselves from pathogens during warm temperatures, as well as in some circumstances protect themselves against novel or more hostile insects or diseases. Some pests as well as pathogens attack plants during flowering. When heating makes pest or pathogen arrive before, or after, the flowering opportunity window closes, it possibly will not affect their plant host. The differential warming effects during flowering time as well as pest and/or arrival of pathogen make it challenging toward understanding how warming affects such diseases plus insects. Under these conditions, the blood sucking vectors feed more regularly, leading to improved egg production. This in turn upsurges the spread of these vectors' potential. Since the geographical distribution and survival of arthropod vectors are limited by minimum and maximum temperatures (and humidity), temperature variation has direct effect on their distribution and survival. Furthermore, high relative humidity directly favours the metabolic process and natural history of many vectors. However, such high relative humidity creates favourable conditions for the arthropod vectors to be susceptible to fungal and bacterial infection, which could reduce their population and transmission.

13.4 Climate Change and Disease Control

The main pathogens and the probability of changes in their distribution due to changing climate have been assessed by Leovinsohn (1994), WHO (1994), Martens (1995), McMichael and Bundy (1996), Patz *et al.* (1996) amongst others. Through this assessment and classification, the environmental spreading of malaria is probable to be affected through changing climate. The other diseases distribution like dengue and yellow fever, schistosomiasis, onchocerciasis, are expected to be affected through changing climate. Malaria stands out in this group of diseases because the transmission of malaria like most other infectious and parasitic diseases is closely related and in fact controlled mainly by rainfall, temperature and air humidity (Bruce-Chwatt, 1991; Raimi *et al.*, 2017). These regulate the biology of development of both vectors and pathogens. Hence, de Zulueta (1987) reported that climatic changes of the past have indeed greatly affected the distribution of malaria. One report suggests an additional 100-700 million (to the current 2.4×10^6 at risk) people could be at risk from malaria caused by human-induced climate change by 2050 (Marten *et al.*, 1997). This malaria situation is provoked mainly by expected global increase of the seasonal transmission potential of the disease vectors. This phenomenon according to Martin and Lebevre (1995) would bring about the seasonal zones encroachment on those that are perennial in nature and through the seasonal expansion of malaria into areas previously free of such disease before.

13.5 Climate Change, Waste Management and Sanitation

Intense hurricanes and flooding occasioned by climate change can increase a wide variety of health impacts including drinking water contamination from raw sewage due to water infrastructure damage and the washing of waste (including human excreta) into bodies of water. Human excreta are important sources of pathogenic organisms. Contamination of portable water supply with sewage may result in a number of water-borne diseases such as typhoid, diarrhoea, cholera, etc. Consequently, environmental sanitation is undermined and serious challenges are posed to healthcare management. For example, excessive flooding of the environment in the rainy season throws up an abundance of waste water with loads of germs and parasites plus other organic or biochemical agents most of which may be detrimental to good environmental healthcare. The situation is worsened by the lack of adequate or effective drainages. Likewise, poor and inadequate waste disposal systems contribute substantially to problems of environmental sanitation (Jegede, 2010; Olalekan *et al.*, 2018; Raimi *et al.*, 2019; Gift *et al.*, 2020).

13.6 Climate Change and Marine Ecosystem Management

Global changing climate is visible and has a profound impact on the oceans and seas with serious impacts on the health of human. The ocean waters warming contributes to increased frequency and severity of algal blooms that are toxic, aquatic alternations in estuarine food webs as well as quality of seafood availability, plus impact on sentinel aquatic ecosystems (Chauhan, 2011; Okoyen *et al.*, 2020). The large amount of carbon dioxide concentrations in the atmosphere increase digestion in the ocean and leads to acidification and ecosystems disruption. Since large parts of the global populations, as well

as individuals in the Niger Delta region of Nigeria live in the wetlands regions and lots hinge on marine protein for their day-to-day subsistence, severe implications and turbulence will cause the delicate ocean as well as coastal systems to be far-reaching (Chauhan, 2011; Okoyen *et al.,* 2020).

14. Indirect Implications of Earth's Changing Climate on Environmental Health

Other consequences of changing climate not directly related to the aforementioned environmental health indicators but having indirect links with the environment and affecting health include for example the following:

14.1 Climate Change and Food Security

The impact of changing climate on global food security is a priority in public health that requires a holistic intersection of evidence, implementation science, multispectral policy and politics approach to foster collaboration, facilitate dialogue, and advance evidence-informed decision-making (EIDM). Overcoming both the changing climate and food insecurity is not only a matter of finding solutions to provide more food, but also will entail multi-stakeholder policies that can combat ecosystems and provide more sustainably and effective food, as well as with the additional goal of improving the livelihood of the poor people. Climate change has been known to be linked with stable shortages of food, malnutrition and contamination (e.g., of seafood with chemicals contaminants, bio-toxins and pathogenic microbes, contamination of crops by pesticides). Malnutrition is a major health crisis globally. Accordingly, UN Food and Agricultural Organization (FAO) estimated about 790 million people in emerging countries particularly in Sub-Saharan Africa are malnourished (IPCC, 2007). Changing climate is putting more pressure on worldwide food supplies as up-to-date models show that agricultural production will rise in the high and mid latitudes, but will decline at low latitudes. The probable impact is to be predominantly worst in Africa, which is already burdened by poor infrastructure for agriculture (IPCC, 2007). Small changes in the production of food or crop yields can cause significant price changes, particularly where unregulated assumption is likely on the exchanges of commodity. Increase in the prices of food is a key hunger source and malnutrition, which in turn can lead to child mortality rates increase; hence, this problem may perhaps develop over the succeeding 20 years as the initial indicators of the impact of changing climate on health. In addition, the governments essentially should provide regulations on consumption of food. A unique starting point is to outline and promote a diet that is sustainable, which aims to reduce the risk of obesity, cancer, incidence of heart disease and diabetes.

14.2 Climate Change and Social Dislocation

In some setting, the effects of changing climate are causing social disruption, decline in economic and populations displacement. Migration on large scale is expected, in reaction to drought, flooding and other natural disasters. Coastal populations are mostly affected by rising sea-level and flooding. In Bangladesh for instance, it is estimated that approximately 20% of land area disappears from a one-meter sea level rise and this will affect over 10% of the population. Similarly, such dislocations

have been recorded in many of the coastal communities in Nigeria. All local ecological disturbances triggered through extreme event and the situations of population dislocation and resettlement could affect the possibility of outbreaks of infectious disease (Chauhan, 2011).

14.3 Changing Climate and the Phenomenon of Heat Waves and Milder Winters

Heat waves pose a real risk to communities that are vulnerable and remarkable risks increase in extreme heat are predictable in all climate change scenarios. Moreover, heat stress is a direct consequence to high temperatures exposure. "Stressful hot weather episodes (heat waves)" lead to elderly death, equally heat related illness as per heat exhaustion and heat stroke. Changing global climate, plus an upturn in the severity and incidences of heat waves will affect life quality in several urban centres. Heat waves causes remarkable disease-related death proportion in developed countries like Australia and United States. Similarly, in Nigeria, exposure to heat has a variety of health impact due to mild heat rashes in Southern parts of the country to deadly heat stroke in the North. On the other hand, milder winters induced by increases in temperature would reduce the excess mortality and morbidity due to winter and represent some of the short-range benefits to climate change in some portions of the world (Confalonieri *et al*., 2007; IPCC, 2007).

Improving climate modelling will aid the reduction of the reliability of extreme meteorological events to future expectations, in relations to temporal and spatial distribution, incidence and magnitude. Global advances in monitoring, particularly satellite technology such as remote sensing and Geographic Information Systems (GIS) as well as improved communications, can assist in providing temporary signals of floods and windstorms as well as early droughts warnings and heatwaves, ensuring "effective emergency management planning as well as water resource and supply arrangements". Improving coordination between international organizations on extreme droughts and flooding will assist in reducing the risk of these public health events as well as guarantee a swift arrival to normality. Figure 13 below shows the disparity of surface air temperature at different year between 1990 and 2090.

Likewise, research also shows that earth's changing climate will rise earth areas that are likely to experience harmful heatwaves, consequently approximately three quarters of all the individuals alive could be affected come 2100. Figure 14 below indicate how a trifling shift in mean temperature can cause a big change in the number of hot weather days. The blue bell-shaped curve branded "previous climate" indicate the spreading of days in a certain place (e.g., a city) throughout a year. In this area there are relatively few hot days as well as relatively few cold days (the curve height is a measure of exactly how frequent the temperature is usually reached on a certain day of the year). As the mean temperature rises upward, toward creating the red "new climate" curve, the sum of days with hot or record hot weather grows dramatically, with approximately 3 times the amount of hot days as well as a whole set of days (the "record hot days") with exceptional heat. That is, when the mean temperature increases, the frequency plus heatwaves intensity increase considerably.

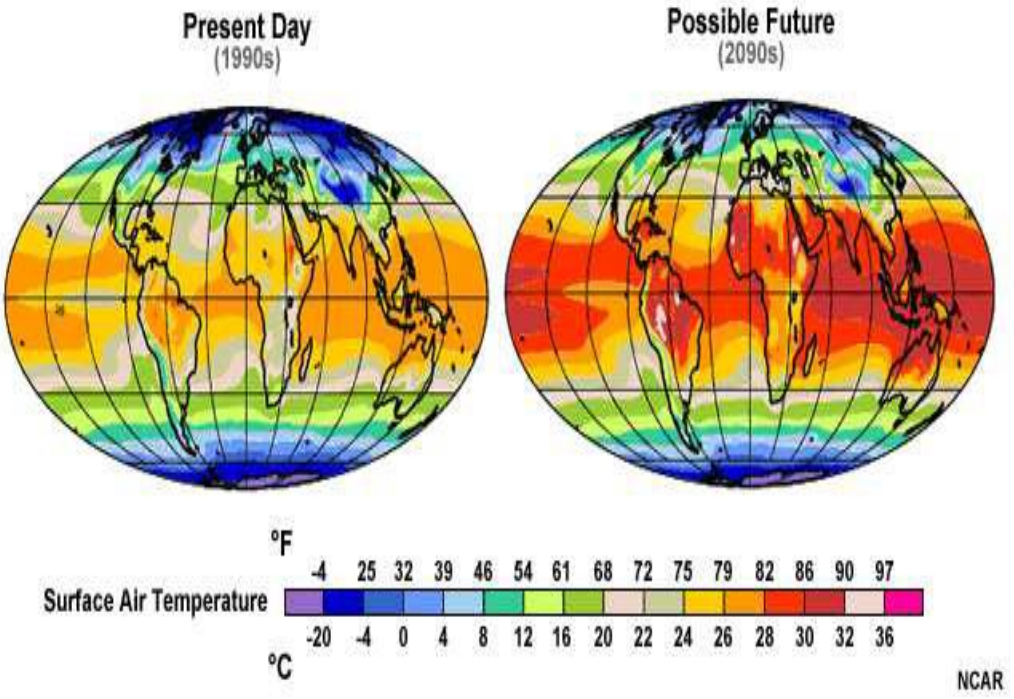


Figure 13. Surface Air Temperature Variation at Different Year between 1990 and 2090 Due to 21st Century Projections of Changing Climate

Source: Adapted from http://www.giss.nasa.gov/research/news/20160120/

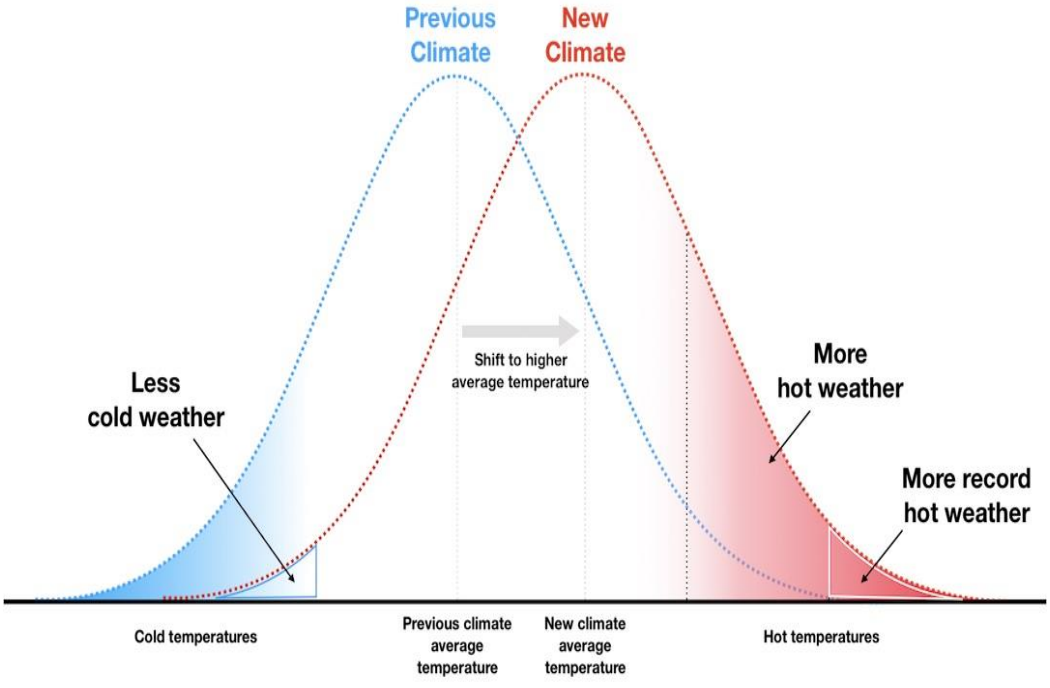


Figure 14. Effects of Increasing the Average Temperature on Temperature Extremes

Source: Adapted from https://courses.edx.org

15. Vulnerability in Nigeria to Changing Climate, Mitigation Options and Adaptation Strategies

The savannah areas of northern Nigeria have been experiencing a reduced amount of rainfall, which attached through increases in temperature, will decrease availability of soil moisture. The savannah and semi-arid regions have already experienced seasonal and interannual climatic variabilities besides there exist a droughts and effective processes of desertification. This condition may well remain deteriorated by further drought probabilities as well as other rainfall variabilities through rainfall decrease. All of these factors will result in reduce availability of soil water and contribute to the increase in adverse features of savannah ecosystems, as well as erosion of water and wind, which affect livestock and food production, access to fuels and human settlements identity. Changing climate is causing serious damage to forest ecology as well as the ecosystems. In several parts of Nigeria, as in other parts of West Africa, rangelands and tropical forests are threatened due to demographic pressure in the land use process. Thus, any changes in the forests are also likely to be worsened by human competition for land. Thus, the apparent threats of climate variability and change will lead to biodiversity loss, rapid land cover deterioration and depletion of water accessibility due to catchments and aquifers destruction. In particular, there will be forest and land cover changes, biodiversity distribution, composition and patterns of migration, and poor distribution of biome. In some of these situations, the ecological situations changes, and do not allow existing ecosystems to result in new ecosystems while slowly attacking the neighbouring environment where the climate seems more favourable. Therefore, climate variability and changes can affect ecosystems boundaries and the species mix that constitute them, so that the dispersal of different patterns of biotic and abiotic communities will reflect how the diverse ecosystems have remained adapted to the predictable climates (Abiodun *et al.*, 2007; Afiesimama *et al.*, 2006).

In recent years, there have been a lot of problems arising from climatic variations and variability and providing sufficient food for an estimated population of 201 million people, growing at the rate of 3.2% per annum (Raimi *et al.,* 2019; Olalekan *et al.,* 2020). Nigerian population is becoming more challenging as the numbers increase, and as land, water and vegetative resources progressively degraded for example, through the consequences of drought and desertification. These snags can exacerbate future climate change, which will thus significantly affect food production. In general, five facets of the direct consequences of changing climate may depend on agriculture. These include the implications resulting from (a) increased precipitation and rising air temperature. (b) Increased precipitation intensities and rainfall variability. (c) agro-climatic and agro-ecological changes (d) Impacts on agricultural systems (e) implications of sea level rise on coastal agriculture (IPCC, 2000; Afiesimama, 2000). As already noted, the Sudano-Sahelian region would be drier and agriculture in the region would face problems of water stress. On the other hand, if the very humid southern parts of Nigeria become humid with greater intensity as flooding and soil erosion may be exacerbated, resulting in destruction of corps and loss of arable land. Heavier rainfall in southern Nigeria would also cause increased and more frequent growth of weeds, creating greater problems of management. If, the present

trends of decreased rainfall should continue in southern Nigeria, and with increase in temperature, there would be greater water stress even in this part of the country. Changing climate can also directly affect agriculture by way of creating lasting agro-ecosystems changes due to increased frequency as well as extreme weather severity and climate events, for instance flooding and droughts, all of these factors can contribute to the patterns of plant diseases and pest infestation. The unpredictable indirect impacts of climate variability on agriculture changes would comprise the pests and diseases impact as well as the effects on agro-related socio-economic activities. For example, plants pests and plant disease vectors are often arthropods their geographical distribution is therefore determined by temperature, precipitation and the availability of host plants. Some agricultural pests, such as aphids are favoured by dry conditions although others including locusts, proliferate in wet conditions. But all insects' herbivores, fungi, bacteria, plant viruses and their vectors, function within certain ecological limits and can be expected to be affected by climate change. The frequency increase in catastrophic events by way of prolonged drought or severe flooding can create situations that are favorable to diseases or outbreaks of pest and severely interrupt the associations between predator-prey that typically limit pest's proliferation (Afiesimama, 2007).

The climate variability implications as well as changes in water resources in West Africa are noteworthy for some reasons. For instance, changes in the size as well as water resources timing, which require modifications in management strategies as well as greater conversion efforts toward balancing demands for water and its supplies. Moreover, most water resources around the coast have often turn out to be polluted through salt water intrusion, as well as management of water resources will place more importance on desalinisation. Because there is presently increase in variability in rainfall, occasioning flooding in humid regions, and a decrease in rainfall leading to drought in savanna and the semi-arid regions, the component features of the hydro climatologically systems in diverse ecological zones are altered, with implications on water resources availability. This situation will also result to changes in the management strategies to balance supply of water and its demand by conservation efforts. In specific, higher temperatures would increase evaporation rate from land as well as water surfaces plus evapotranspiration from plants. It is also important to note that climate variability and changes affect the use of water in a critical socio-economic sector as well as consequently water demand. In this regards, five major uses may be noted. This comprises energy, industrial, agricultural, municipal as well as reservoir losses. Use of water for agriculture comprises irrigation and livestock, which has been observed to be adversely affected by changing climate. In lieu of industrial purposes, the reduction of rivers flow due to changing climate can place increased pressure on the wastewater treatment processes, which in turn leads to water re-cycling increase and decline in industrial water use. The use of water for production of energy takes dualistic forms viz: thermoelectric and hydroelectric. It is important that the reduction of river flows will decrease the storage of hydropower reservoir as well as decrease the production of energy potential.

The most catastrophic climate affecting Nigerian coasts, ports as well as harbours activities is the

floods that cause rising sea level due to storm surges and changing climate particularly from April to October, coinciding with high period of the spring tides. Notable potential impacts include loss of agricultural lands as well as coastal infrastructures due to coastal erosion outbreaks as well as flooding. For instance, Victoria Island beach bar, Lagos (Nigeria's most famous beach), located approximately 1,500 meters from the Ahmadu Bello route (on Victoria Island, Lagos) in 1964, in 1976 it remained reduced to less than 200 meters. The beach has almost occupied more than a lane of the dual-carriage way resulting in coastal erosion. The projected yearly rate of land loss on this beach is approximately 30-40meters.

Some actions that the government could take by to solve the above snags include:

1) Improving agricultural inputs toward guaranteeing the supply of food and sustainability by increased population as well as urbanization through the activities of the nation's agricultural output activities which consist of,

a. The Agricultural Development Programme (ADP)

b. The National Fadama Development Program (NFDP)

c. The National Agricultural Technology Support Program (NATSP)

d. The National Japanese Assisted Rice Production Program and other related programmes, etc.

2) Expanding export crops production to stimulate as well as increase the earnings of foreign exchange.

3) Implement large-scale construction of capital farmlands projects.

4) Undertaking comprehensive agricultural cultivation projects.

5) Using genetically modified food crops to supplement local production.

Government can also address water resources by:

6) Provide a thorough water resources assessments to stop water pollution as well as imposing standards as well as regulations. These measures can be taken to reduce the negative impact of changing climate on socio-economic related activities in the coastal region, the actions listed below could be taken.

a. Regular sand nourishment projects over the coastal areas and for some areas, groins can be introduced as engineering measures (concrete wall structures) to mitigate the impact of erosion.

b. Enforcement of setback lines to reduce human activities in sand mining and infrastructure developments.

c. Creating inter-ministerial climate committees as well as environmental associated issues

to provide guidelines in managing the country's socio-economic activities.

Nigeria remains keenly involved in several health programs around the world, such as the Roll Back Malaria (RBM) programme, Saving One Million Lives Program for Results (SOML P *for* R), Immunization program and others. The nation has likewise launched the National Poverty Alleviation Program (PAP). These activities should be seriously pursued to alleviate health-related socio-economic problems already highlighted. In the energy sector, the country can continue to explore alternative sources of energy through the following:

a. The use of solar power for most domestic activities

b. Liquefied Petroleum Gas (LPG) introduction as well as kerosene stove as options to rural fuel wood as well as urban areas.

c. Improved awareness of energy-associated environmental degradation with earths changing climate,

d. Introduction to energy efficiency progammes viz.

a) Industrial energy saving program

b) Energy consumption in building cum

c) Energy savings in the transportation sector

The energy plus industrial sectors are most affected via the "United Nation Framework on Convention for Climate Change (UNFCCC) (ratified by Nigeria in 1994), the Kyoto Protocol on Climate Change and the Montreal Protocol implementing the convention on issues merely based on GHG emission" are predominantly from fossil fuels use and their sinks (especially Carbon dioxide) are significantly being lost through changes in land use (deforestation).

16. Climate Change Management

The management of a global changing climate is anchored on two strategies namely; "adaptation and mitigation". "The United Nations Framework Convention on Climate Change" (1992), define "Adaptation" as initiatives as well as measures toward reducing the natural as well as human systems vulnerability on actual or expected climate change effects. "Mitigation" alternatively, refers to activities that constrain the amount as well as climate change rate through limiting greenhouse gases emissions or else enhancing sinks.

16.1 Adaptation

Adaptation involves the process of adjusting. Adaptation measures have always focused on reducing risks as well as climate change impact toward moderating the adverse effects as well as toward exploiting beneficial opportunity. Adaptation is a proactive procedure since it predicts potential future climate changes into account, as opposed to the coping measures that are usually reactionary. So as to be effective, measures of adaptation remain formulated through genuine research supports on present plus future climate information derived at the level of community (Onwuliri, 2009; Raimi *et al.*, 2018; Raimi, 2019). Climate change adaptation or coping will turn out to be important in Nigeria as well as around the globe. Many adaptation strategies strive for change towards human environment as well as decrease the risk of illness plus death through assisting toward preventing the negative effects of changing climate. Water as well as food security are key environmental factors targeted; and the essence is to initiate some feasible measures towards addressing and ameliorate those impacts that cannot be avoided (Ayuba & Dami, 2011; Raimi *et al.*, 2018; Raimi, 2019).

Given the possible changes that are likely to occur in the patterns of rainfall, temperature as well as life-threatening weather events, adjusting the ways they are stored, managed and use water are

important to prevent water security changes. Likewise, food sources – be it livestock, crops, marine, or else freshwater can exist underneath greater stress, thereby underscoring the importance toward advancing adaptation strategies on better access toward food security. Potable water plus sufficient access to safe food for human health remain a fundamental need, so appropriate adaptation measures that maintain as well as improve potable water availability and healthy food are essential to prevent further major health impact resulting from changing climate. There are also requirements for adaptive approaches aimed at community development as well as the built milieu, public health infrastructure and transportation (Olorunda *et al*., 2007; Raimi, 2019). In addition, few actions have been suggested as an adaptation option for response towards current as well as anticipated changing climate impacts on a number of sectors in the Nigerian economy (Ayuba & Dami, 2011; Raimi *et al.*, 2018; Raimi, 2019). The "Building Nigeria's Response to Climate Change (BNRCC) project" has aimed to ensure the practicability plus effectiveness of other suggested adaptation services in several regions as well as sectors.

The additional adaptation actions suggested include:

1) Issues relating to Desertification as well as Drought: Restoration of over-grazed plus irrigated and agricultural land, reduction and the appropriate burning of biomass management particularly in Sudan-Sahel regions; restoring of degraded forest plus woodlands as well as resettlement.

2) Issues relating to Health: Public sanitation improvement plus controlling disease vector population, immunization coverage, strengthening of health care delivering systems as well as improving public awareness on health issues (Raimi *et al.*, 2017; Raimi *et al.*, 2019; Gift *et al.*, 2020; Olalekan *et al.*, 2020; Raimi *et al.*, 2020).

Further suggested adaptation strategies in Nigeria according to Ayuba and Dami (2011) include:

3) Improvement of important swift warning systems for timely and accurate remedial measures and intensified monitoring to improve data reliability.

4) Capacity building for stakeholders and gender empowerment.

5) Shared basin management, necessitating international agreements.

Approaches to Changing Climate Adaptation

Two (2) key adaptation types are:

Autonomous and Planned adaptation

For example, adaptation due to autonomous is a farmer's response to changing rainfall patterns, such that changes in crops or using different harvest as well as sowing dates.

Planned adaptation approaches are sensible policy decisions or response strategies, frequently multispectral in nature, with the aim of changing the agricultural adaptive capacity system or enabling specific adaptations. For instance, deliberate selection of crops as well as strategic distribution in different agro-climatic zones, changes of crops that are new for old ones as well as resource swap brought as a result of scarcity.

16.2 Mitigation

Mitigation basically denotes intervention measure or policies directed at emission reduction or enhancing the sinking of greenhouse gases. Remarkable to know, there is currently no mitigation strategy or technology that can prevent earths changing climate which is already being experienced. Right now, human capacity toward mitigating climate change magnitude over the following 100 years is restricted as a result of the recent atmospheric make-up, in addition to anything we can avoid as well as what we can get out of the future atmosphere. The main objectives of the changing climate mitigation strategies are:

1) Use of fuels substitutes plus conservation of energy — transitioning from fossil fuels as well as other sources of greenhouse gas-emitting energy toward cleaner alternatives as well as the use of carbon capture plus storage technologies to reduce the proportion to which greenhouse gases is release into the milieu.

2) Changes in the patterns of land use, for instance limiting forests destruction plus replanting of many trees will aid toward increasing the storage of natural carbon.

3) Sustainable development of the built environment (based on activities toward preserving other specific ecosystem services, for example control of flood through wetlands protection or vector control through biodiversity conservation) can significantly decrease climate change severity and associated problems. Furthermore, changes in the codes of building, housing density, transportation infrastructure, coastal development as well as other metropolitan planning approaches can decrease the usage of energy and thus mitigate some parts of earth's climate change.

4) Carbon capture and storage ‾ conservation of energy as well as energy modifications will likewise decrease emissions into the atmosphere (Ayuba & Dami, 2011).

In particular, any disaster mitigation response plan in Nigeria ought to consider a wide-ranging weather-climate as well as water associated phenomena that may perhaps affect the various regions. In addition to the major climate mitigation strategies listed above, it is recommended also that the following actions be implemented immediately to address climate change-related issues.

1) Knowledge transfer from "scientific community" through studying earths changing climate as well as relating weather forecasting toward other relevant sectors of the economy.

2) Establishment of a well–function early-warning system for damage reduction around flood plains and coastal deltas, etc.

3) Recycling and reducing wood waste, establishing gene banks to prevent forest species extinction, introduction of domestication programs and legislation in the forestry sector.

4) Conducting research on different facets of earths changing climate based on multi-disciplinary approach to generate reliable empirical data.

5) Promotion of rational plus educational-based policy towards earths changing climate.

6) Strengthening the relevant government institution in the various sectors dealing with climate change e.g., "Federal ministry of Environment, National coordinating committee on climate change", etc.

7) Enforcing well-articulated Environmental Impact Assessment (EIA) as a precondition for approving projects in the various sectors.
8) Adopting strategies to involve the public plus private sector in bearing the financial involvements of earths changing climate related issues.
9) Promoting partnership among communications practitioners including media, entertainment as well as advertising industries anteater groups toward promoting a more energetic public discussion on climate change.

17. The Cost of Climate Mitigation and Adaptation

What are the costs to prevent earths changing climate? Based on the British Government, Stern in 2006 ordered an economics review of climate change, if we now make every towards reducing overall greenhouse gas emissions as well as making sure we highlight the effects of changing climate, the average expected cost represent 1% global Gross Domestic Product (GDP) per year (Stern, 2007). But if nothing is done, the effects of changing climate may possibly cost 5-20% of global GDP each year. These figures are controversial. Pielke *et al.* (2008) argue that the rate of global economic transformation to a low-carbon economy could account for more than 1% of global GDP, since world emissions have grown quicker than worst forecasts. Stern newly revised the 2% estimate to the global GDP. Yet, Parry and colleagues (Millennium Ecosystem Assessment, 2005) submit that the impacts as well as the related global warming costs have been taken into account by IPCC (IPCC, 2007) plus Stern (Stern, 2007). The probable costs or benefits toward public health mitigation plus adaptation have not been determined. Even though the cost benefit ratio towards resolving global warming stands below what Stern suggested, the moral problem of preventing the deaths of millions of people as well as increasing human suffering for the billions remains clear. Furthermore, the house of Representative has voted for a bill to create a legal framework aimed at mainstreaming responses to earths changing climate as well as actions into the formulation and implementation of government policies. The bill proposes the creation of a committee to improve the management and governance of climate change and support adaptation plus mitigation of negative effects of earths changing climate in Nigeria. This will help expedite the treaty domestication as well as will allow Nigeria toward efficiently implementing its commitments, especially in the area of emission reductions target. However, the climate change bill is now before the Nigerian Senate for consideration and onward passage for executive assent.

18. Environmental Health and Management of Climate Change

Since climate change has become a reality, there is a need to put in place necessary public health measures/actions to forestall, manage, as well as ameliorate extreme health problems the situation will provide. Some suggested environmental health actions to address climate change in Nigeria include;

18.1 Build the Capacity of Health Workforce/Professionals

In order to prepare environmental health professionals and experts toward dealing with earths changing climate and associated health problems, it is essential toward training, informing as well as building capacity of health professionals, comprising information around improved health systems burden, novel plus evolving infectious diseases patterns, early warning mechanisms, effective interventions, how best to reduce CO_2 emissions, etc. (Ayuba & Dami, 2011; Raimi *et al.,* 2018).

18.2 Boosting Intelligence in the Health System

A timely operational health information system guarantees the creation, analysis plus dissemination of effective as well as suitable information as well as its uses through decision makers plus other crucial stakeholders in the health system on a consistent basis plus during emergencies. Therefore, effective communication is important towards ensuring the appropriate prioritization, targeting, choice, monitoring plus evaluation of activities towards protecting health against earths changing climate. This entails access to reliable and specific information, such as the outbreaks of diseases, environmental surveillance and monitoring, or individuals at risk. Environmental health system should for instance strengthen her intelligence in the surveillance of diseases outbreak due to climate change and put in place appropriate measures to protect affected populations and groups at risk, etc. (Onwuliri, 2009; Raimi *et al.,* 2018).

18.3 Partnership toward Protecting Health against Earth's Changing Climate

Partnerships offer the opportunity to consolidate as well as share the best knowledge plus practices, capacity and experience of experts, institution as well as countries all over the world as well as towards bring their proficiency to bear to improve health development. Environmental health professionals should forge partnerships with other institutions (local and national) on best practices to protect health from climate change (Jegede, 2010; Raimi *et al.,* 2018).

18.4 Risk Communication and Public Health Education

Knowledge has become a unique tool of the strategy towards decreasing health snags in any milieu. It permits us to have an understanding of whatever remains detrimental, as well as possibly in what manner toward preventing such damage. Research is important, then again knowledge not disseminated efficiently to the right target group is wasted. Health impacts knowledge associated with earths changing climate will be invaluable in raising awareness of the risks and complexity of problems without improving communication and training strategies. Beyond organizing annual meetings, environmental health experts should endeavour to create more fora to educate the public on health impacts due to climate change (Chauhan, 2011; Raimi *et al.,* 2018).

18.5 Research [Including Environmental Health Impact Assessment (EHIA)]

Several lines of ecological and environmental health research are required toward providing data-based support to public health actions on earths changing climate. These consist of in-depth studies of the relationship amongst climate change as well as health, ability to predict health as well as vulnerabilities impacts, development plus testing of approaches towards reducing risk, etc. Toward being successful, a

research plan must be focused, integrated, interdisciplinary, supported as well as sustainable, nonetheless flexible enough toward adjusting to novel information as well as sufficient enough toward covering the actual varied components of the environmental health research. Furthermore, research efforts must be multiagency, multidisciplinary as well as multinational with the full collaboration and strengths of all development partners (Spore, 2008; Olalekan *et al.,* 2019; Raimi *et al.,* 2019; Omidiji and Raimi, 2019; Olalekan *et al.,* 2020; Ajayi *et al.,* 2020; Olalekan *et al.,* 2020; Adedoyin *et al.,* 2020; Raimi *et al.,* 2020).

18.6 Mutual Support

The vulnerabilities of many regions towards earths changing climate remain under intense pressure against forces like poverty, population growth as well as resources depletion. Policies that encourage environmental risk management that reduce pressure on resources and improve the quality of life of the least active members of society, while simultaneously promoting sustainable development as well as justice, improving efficiency and reducing vulnerability toward climate plus other pressures. Climate risks inclusion can promote more sustainable justice and sustainability in the design and implementation of national and international development projects as well as reduce vulnerability to earth changing climate (Raimi *et al.,* 2018).

18.7 Influence Enactment/Legislation of Laws and Regulations that Protect Health and Guarantee Climate Change Safety

Obtaining a public health laws as well as regulations has a direct impact on earths changing climate. Yet, environmental health professionals can put their knowledge as well as skills towards informing and influencing the actions that guide key local, national plus global approaches guiding policy as well as resources allocation for work on tackling earth's changing climate. This could be in the form of formulating nationwide action program on global agreements and adaptation (Onwuliri, 2009; Raimi *et al.,* 2018; Suleiman *et al.,* 2019; Olalekan, 2020; Ajayi *et al.,* 2020).

18.8 Mitigation of Environmental Health System Contributions Towards Earths Changing Climate

The challenges the health sector poses as well as an opportunity towards demonstrating its leadership role plus accountability in preventing earths changing climate through taking action towards reducing the environmental carbon footprint. Accordingly, shielding health against earths changing climate will not only entail science plus active adaptive actions, then also an important moral authority plus commitment. Environmental Health Systems as well as their employees need to show they truly comprehend what is appropriate as well as change attitudes and choices (including use of low carbon options, etc.) as they continue to advocate for global, national plus local solutions towards earths changing climate (Onwuliri, 2009; Raimi *et al.,* 2018).

19. Conclusion

Changing climate has come to be one and only biggest over-all threat to health, aside COVID-19 and the most challenging environmental concerns in the 21st century with significant health impacts both

domestically and globally. Moreover, the Nigerian political plus the health sector at the moment presently have little capacity toward adapting to the extra health impacts of earths changing climate. Couple with related statistic that "vital event registration" remains unreliable as well as patchy. Thus facility-based data, is the most important public health statistics, as merely a segment (and not a representative fraction) of the inhabitants in these countries make use of health care services once ill. As a result, the high exposure combination, high pre-existing frequency of climate-sensitive disease, as well as low adaptive capability leading toward the utmost health vulnerability from changing climate.

Global response calls for a novel public/environmental health initiative which is multidisciplinary as well as multisectoral, and creates significant coordinated thinking as well as actions between governments, development partners (i.e., NGOs), international agencies, friends of the environment plus academic institutions (Olalekan *et al.,* 2019; Raimi *et al.,* 2020; Olalekan *et al.,* 2020; Raimi & Raimi, 2020). All adaptation measures and interventions must be based on the importance of primary mitigation: such as greenhouse gas emissions reduction. Indeed, national government as well as voter's recognition that changing climate has major health consequences, also this should help policy makers in advocacy as well as political change towards addressing mitigation plus adaptation (Raimi *et al.,* 2019; Omidiji and Raimi, 2019; Olalekan *et al.,* 2020; Ajayi *et al.,* 2020; Raimi *et al.,* 2020; Adedoyin *et al.,* 2020; Olalekan *et al.,* 2020). Whether governments choose mitigation strategies or adopt a change towards a carbon-free economy will have an inclusive health benefits, which need to be emphasized to avoid worst case health and economic consequences. Based on the known facts surrounding the current COVID-19 pandemic. It appears that a win-win solutions studies is required, which remain equally imperative in developed as well as emerging countries such as Nigeria. Although some gaps exist in our full understanding towards the relationship amongst changing climate and environmental health, there is ample evidence that both interact to produce environmental consequences that are detrimental to health. Some of the direct environmental health indicators that are affected by climate change consequences include sanitation, management of water resources, waste management, pest, vector as well as disease control, air quality management, marine ecosystem management, etc. Several adaptations as well as mitigation strategies are applied in the management of changing climate in Nigeria. Similarly, a few environmental health actions have been suggested to address climate change. These include workforce capacity building, "health system intelligence strengthening", national and international partnership, risk communication and public health education, research, mitigation of environmental health system contribution to climate change and influence enactment/legislation of laws as well as regulations protecting public health and healthcare programs towards ensuring safety from climate change. Based on the devastating impacts of changing climate in Nigeria and the current COVID-19 pandemic, it has become expedient to ensure medical countermeasure development, national and international partnerships as well as the sustenance of urgent actions to address this menace. This is especially important if Nigeria hopes to aligned with the Sustainable Development Goals (SDGs) and the Paris Climate Agreement as well as achieve her

developmental priorities of poverty reduction and re-creation of wealth prosperity for her citizens as envisioned in the "Seven-point Agenda", "Vision 2030", and SDGs towards achieving health planning as well as policy development. Hence, findings reveal that policy makers need to invest more funding into basic research**,** and better ways for science to advise policy and decision making. As series of studies stated that policy makers had not sufficiently taken scientific advice into account to mitigate earth changing climate. Likewise, governance, institutional, policy and regulatory frameworks should be aligned to the local realities and should not hinder Nigeria economic growth.

20. Recommendations

The year 2020 marks a turning point in the global battle for sustainable development. As the world enters the "Decade of Action", the ten-year period during which national and local governments, the private sector, development partners and civil society must accelerate their efforts toward delivering the Sustainable Development Goals come 2030, the policy recommendations in this review report will provides evidence and policy analysis as well as will be beneficial to governments at all levels, enabling them deliver programmes and strategies that enhance and promote the mechanisms for raising capacities for effective climate change related planning and management, and in the process, contribute towards achieving the Sustainable Development Goals (SDGs) through the effective implementation of the green climate fund. Other policy recommendations include:

1) Establish a national multidisciplinary leadership team toward leading the reform on adaptation and mitigation scenario planning (Jackson, 2007).

2) Improving Climate Forecasting Capacity by strengthening the capacity and capabilities of relevant national environmental bodies, ministries/agencies and departments domestically (e.g., "climate change department of the federal ministry of environment", ecological fund office, NIMET, NESREA, NOSDRA, NCDMB) and at the levels of the state in order to make it more effective, while ensuring compliance as well as enforcement of sector policies, plans and programmes.

3) Create a support executive-level policy task force with septic criteria or requirements aimed at development of policy, negotiating of parastatal/agency and ministry deliverables, and timelines, as well as the attainment of greenhouse gas emission targets. This data/information should be publicly reported immediately.

4) Policy coherence between global, regional, national and local stakeholders is crucial for meeting climate change agreements towards enhancing the value of environmental restoration. Additionally, strong multilevel governance frameworks are key towards fostering vertical and horizontal cooperation among different levels of government and between local governments.

5) Capitalizing on Indigenous Knowledge and Adaptation Strategies and document, disseminate as well as encourage usage of local knowledge towards environmental conservation as well as protection.

6) Promote and build systems support on environmental capacities as well as prepare intermittent reports for the public on environmental state. Also, media training for climate health professionals

should be emphasised upon, in order to learn the nuts and bolts of communication with the media, including tips and tricks to improve their skills.

7) Consider several additional recommended strategies made through the Intergovernmental Panel on Climate Change that were newly released through the Working Group III (Intergovernmental. Panel on Climate Change, 2007).

8) Involving Local Actors and Stakeholders in Environmental Management and ensure the creation as well as maintenance of procedures to coordinate plus constant implementation, consistent monitoring and evaluation agreements on climate change. Also, National governments should strengthen local governments' involvement in the definition, implementation and monitoring of national climate policies especially, as the world enters the Decade of Action to deliver the Sustainable Development Goals (SDGs) by 2030.

9) Integrating and Promoting Climate Change/modelling in Regional Development Strategies by NDDC, Ministry of Niger Delta, etc. and build the capacities and capabilities of selected national institutions plus agencies responsible for protection as well as coordination on all environmental related matters.

10) Establishment as well as sustenance of a "National Environmental Data Collection and Information System coordinated through the Department of Planning Research and Statistics (DPRS) within the Federal Ministry of Environment". Also, the effective implementation of the climate change policies through supportive governance structures, territorial planning, as well as effective means of implementation, adequate financing, capacity development, information, technology and innovation will help harness the dimensions of changing climate.

11) Co-opt environmental costs in financial transactions to address environmental restoration as well as local communities' compensation for damages suffered. Also, government at all scales need to implement the climate change agreements on at least in the short to medium term, within the context of the impacts and uncertainty associated with changing climate.

12) All companies must take responsibility for the impacts of their activities, together with the financial burden of negative consequences, as well as promote a culture of shifting from the use of dirty energy towards alternative energy options for renewable energy.

13) Partnerships amongst government, development partners, private sector as well as civil society, business and individuals should be encouraged to contribute to an Environmental Endowment Fund that will be used for emergency planning and responses on environmental issues, excluding environmental criminals which the polluters-pays principle applies as well as those where incidents are affected by bodies who essentially endure the costs.

14) There should be a sense of urgency and a long-term commitment towards implementing the climate change agreements as the basis for achieving global partnership for sustainable development in combating climate change and its impacts. Likewise, Implementing the 2030 Agenda on climate

change commitment is key towards enhancing the climate change policies and investments toward institutional capacity should be evidence-based and grounded on realistic targets that can be monitored.

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