International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

The Evils Climate Change Pose to the Environment: A Special Focus on Sierra Leone

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Abstract

This is an attempt to throw light on climate change as a problem not only felt in Europe, America, and Asia, but Africa as well, with a special emphasis on Sierra Leone. The poverty level in Africa has made climate change and global warming a great concern. Many people have asked many questions in the past, certain critical questions such as these: What is climate change? What are the causes? What could be the impacts? Is it only affecting humans? If it affects other spheres that aid human existence, how does it occur? Answering these questions, I adopted descriptive analysis. I reviewed textbooks, previous studies, journals and other related materials on the internet, university papers, and interviewed people in order to carry out the study. In order to achieve the aims and objectives of this project, the necessary information collected were mainly divided into the following: Introduction, content and recommendations. The content contained the effects or impacts of climate change on life supporting elements, including the ocean/water, air and air quality, land, food security, the economy of a state, and the implications on human health. In light of these findings, I forwarded some recommendations for personnel working for a reversal of the aforementioned implications. Among the recommendations was a reduction of the use of fossil fuel at homes, putting a hold on deforestation, fighting disinformation etc.

Keywords: Climate change; Greenhouse effect; Sierra Leone; Impacts; Land; Air quality; Ocean; Health; Economy; Food security.

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1. Introduction

Climate change is an occurrence which tends to increase both frequency and intensity of severe weather conditions which include heatwaves, droughts, as well as floods. These changes will possibly heighten property, crop, and human losses. The effect on society is generally destructive. For every human society, there are cultural, traditional, social, economic and political structures which control normal life activities. These structures are based on appreciable prevalent climatic conditions. What is clearly evident is that climate change is greatly influenced by burning fossil fuels in the form of oil, gas, and coal. During combustion, the fossil fuels normally release carbon dioxide into the air, thereby giving the cause for the planet to warm or heat up with damaging effects. Record (Met Office) shows that climate change began occurring 4.5 billion years ago. It has been recently observed that during those years, natural causes have been the major factors. Natural factors such as shifts in the earth crust (plate tectonics), volcanic eruptions, and orbit variation have been among the main causes. [6] As far back as one million years ago, the earth has been going through changing patterns of ice-ages with warmer interglacials which usually lapse for 100, 000 years and are influenced by the earth's orbit [12,13].

This trend in the cause of climate change, from natural factors to human activities with the advent of Industrial Revolution which set in, about the 1800s is worrying. With manual work graduating to the works of machines, global temperature has risen at an alarming rate. It is observed from this point that human activities form the major reasons for climate change [8].

Studies have shown that greenhouse gases and their effect can cause change in climate. Greenhouse effect is influenced by both human activities and natural phenomena. When some gases in the earth's atmosphere force heat to escape into space because of their trapping ability, it is called the GREENHOUSE EFFECT. Certain gases like carbon dioxide, methane, together with nitrous oxide are normally present in the earth's atmosphere. Other gases like chlorofluorocarbons (CFCs) are exclusively produced from activities conducted by humans [17].

When the sun shines, most of the radiation hits the surface of the earth. There is absorption of this radiation by the earth to produce very hot or warm atmospheric conditions. Other than going straight into space, these radiations are absorbed into the greenhouse gases. This will cause the atmosphere to release radiation, some of which are sent back to the surface, resulting in warming of the earth which is also referred to as greenhouse effect. Even though humans cannot survive without greenhouse gases since our environment will appear far colder than it is; however, it can cause hazards [9,17].

The Industrial Revolution saw more greenhouse gases into the atmosphere, resulting in more heat. Rather than just warming the earth at a normal rate, with an appreciable temperature, these gases heat the earth more than normal. Prior to the Industrial Revolution, atmospheric levels of CO2 were around 280 parts for each million. In 2013, the Mauna Loa observatory in Hawaii, which has been assessing atmospheric CO2 levels starting around 1958, recorded the milestone worth of 400 parts for every million of CO2 in the air, a level inconceivable since around 35 million years prior. Earth was an entirely unexpected spot then — normal worldwide temperatures were around 34°C higher and ocean level was around 540 meters higher [21].

Today, the earth contains more carbon dioxide in the atmosphere than ever. The grouping of CO2 in the air has risen 40% since pre-industrial times thus has methane and nitrous oxide and is currently the most elevated it has been for 450 000 years, maybe considerably longer. There is a general arrangement that climate warming will inevitably be 2°C if not 4°C above pre-industrial level. The current level is of 40 gigatons and ought to be diminished to net zero which implies that the CO2 focus in the climate ought to be decreased by 7.6% each year from now until 2030 to forestall a temperature increment of 4 to 5% before the century's over [11,17,21].

2. Greenhouse gases are produced in several ways. They include the following

When fossil fuels, including oil, gas, and coal are burned by human activities, there is an emission of carbon dioxide into the atmosphere [12].

Deforestation, which is the cutting down of trees, also contributes to climate change. The green vegetation of forest trees takes in carbon dioxide from the atmosphere and stores it. By cutting them down means to force carbon dioxide to saturate in the atmosphere because the trees which shall have trapped or absorbed them are cut down [12].

Crops and farm animals emit a variety of greenhouse gases (particularly methane gas), whose effect is 35 times greater than carbon dioxide on the environment. Besides, fertilizers are even worse because they contain nitrous oxide which is also intoxicating than carbon dioxide.

Cement can as well play a role in climate change since its substance contains carbon dioxide which can be released into the atmosphere.

The major factor for climate change is attributed to human activities; nevertheless, there are natural causes as already stated. Natural cycles such as Milankovitch, El Nino Southern Oscillation (ENSO), Solar irradiance, and Volcanic eruptions serve as natural agents.

Climate change is a global phenomenon and it has affected human society in several ways; Sierra Leone is no exception. Sierra Leone currently battles severe environmental challenges, ranging from land degradation, deforestation, loss of biological diversity, pollution of freshwater and coastal area degradation. To address these negative impacts, the National Adaptation Programmes of Action - Sierra Leone (NAPA-SL) was instituted with the objective of amplifying and directing channels of communication for urgent adaptation needs of the country [1,3].

Like any other country in the world, Sierra Leone is exposed to climate variability. During the dry season, the harmattan season will produce a climate that results in an average temperature of 16 ^{0}C (degrees Celsius) which is the lowest per day. But recent research has shown that the harmattan itself now exhibits a warmer climate. We now experience dryer weather from September to November instead of frequent lightning and thunder, and heavy rainfall, short-lived, though [2].

The rainy (wet) season, experienced between May and October, comes with heavy rain with an average score of

2746 millimeters (mm); however, it is a period that is now characterized with delayed rainfall. Usually, the interval of dryness has been accompanied by heavy rainfall with its consequent extensive flooding right across the country. This has further resulted into poor agricultural productivity, water supply and sanitation. With reference to the Third National Communication of Sierra Leone to the United Nations Framework Convention on Climate Change, Sierra Leone is experiencing climate change and severe weather variations [2,3,5].

Sierra Leone has joined other parts of the world to record climate hazards, among them are seasonal droughts, strong winds, thunderstorms, landslides, heatwaves, floods, intense seasonal rainfalls, shifting rainfall patterns, and so on. Areas in the South-East of Sierra Leone, as well as the Western Area have been hit by seasonal droughts and floods, which have impeded or reduced successful food production capacities. This research is, therefore, intended to have an in-depth analysis of the impacts of climate change on the waters, air, land, economy, human health, and food security, with tangible recommendations to address them. With about seven million plus people, congested in a relatively small West African nation, Sierra Leone continues to suffer if remedies are not sourced [1].

3. Aims

The aim of this research is to investigate climate change and its impacts (negatives) on Sierra Leone, with few global and continental illustrations.

4. Objectives

To find out how climate change affects the following important tenets of human survival:

- Oceans/Waters

- Air Quality

- Food Security

- Human Health

- Land And Its Use

- National Economy

This study will also provide recommendations which will serve as tools to remedy the negative impacts of climate change.

5. Justification of the research

Climate change falls within the category of major hazards that affect every facet of human life. Studies have proven that even though there are natural factors responsible for climate change, there are factors that are

measured on human activities. This goes to suggest that if humans are the causal agents for climate to not only change, but to also result in impacts that threaten the very human existence, the same humans will examine their activities, to help find solutions to the problems of climate change in Sierra Leone. This study is, therefore, a modest way of initiating an investigation of climate change and its negative impacts. In this regard, it is hoped that the study will achieve the following:

(i) It will be a useful tool for the National Climate Change Project of the Meteorological Agency and the National Communications to the United Nations Framework Convention on Climate Change (UNFCCC).

(ii) It will also stimulate behaviour change, which will gear towards a better living environment and the economy.

(iii) This research also stands to benefit future researchers as a worthy tool to source their findings.

6. Research design

This piece of work is written in a descriptive form. Because of this, all the data and information gathered are analysed through qualitative means. This is to suggest that no statistical methods are used in the data analysis. Instead, simple prose style is used to illustrate findings.

This work is divided into seven chapters, preceded by the preliminary section, which comprises the SYNOPSIS.

7. Instruments of data collection

For this study, most of the information and data were collected by means of the traditional libraries (Freetown and Bo libraries; Paramedical School, Njala University; College of Medicine and Allied Health Sciences, University of Sierra Leone; University of Makeni, Bonthe Technical Training College) and through the use of the internet. Samples of online libraries and other text materials provided current occurrences related to climate change and its impacts.

8. Validation of instruments

To make sure that data instruments are validated, the author of this research work, who happens to be me, Juliet Rogers, consulted several textbooks and magazines that share the topics which form the nucleus of the work. These were, in turn, compared with online libraries of various sorts. This enabled me to pick out the best materials and the appropriate approach to gain quality outcomes.

9. Method of data collection

First, I selected the types of library and other resource materials to use; texts that are related to climate change and its impacts on Africa, with special emphasis on Sierra Leone, were considered appropriate. Samples of persons, mostly farmers, waste managers, environmental scientists, public health officers, medical doctors, green economists etc., were interviewed. After identifying the resource centres, persons, and materials, I

carefully selected related topics and collected facts that are common, but are adequately treated. This gave me the opportunity to read and draw inferences hinging on the aims and objectives of the study.

10. Method of data analysis

The data collected for this research was analysed qualitatively. This is to say, a descriptive method was used. No statistical methods were used to illustrate climate change illustrations, the related impacts and recommendations.

11. Impacts of climate change on the oceans/waters

Among the natural elements greatly affected by climate change is the water bodies, including the oceans. Climate change which results in global warming has greater effects on the sea levels, coastlines, ocean acidification and currents, sea water, sea surface temperature, tides, sea floor, and weather; it can also cause changes in ocean biogeochemistry; at the end of it all, these can translate into severe obstructions of the functioning of human society [14].

Climate change and global warming affect the sea level in several ways. For instance, it can induce sea level to rise, thermals to expand, glaciers and ice sheets to melt.

Every research that has been carried out will indicate that the past centuries have witnessed rising sea level the world over. This had further given rise to excess heat released into the surface of the earth [11,13].

Besides, the coastal lines have had their own toll. A review of literature in recent times has shown that sea level has risen approximately to 30-35% in 1993 because of thermal expansion and about 60% owing to continental ice melt. In a related research, estimated heat waves have risen considerably from 1955 to 2010 - which means there is a change in sea level, owing to global warming. Satellite measurements from space have also confirmed the melting of the sheets, thereby resulting in extensive heat release on the ocean surface and the earth - which is measured at 500m [9,13,14].

The relationship between sea level rise and the expansion of ocean thermal are in line with the law of volumes. This law states that "the volume of a given mass is proportionate to its temperature." There have always been oceanographers to also confirm these facts about rising sea level and the corresponding extra heatwaves. The international body called International Panel of Climate Change (IPCC) indicated that the upper surface as deep as 750 meters is warming at "0.09 to 0.03 degrees celsius per decade over the past 40 years." This is indicated in the 5th Assessment Report. According to the United States Environmental Protection Agency (US-EPA), climate change and global warming will force glaciers and ice-sheets, including the one in Greenland to melt and flow into the oceans. This will increase the amount of ocean water, thereby resulting in the erosion of beaches; hence, high risk of flooding [11,15,17].

Regions that have indicated a great rise in sea level are Western Tropical Pacific, United States of America, North-Eastern Seaboard, and West Coast of Africa. It has also been observed that heavy storms, post-glacial rebound, sedimentation, and geomorphology are responsible for the regional variability of ocean rise; all of

these are precipitated by climate change and global warming.

Climate change equally subjects marine life to peril; it has destroyed marine ecosystems. Owing to an increase in ocean temperature, there is a drastic fall in plankton in the marine ecosystems. Plankton are organisms drifting in oceans, seas, and bodies of freshwater. As a result, the entire food web is destroyed; either the heatwaves kill them or they are forced to migrate to other zones. Although species depletion is common with the Indian Ocean, it is also affecting other oceans, as well as fresh water. Biological oceanographers and marine biologists who study plants and animals in marine environments have concluded on a forecast which suggests that if global warming continues to affect the oceans, very shortly, the Indian Ocean and others will change into ecological desert in such a way that they will not contain the kinds of species to meet human needs. Recent studies have concluded on a drastic reduction of fish species in aquatic life, with a graphics picture of 50-90% reduction, projected over five decades [19,20].

In accordance with an article put forward by Hindawi, in 1999, these reductions were attributed to a low-latitude mesosphere, thermosphere, and ionosphere owing to greenhouse effects. It has generally affected stratification of the low-latitude and near-equatorial F2 layer, topside ionization ledge and F3 layer. This has created a relationship between the physical environment and ocean biology which has further negatively affected the much needed nutrients for the survival and the growth of phytoplankton.

All indications have shown that ocean pollution is among the causative agents in the reduction of ocean species. Ocean pollution is resulting in the consumption of plastic materials by marine creatures. The effect of climate change on the ocean is interchangeable. Owing to climate change which will lead to increase in ocean temperature, it has further affected the sea floor. As greenhouse gases heightens the temperature so it affects the bicarbonate buffer of the ocean. Bicarbonate buffer refers to a high proportion of bicarbonate ions which is responsible for the maintenance of ocean acidity within 7.5 to 8.4. This helps us to understand that as the presence of carbon dioxide increases in the ocean waters, it will lead to a corresponding increase in acid in the ocean. It is important to note that high acidity of the ocean negatively affects planktonic organisms, especially for the formation of shells which are dependent on calcium. Therefore any increase in ocean acidity will result in the destruction of calcareous organisms because there will be a decrease in calcite compensation when ocean temperature increases. When ocean temperature increases, its effect will negatively reach the ocean floor. This will bring about additional greenhouse gas, methane gas. Because of an increase in temperature deep beneath the ocean floor, it will hydrate and begin to melt, which will result in the production of methane gas; hence, global warming. Besides what has already been stated as climate change impact on phytoplankton, there is also a damaging effect on coral reefs [6,14,19].

The impact of climate change on marine mammals needs special emphasis. As already stated, high ocean temperature will lead to migration of endangered species to more suitable habitats. If this continues, most fauna may migrate to cooler aquatic habitats. Since the plankton serve as sources of food for mammals, and they are on the move for more comfortable waters, their shift will create a shortage of food for marine mammals [20].

12. The implications of climate change on air quality

Chemical composition of the atmosphere has been experiencing a steady change, owing to heavy industrialization, intensive agriculture, urbanization, road construction, maritime and air traffic. These occurrences have caused changes in the earth's temperature and hydrological cycles. All of these are products of massive concentration of carbon dioxide in the atmosphere. The release of fossil fuel combustion, greenhouse gases, as well as methane and nitrous oxide are on the increase because of human activities. The emission of sulphur dioxide, precursor of sulphate aerosol particles of black carbon and organic particles have greatly affected radioactive transfer in the atmosphere, with its attendant impacts on the climate. As submicron sulphate aerosol particles stimulate and scatter fractions of incoming solar radiation back into space, so black carbon particles absorb a greater portion of shortwave solar radiation which affects the flux of terrestrial longwave radiation [9,17].

Added to these is the provision of condensation nuclei by aerosols. They facilitate the formation of cloud droplets. Once they are present in the atmosphere, there are changes in the cloud albedo which affects the earth's climate. It also impacts the vertical stability of the atmosphere and tends to reduce the albedo of snow with a strong impact on climatic conditions.

With these conditions, it is worthy to investigate the chemical composition of the atmosphere at different levels and scales. This investigation will include changes in temperature and precipitation which are attributed to human activities and the impact on air quality. We have learned that changing land use by deforestation, irrigation, and urbanization will result in climate change with its related impact on air quality. These impacts of climate change occur in different ways:

- When changes occur in atmospheric temperature, it will certainly affect the rate of chemical reactions. It is also possible that there is a destruction of chemical species, and the increase the loss rate of tropospheric ozone.

- Also, the more lightning becomes intense, the likelihood that it will obstruct the atmospheric production of nitric oxide. This, in itself, will pose a negative effect on the quality of the ozone layer, especially in the troposphere.

- Variation in clouds in the atmosphere will modify the penetration of solar radiation; therefore, the photochemical activity, aqueous and heterogeneous chemistry also become evident.

- As soluble species are removed from the atmosphere as a result of climate change, there are series of changes occurring in the frequency and intensity of precipitation.

- When changes occur in the surface temperature and precipitation because of climate change, it affects the release and deposition of chemical compounds.

The impacts of climate change on ocean temperature further affect the atmospheric ocean exchanges of certain compounds. Such compounds include dimethyl and sulphide. Remember that these compounds serve as a source

for the production of sulphate aerosols.

Global warming and climate change will create variations in the frequency and persistent stagnant air. This will negatively impact the dispersion of pollutants which will further intensify pollution. It results in lots of inconveniences and health implications [9].

Further changes in surface wind modifies mobilization of dust particles, especially in arid regions; hence, aerosol burden in the troposphere. It will also result in modification of trace gas exchanges at the ocean-atmosphere interface. At the end of it all, emission of sea-salt particles into the atmosphere will be affected.

Besides all these, when lightning is induced by climate change circumstances, there is a possibility of the prevalent natural fires which in turn emit pyrogenic chemical compounds into the atmosphere. These affect air quality.

Effects of heatwaves on regional air quality are quite enormous. In this respect, the heatwave that was experienced in Western and Central Europe in August, 2003 was as high as 35 or 40 degrees celsius. As a result, more than 30, 000 deaths were recorded in France, 5,000 in Germany, 6,000 in Spain, 5,000 in Portugal, and 5,000 in the United Kingdom.

Coming back home in Africa, especially Sierra Leone, the air quality has been considered somehow unsafe. A careful examination of the World Health Organization gives the most recent statistics which reveals countries' annual mean concentration at PM 2.5 is 22 ug per meter cube; this figure is overboard, regarding the expected maximum of 10 ug per meter cube. Causes to poor air quality in Sierra Leone comprise mining, manufacturing, and refining industries and release of carbon monoxide from vehicles. This report further reveals that air pollution which undermines air quality contains a mixture of chemicals, particulate matter, and biological materials. These have the ability to create a reaction among themselves to release dangerous particles in the atmosphere. The impact to human health is hazardous since it results in chronic diseases, serious breathing problems and consequently death. The heavy presence of these particulate matters (PM) undermine the quality of air in the atmosphere. There are two classes of particulate matter which helps in the analysis of air quality. They include fine particles and coarse particles. Fine particles are measured with the diameter of about 2.5 um or PM 2.5, while the coarse particles are of a diameter about 10 um or PM 10. The fine particles attract a wide range of focus because they can move deeper into the cardiopulmonary system [6,10,11].

Urban and rural areas anywhere in the world are exposed to air pollution. Once the air quality is negatively tampered with by pollutants, symptoms that become noticeable include itchy eyes, nose and throat, sneezing and coughing, shortness of breath, chest pain, headaches, nausea, and upper respiratory infections also known as bronchitis and pneumonia. Illness like asthma and emphysema become worse. It also worsens long term infections like lung cancer, cardiovascular diseases, chronic respiratory illness and development of allergies. Air pollutants are also related to heart attacks and strokes [7,9].

13. The impacts of climate change on the land

Climate change is a major contributing factor for land degradation. Land degradation is a loss of land potentials which are required for economic activities like agriculture. It entails a change in chemical, physical, and biological properties of the soil. A change in soil properties will reduce the ability of the soil to support plant growth. Wind and water erosion are powerful agents of land degradation [7].

Wind erosion results in the removal and disposition of soil particles from the top soil. Besides the negative impact land degradation has on agricultural productivity, it increases the speed of tropical cyclones which negatively impacts soil texture. This is as a result of loss of certain soil properties, which in turn reduce the soil potential for plant growth. There are several climate change induced factors militating against soil quality. They include wind and water erosion. But what is worth noting is the impact on the land.

Besides the removal of soil particles from the topmost part of the soil, erosion can also bury houses, machines and leave a land surface without value.

In Sierra Leone and other parts of the world, water erosion occurs in various stages and forms which include splash, rill and gully erosion. Generally speaking, erosion begins with a splash which comes in the form of raindrops which fall on the top soil and break the soil aggregates and deposit particles into the atmosphere. This will cause the volume of rainfall to reduce. Because the rainwater passes through the soil, it increases runoff. As the rainwater runs on the surface of the land, it often picks soil particles along with the moving volume. This will result in the depreciation of the land surface consistently. Occurrence like this is described as sheet erosion. In the case of rill and gully erosion, runoff water finds its way into channels. Little streamlets (cuts) which can be checked by tilling are what we consider as rills. The movement of this concentrated volume of water moves with such a speed that a significant portion of the soil on the bed and sides of gullies are eroded, causing more flooding along its way; besides, it pollutes the rivers and oceans which may not be too favourable to aquatic ecosystems [5,7].

Also, climate change will negatively impact organic matter levels. Organic matter is an important part of soil composition. It has all the qualities for agricultural productivity. It is responsible for soil stability; it stores water, oxygen, and nutrients which are the right soil composition for plant growth. These make it possible for organic matter to provide a storage facility for micro flora and fauna. However, a reasonable amount of this organic matter has disappeared in the form of carbon dioxide into the air. This stands to suggest that as agricultural activities increase, it leads to a corresponding increase of carbon dioxide into the atmosphere to add onto the amount of greenhouse gases.

Another impact of climate change on the land is illustrated in acidification. Acidification is a natural process that usually occurs as a consequence of nitrate leaching in high-rainfall areas. It has far reaching consequences, in that, carbon dioxide concentration of carbon dioxide in the atmosphere is driving up ocean surface temperatures, thereby resulting in ocean acidification which will be hazardous for marine ecosystems. Acidification is regulated by climate change. The higher the rainfall, the more leaching; hence, acidification. In

sub Humid and Arid geographical zones like the Sahara, Sahelian, Sudania, Guinean, and Guineo-Congolian regions, soils are negatively impacted by seasonal changes - from conditions of leaching to the conditions of evaporation. This is common to all acid sulfate soils. Sierra Leone stands at a peril because such soil conditions which suffer from persistent acidity because of oxidation of pyrite are stretching from the Fouta Djallon highlands into North-Eastern regions of our country, Sierra Leone [7,14].

Acid sulfate soils are natural; they contain acid sulfide in the form of iron pyrite. This natural soil content is formed in two ways. First, it occurs when pyrite remains in 'reducing environment.' In the other, pyrite can be oxidized when exposed to air; this will lead to geological formation of sulphuric acid. These processes are responsible for environmental degradation, especially the land. Climate change has a great impact on acid sulfate soils with a high magnitude of weather events like heavy and consistent rainfall, as well as droughts [14].

The impacts of climate change on land greatly affect soil nutrient quality and quantity. As already stated in the impact of climate change on agricultural productivity, a downward movement of water in a soil will cause loss of soil nutrient; therefore, it is convincing to suggest that movement of water will cause a reduction in soil nutrient.

Soil structure is very important, as it determines soil value. Soil functional ability includes the capacity to hold water, transfer nutrients, effect nutrient leaching, and drainage. Climate change can cause damage to soil structure. Owing to the manner of land use and management, changes that occur in soil structure are difficult to be presented in statistical forms. When soils contain high clay contents, it can easily shrink in dry weather, but can inversely swell when the weather turns the opposite. This creates very large fissures and cracks. When the climatic condition becomes dry, it can lead to an increase in the size and frequency of cracks in soils, especially in temperate areas like India, Canada, Japan, New Zealand, Middle East, and North Africa. These situations are extending to West Africa where we now experience land cracks with significant increase in the presence of metals, including iron, manganese, heavy metals that are borne out of climate change [10,4].

Satellite observations have indicated "vegetation greening" over the entire world with a few exceptions. Generally speaking, 'greening' refers to a systematic increase or positive trend in a vegetation measurement associated with growth observed over a period of time set by the researcher. Greening is caused by extended growing season, nitrogen deposit, carbon dioxide fertilization, and land management. "Vegetation browning" has been observed too. Browning occurs when there's a systematic decrease in vegetation growth or the death of vegetation that affects a negative trend in productivity. It comes about because of water stress. Prevalent water stress situations have led to dust storms on an alarming scale in the last two decades. The impact on human health has been deadly, especially in the Arabian Peninsula, greater middle East, Central Asia and Africa, North Africa, and partially West Africa. In the North of Africa, and in certain areas of West Africa, high increase in land surface air temperature, evaporation, and decrease in precipitation, coupled with climate variations and human activities, have immensely contributed to desertification.

Land and its activities and climate change factors are interrelated, with the land bearing the burden of the bulk of the impact. Agricultural preoccupations, forest works, and other human activities account for about 13% of

carbon dioxide (CO2), 44% of methane (CH4), and 82% of nitrous oxide (N2O) discharge into the atmosphere — all as a result of land use activities from 2007—2016. The result of these will either occur in the form of 'greening' or 'browning' — In whatever way climate change affects the land, humans stand to be affected either by health related conditions or agriculture [18].

14. How climate change threatens food security

Climate change has always threatened the livelihood of humans, as well as cattles, keeping them hungry and undernourished; it has sent diplomats away, has increased the range of inequalities, and has undermined sustainability in development.

Extreme weather conditions have dramatically reduced food production in major crops, worldwide. Examples include: rice, wheat, oats, rye, barley, millet, quinoa, and corn. There has been observed a rise in prices of these food items with corresponding decrease in the income that would have come to farmers in crop farming. Climate change and global warming have greatly disadvantaged low-income earners. Matters have become worse in such a way that low-income earners cannot easily access food. It is, therefore, important for any research work to focus on the connection between climate change and food security, as it was emphasised in the 2019 Global Hunger Index, Concern Worldwide and Welthungerhilfe. Unfortunately though, this challenge climate change is posing on food security is not going away just now. With a projection, predictions have it that there will be higher average temperatures the world over, especially in Africa. African coastal areas are no exceptions. Of course, flooding and drought are the main agents; besides what is prevalent now, there is a high probability of more droughts and floods in some areas like North, South, Central and West Africa, and African coastal cities. The report from Welthungerhilfe suggests even though there are steps taken to reduce global hunger, it is also concluded that the number of people going to bed without food is on the increase. Going to bed hungry has resulted in high rates of undernourishment, child stunting, old age nutritional imbalance, and child mortality. Some of the ways climate change poses a threat to food security are analysed below:

- The hungriest countries in the world are subject to high vulnerability to climate change, and studies have shown that such countries have very low capacities to adapt to varying patterns of global warming.

- Climate change does not only affect food production as earlier indicated in this document, but it also affects other aspects like accessibility, quality, utilization, and stability of state control will be grossly undermined.

- Natural disasters like flooding and drought which are related to weather conditions are on the rise, and can result in reduction of yields of main crops like rice, millet, corn, and so on.

- Increase in the emission of carbon dioxide in the atmosphere will reduce the nutritional value of crops.

- Global food production contributes about one-third of the greenhouse gases released in the atmosphere. As a result, about two-third of foods are completely lost or wasted by the time they reach the final consumer.

- Combination of climate change and political conflict destroy livelihood, increase displacement, widen the gap

between the rich and the poor, and hamper sustainability in development. According to the Food and Agriculture Organization (FAO), the production of cereals has been unpredictable in most countries in Africa, especially in the Sahel region. Eighty percent of this unpredictability has been attributed to the changing patterns of climate change. There has been a glimmer of hope, but the fall in global hunger level has always been short-lived, as people who are still hungry worldwide are in the ratio of one in nine. Among the ten hungriest nations in the world are Chad, Timor-Leste, Madagascar, Haiti, Mozambique, Liberia, Sierra Leone, Lesotho, Nigeria, and Afghanistan. In all these countries, the rise in the sea level has forced salt water to access coastal farmlands, thereby destroying cereal crops. This situation is more common with Vietnam and Bangladesh.

When climate change induces flooding, the livelihood of livestock will be at risk. In the horn of Africa, Central and parts of West Africa, their farm animals that drink the contaminated flood waters get infected, and in extreme cases, they die. This has been exacerbated by drought: animals in countries like Niger, Somalia, Mali, Guinea, Sierra Leone etc most times runout of pasture because of what is known in these regions as 'Extended Dry Season.' As plants wither and rivers dry, the animals are left with no alternative but to drink the contaminated waters, although sometimes the OASIS may help, but very little as they may be 50 miles apart, from one to the other.

This tells us that Sierra Leone is in the line of nations suffering from climate change situations. When the water table significantly falls, the lakes dry up and a reduction in the flow of rivers. The direct result is fewer water supplies for agriculture, as well as hydropower generation and some sort of domestic uses. The results or impacts of climate change on agriculture and the general livelihood of Africans are in no contrast with IPCC Assessment Report and Predictions. 47.9% of Sierra Leone's Gross Domestic Product (GDP) is from agricultural activities. The agricultural sector takes 80% of the working population. Because of this dominant role agriculture plays, a slight climate obstruction will cause far-reaching consequences [2,11].

Sierra Leone is placed in an advantageous position over the others in export resources in diamond, rutile, cocoa, coffee, and fish. This is recorded by the National Export Strategy. In practical terms, Sierra Leone is monocultural, with about 80% of Government income and 90% of the foreign exchange revenues come from agricultural and mining sectors. It means that Sierra Leone's economy will be negatively affected by a sustained reduction stimulated by climate change.

Regrettably, though, political and public discussions hardly pay attention to climate change related problems. Since 2020, and up to now, the attention of stakeholders have been focused on fighting and containing the COVID-19, coupled with domestic politics and the fight against corruption; hence, the issues of impacts of climate change on agricultural activities have not really attracted the government, experts or development partners.

Moreover, strategies in combating climate change are not reasonably enshrined in the political thoughts in Sierra Leone. Considering that climate change will result in more dry areas with wet areas becoming wetter, its threat on food security is unprecedented. If actions are not taken now, Sierra Leone will experience vertical rise and fall in air currents which will hazardously place the country between droughts and floods.

15. Climate change impacting health

It is estimated that over 42 billion tons of greenhouse pollution is discharged into the atmosphere worldwide, with a steady increase every year. It experienced a further increase in 2018 by 12.7 percent. This increase is attributed to a rise in oil consumption. The USA and China are the main competitors in greenhouse pollution discharged into the atmosphere [8,17].

20 percent of U.S. greenhouse pollution is tailpipe emissions and 30 percent is from coal fired power plants. Restriction policies in the U.S. on methane emission into the atmosphere have not been successful. Methane is considered a more potent greenhouse gas than carbon dioxide. Because of the failure of restriction laws to take prominence, the concentration of methane emission into the atmosphere is rated the highest. Nevertheless, tailpipe emissions are a serious threat to humans and environmental health. The combustion of petroleum-based fuel results in the release of noxious chemicals into the air [6].

As we have observed, a change and an increase in temperature, result in corresponding negative effects on human health. When air becomes warmer, it takes more water, which means rainfall is usually characterised by "rain bombs." A direct impact of this will increase the intensity and frequency of hurricanes. One clear example is Hurricane Harvey, which is partly caused by the increase in temperature of the Gulf surface. Another is Hurricane Maria, which was considered the deadliest, causing about 3000 deaths. Among these was Hurricane Michael, which was measured — 155 mph. In the published journal titled "NATURE," it indicated that global warming will be a major future cause of deadly hurricanes and intense rainfall and high wind speed.

Besides these chains of hurricanes attributed to global warming, another health related impact is having its origin from rise in sea level, which has already been highlighted. We have also learned that the rise in sea-level is as a result of ice-melt. The West Antarctic ice sheet is partially disappearing too fast. If this trend continues, many cities including New York and African coastal cities will experience destructive floods. We cannot be surprised at this because what we call the mega cities (cities with 15 million people) are built on the coast. These include Jakarta, Los Angeles, Manila, Osaka, Shanghai, and Tokyo. Added to these, African coastal cities which include Freetown, Monrovia, Conakry, and so on. Having dilated a lot about rise in sea-level, high sea temperature, hurricane, and flooding, let us see if there is any connection to human health. It is, indeed, justifiable that these events will greatly affect drinking water. Also, human waste water treatment, as well as storm water disposal will increase the risk of water borne diseases relating to pathogens like bacteria, viruses and protozoa. Sixty-eight percent of water borne diseases around the world have their origin from these events. Recent researchers have proven that one such cholera that is borne out of storm events is vibrio. Cholera, caused by vibrio species. Added to this pathogens are: salmonella and noroviruses. It is now observed and understood that global warming is greatly resulting in an increased rate of pathogens in the food chains; several cases of legionnaire diseases occur due to contaminated aerosolized water as a result of flooding. And there has been an increase of nearly 20 percent between 2000 and 2009 [9,13,14].

Reasonable analysis of the impacts of global warming should not put aside droughts and fires as causative agents to human health. It is worth understanding that steady heat and drought will lead to an increase in the

intensity and duration of wildfires. Other parts of the world, like California, have recorded the deadliest wildfires in United States' history. The story in the USA is not carrying a significant difference with Africa, particularly Sierra Leone. Sierra Leone may not have experienced a strict drought, but something nearer drought. This country has witnessed late rainfalls and its early end. Instead of April which is recorded as the beginning of the rainy season, rains have a late start in Sierra Leone, usually towards the end of May; recent as 2020, the rains seceded in September when it is supposed to rain up to mid-October. This is because the amount of carbon the fires, including domestic and bush fires, released into the atmosphere is quite massive. It has become a global disaster. Indonesia, for example, has an estimated release of carbon of 40 percent of total carbon emission per annum. How has it impacted the health of humans? It is important to understand that fires have a devastating and lasting impact on the quality of air which has resulted into serious health hazards. It is now anticipated that by 2050 fires will be the cause of 40 percent elemental carbon aerosol concentrations. These are bound to result in such ill health conditions as asthma, acute bronchitis and pneumonia. Moreover, fires, heat, and drought (reduced rainfall) have resulted into ground level ozone pollution and particle pollution, thereby increasing the levels of aero-allergens like pollens which cause serious health implications too. If this trend continues, research indicates that future ozone-related human health conditions will give rise to hundreds of thousands of premature deaths, with children carrying the highest percentage of such deaths [2,18,19].

Furthermore, high temperature can result in heat exhaustion, heatstroke, hyperthermia, and dehydration. In severe cases, these situations can lead to death. It is even worse for persons with a history of hypertension, cardiovascular, respiratory cerebrovascular kidney and diabetes health conditions. High temperature will also increase vector-borne diseases carried by mosquitoes, fleas, ticks, and rodents. Higher temperature is also responsible for an increase in the reproductive cycle of cold blooded mosquitoes, resulting in mosquitoes borne diseases like dengue fever. For now, 14 vector-borne diseases such as West Nile virus are prevalent and it has become a national public health concern in the United States of America. From 1990-2020, the burden of cardiovascular diseases faced by African countries doubled, with the aged, middle-aged and the poor people suffering more than any class of persons.

Climate change has also resulted in mental and behavioural health conditions. This range includes: anxiety, depression and post traumatic stress and suicide. For instance, after Hurricane Katrina, in 2005, cases of mental illness and suicide attempts increased. In Africa, especially Sierra Leone, fear of heat has kept the poor in rural and urban areas in the open air since they cannot afford cooling gadgetry in their bedrooms. Such a situation has exposed them to mosquito bites, thereby resulting into malaria and its related health implications.

16. Climate change impacts on the economy

There is no paradox in realizing that climate change has economic effects on Africa. Some of the ways climate change plays out with the economy are therefore analysed.

We have learned from previous discussions that climate change can cause desertification. This is not a welcome event for agriculture which is pivotal to the economic growth of any nation; Sierra Leone is no exception. When desertification occurs because of hotter weather and drought, it will cause a decrease in crop yield. In some

cases, crops wither when obstruction occurs in the rainy season. This will occur in two ways: There are times when the dry season will extend into the rainy season, and for farmers who would have planted at normal times in April and May, meet unexpected dry and hot weather. In a circumstance like this, either food crops become withered or recline into slow or stunted growth. If, on the other hand, the rainy season ends abnormally because of human activities, resulting in climate change, crop growth will be impeded. In either circumstance, the ultimate result will be a poor yield.

Obstruction of weather conditions that will result in extreme heat, will also affect cash crops. Cash crops like sugarcane, tobacco, cotton, coffee, and fruits are widely grown in West Africa. Extended dry season with its complementary increase of extreme heat will badly affect crop yield or production. There are several ways this will affect the economy.

First of all, it denies subsistence farmers the required food stuff for their families. Consequently, the money they would have used for developmental purposes will be used to buy what they eat. This will further shoot up the demand of not only our staple food (rice), but also other cereals as well.

Climate change related flooding mostly caused by rising seas and frequent hurricanes negatively impacts Africa's economy — Sierra Leone inclusive. Such flooding has destroyed farmlands in the past, and it continues to cause havoc to food production, which in turn will translate into economic challenges for both the farmers and the country. Flooding into the waters or seas will cause water pollution which destroys marine ecosystems. Lack of good fish products will discourage investors who would like to invest in marine life or fisheries. Our national business partners or investors will lack the capacity to help the country to contribute to Gross Domestic Product (GDP); hence, there will be economic starvation in foreign reserves. Lack of this foreign reserve can lead to prices of essential commodities skyrocketing.

About two-thirds of the labour force in Sierra Leone is in agriculture, which is the primary employer. Agriculture, the economic backbone of Sierra Leone, accounts for 50% of the Gross Domestic Product (FAD, 2012). 59.2% of the working population are classified as self employed in agriculture.

The economic impact also affects employment. Forestry and fisheries represent the mainstay of Sierra Leone economy, as they employ a little over 60% of the labour force mostly at the subsistence level. Any challenge faced by master farmers will result in forceful redundants which will increase the level of unemployment in the country — a real economic burden on the central government.

A significant percent of crops and products with commercial value are processed in the rural areas. Unfortunately, though, 90% of these rural roads in Sierra Leone are awkward. Their conditions become worse when climate change related rainfalls and flooding (partially because of rising seas and frequent hurricanes) dig little trenches and gullies along them. Some rural or feeder roads are destroyed in a way that keeps off commercial traffic, sometimes for several months. Perishable products are destroyed before they reach the final consumers. For the vehicles that will brave it to take several painful and perilous days on the bad and dangerous roads, they usually take a high transport fare from traders. No doubt, they often sell such products at increased

prices. This will become an economic burden on both traders and the final consumer. Besides, rebuilding those roads become an economic burden either on already impoverished ruralites, or the government.

When farm products fail to reach the markets in towns and cities, it affects taxation, as it will be levied by the local councils. This will lead to a significant loss of the economic productive capacity of the national economy. As earlier stated, rebuilding the dilapidated roads might be very expensive, but at least, the expected result is worth the cost incurred.

Similarly, cattle rearers are also caught up in the web of economic challenges. As pastures are wiped out, owing to climate change factors, the cattle rearers will face a serious economic challenge. Where they used to provide for their cattles greener pasture to graze free of cost, it became expensive. This is because supplements can be expensive too. This is bound to skyrocket the prices of meat products.

According to Columbia University, Earth Institute, the Fourth National Climate Assessment of 2018, a suggestion was reached which advised, almost sounding a warning that if drastic actions are not marshaled to reduce greenhouse gas emissions and climate change impacts generally, especially in the adaptive way, these phenomenal will seriously obstruct global economy with the hardest hit on African economy. Warmer temperature, sea-level rise and severe or extreme weather conditions will result in property damage, poor human health and productivity. That research also believes that climate change impact on sectors like agriculture, forestry, fisheries and tourism will give rise to a poor economy in Africa; Sierra Leone is no exception. It will also exacerbate the problem around poor energy supply.

17. Recommendations

Climate change is believed to be among the leading changes mankind has ever experienced. As it is now, millions of human lives, uncountable species and ecosystems, the survival of African economies and the sustainable habitation of this planet, stand at a peril. The people of Sierra Leone believe that even if not directly, but indirectly, the country has the technology and the science to address climate change and its impacts. What is left for us in solving this global menace as a global community is a motivational leadership backed by the right spirit. Besides, there are certain actions that, if taken, can drastically reduce climate change impacts in Sierra Leone, and certainly, Africa as a whole.

First, it is expedient to cut emissions of carbon into the atmosphere. The major source of global warming and climate change is the incessant release of carbon dioxide into the atmosphere; this includes heat-trapping gases. Even though some schools of thought believe climate change has no remedy that can completely put an end to it, it can be reduced and slowed. The worst consequence of climate change will be avoided if we work towards a national goal of “NET ZERO” carbon discharge before or by 2050. How can this be possible? That is where attitudinal and behavioural change displays. We should have a clear transformation in the way we produce and consume electricity. Use of cars or vehicles should be a luxury, which means more newer cars. Drivers whose cars release thick carbon monoxide should be discouraged from using the roads/streets — a vehicle of this character will not be considered to be road worthy.

Even so, fossil fuels contain methane — Methane is one of the greenhouse gasses which causes global warming, which in turn, results in climate change. If the government will invest huge amounts of money on massive capacitation of climate change machine innovators like Kelvin Doe and the others, who have invented machines that do not use fossil fuels, and encourage the use of their inventions in homes, they will immensely help us in winning the war against climate change. Scientists and technologists all over the world should also get engaged in this war, and ensure that with collaborated efforts, we gain victory over it, by producing vehicles, generators and other technologies that don't use fossil fuels.

It is also very necessary to put on hold deforestation. Rather, communities, both rural and urban, should embark on Agro-forestry which makes it possible for the planting of trees alongside crops and livestock. To effect these, this nation needs strong regulated policies that will involve cost on carbon use. Subscribers to this opinion, known as Union of Concerned Scientists, Cambridge, believe that success to mitigate climate change impacts requires international cooperation. The Paris Agreement of 2016 was reached with the purpose of minimizing hazards caused by climate change. However, the objectives in practical terms, struck in the Paris Agreement, are yet to be met.

I have already emphasised and established 'net zero' emission of carbon. But there is still a huge presence of it in the atmosphere. This goes to suggest that something more is needed to be done in the fight against climate change effects. It is very necessary to remove carbon dioxide from the atmosphere, or least interrupt its effects on us. Easiest among the many ways to achieve the removal of carbon from the atmosphere is afforestation and reforestation. Since plants release oxygen, it will help suppress extreme heat and make the environment appear natural and refreshing. Afforestation goes further to prevent or reduce soil erosion.

Another way to address climate change is to fight disinformation. Some people do not believe that there is anything called climate change or global warming. For example, fossil fuel companies in the USA have made many to go astray by expressing disbelief in climate change. They have made lots of people believe that there is no special impact of climate change on human society. So, the misinformation has the potential to mislead and confuse the general public about the presence of the consequences of climate change. This has been really tough to implement workable solutions.

It is also prudent for anyone or organization to prepare and adapt for and to climate change consequences. This solution comes when all others fail. For such adaptation to go through, Sierra Leone's climate change policy framework has been put in place, National Adaptation Programmes of Action - Sierra Leone (NAPA-SL) was institutionalized in 2007. Also, the Environmental Protection Agency-Sierra Leone (EPA-SL) was put together in 2008. Through EPA-SL, the National Secretariat for Climate Change (NSCO) was formed in 2012. Regrettably, however, all of these have not totally solved the problem of climate change.

It does not matter how many organizations are formed, or how fast we help to reduce carbon emission into the atmosphere, the real fact is that there are some climate change impacts which are unavoidable. For instance, the seas have to rise, with its attendant high temperature year in and out.

Climate change related disasters like flooding, droughts, severe weather have not only left scars on humans, but also are sustained in most cases, thereby effectuating more damage to human existence.

This research has observed that cutting down carbon could be the best long-term solution, in order to avoid climate evils. For now, as a short-term remedy, adaptation to climate change related conditions can help reduce impact. This is to say, things that can discourage impact from developing in high-risk areas should be implored adequately. For instance, residents in high prone disaster areas should have a plan on how to deal with water scarcity when it occurs. It is also advisable to construct houses that can stand against flood waters in a way that can avoid collapse in the face of flooding.

It will also yield a greater dividend, if the central Government improves financial allocation — that can help find solutions to put a stop to this social menace. It has been observed in the past decades, inadequate funds cannot move Sierra Leone to any victory in the battle against climate change impacts.

It is also important for governments, non-governmental organizations, parastatals and other related institutions or stakeholders that are connected to global change situations to revamp and increase public awareness in a way that can inform everyone about the causes and the impacts of climate in rural areas and cities. These related institutions should also support and promote researchers who would like to probe into the phenomenon of climate change. Such awareness and promotion should be propelled by a special commission that will treat challenges related with climate change, because a mere Secretariat cannot help to produce the required result. All international cooperations, agencies, and bilateral relations are expected to offer more support to these climate change related institutions in Sierra Leone for lasting solutions to climate change problems.

However, even if adaptation is the answer to the hazards of climate change, it helps the rich in Sierra Leone more than the poor. Only the rich, for instance, can afford to easily and quickly move to areas where climate change impacts are far less. We can now see that there is an economic implication in the adaptation system because it involves a huge movement in terms of geographical locations, demographics and technology. That is why William Nordhaus, a Yale economist, believes adaptation cannot be general, but other sources should be made available to help the poor to adapt to climate change implications.

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