Strategies for Climate Hope and Sustainable Water Management

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Abstract

Water is the foundation of everything that lives. However, the persistent problems of flood, drought, fluctuating precipitation and changes in weather conditions clearly attest to an emerging crisis in water management. This study employs a positivist epistemological positioning approach to capture the views/opinions of stakeholders in the geo-political zones of Nigeria on the causes and effects of climate change, and strategies for climate hope and sustainable water management. In all, 240 survey questionnaires were administered to the randomly selected samples of stakeholders i. e. public authorities, business and industry, non-governmental organisations, workers and trade unions, scientific and technological community, indigenous people, children and youth. Of these, 210 completed and usable questionnaires (representing 87.5% response) were retrieved. Secondary data were collected through a systematic review of relevant scholarly publications. Descriptive statistical (Relative Importance Index, RII) tool was used along with SPSS version 28 for primary data analysis. Findings of the study uncovered 'carbon emissions' and 'rise in global temperature' as the major cause and effect of climate change respectively. Therefore, this study strongly advocates 'net-zero emissions' and 'water reuse' as ultimate strategies for climate hope and sustainable water management.

Keywords: Carbon emissions, Climate change, Renewable energy, Water services

1. Introduction

The availability of adequate wholesome water supply is critical to the health, economy and environment of any nation and its people. However, the persistent problems of flood, drought, fluctuating precipitation and changes in weather conditions clearly demonstrate an emerging crisis in water management. As temperature increases, so do natural disasters.

The increased burning of fossil fuels since industrialisation in 1900s has led to a rapid increase of the concentration of "greenhouse gases" (GHGs) in the atmosphere causing our planet to warm [1]. A warm planet often leads to a change in climate, which ultimately affects weather in various ways. Climate change may be described as a variation in weather that persists over a substantial period of 30 years [2]. It is a noticeable increase in global surface temperature (global warming), unpredictable weather patterns, rising sea levels due to melting polar ice caps, frequent storms, shrinking lakes, expanding deserts, and changes in the frequency of extreme weather events, all of which pose challenges to human habitation, as well as animal and plant life on the planet. Changes in climate may be due to natural causes, human activities/exploitation or a combination of these. For example, power- stations that burn conventional fossil fuels such as coal, oil and natural gas are major contributors to global warming, production of GHGs, and acid rain. Acid rain occurs when the gaseous products of combustion from power-stations and large industrial plant combine with rainfall to produce airborne acids [3]. These can have devastating effects on lakes, forests and other natural environments.

In the past, climate change was triggered by changes in the sun's energy output, the changing position of continental plates, or the rotating axis of the earth itself [4]. However, Science scholars opine that global warming is beyond natural occurrence and is due largely to carbon emissions [5]. Climate change is caused primarily by increase in GHGs chief of which are Carbon (IV) oxide (CO2), methane (CH4) which is 20 times as potent a greenhouse gas (GHG) as Carbon (IV) oxide, Nitrous Oxide (N2O), and three fluorinated industrial gases namely: hydro fluorocarbons (HFCS), per fluorocarbons (PFCS) and sulphur hexafluoride (SF6) [6]. However, the effects of climate change have become increasingly evident worldwide since 1992 [2].

Over the past 100 years, the average air temperature near the earth's surface has risen by almost 1 degree Celsius (1.3 Fahrenheit) [7a]. This little warming may not be unconnected with the conspicuous increases in storms, floods and raging forest fires witnessed in recent years. As temperature increases, evaporation increases, sometimes resulting in droughts. Similarly, rising temperatures often appear to melt glacial ice at an unprecedented rate [8]. Glaciers are an important source of fresh water

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worldwide, which may be difficult to restore once melted. In this respect, areas which depend on glaciers for water supply (e. g. Glacier National Park, USA) may have to seek other/alternative sources in future. This implies that many countries may face the risk of water shortages as a result of global warming. The aim of this study is to identify the causes and effects of climate change, and uncover strategies for climate hope and sustainable water management. The paper begins with an explicit introduction, sources of water, sustainable drainage systems, and effects of climate change on water services. A description of the methods adopted in the study is given, followed by the presentation of results and, finally discussion and conclusion.

2. Sources of Water

Millions of years ago, when the earth was a white, hot mass hurtling through space, its hydrogen and oxygen gas content burned together [9]. The result of this combustion was a new substance called water vapour or steam. Because of the intense heat, this remained as a gas and mixed with the atmosphere enveloping the hot earth mass. In time, the earth cooled and so did the surrounding atmosphere. Its water vapour content condensed to water which fell as rain to settle in the surface depressions of the earth and form the seas (Figures 1 and 2) [9, 12, 17]. Priestley was the first to observe that the explosion of a hydrogen and oxygen gas mixture yields water vapour [10]. Later, Cavendish established that the ratio by volume of hydrogen to oxygen in that reaction, at constant temperature and pressure was 2:1 [10, 11]. When dry hydrogen gas is ignited in air, it burns with a faint blue flame to give steam, which will condense on contact with any cold surface to form water. The chemical reaction is as follows:

$2H_2(g)$ (hydrogen) + $O_2(g)$ (oxygen) = $2H_2O(g)$

(hydrogen oxide, i. e. water)

Large quantities of water evaporate, particularly in warmer regions, from the seas and oceans and the water vapour in the atmosphere is carried by the wind and form mists and clouds, from which the water again falls on the earth in the form of rain, snow or hail (Figure 1). To a small extent, water vapour condenses directly on to the surface of the earth in the form of dew. A portion of the precipitation is again evaporated on the spot, either directly or through the intermediary of plants, which have taken up the water from the soil. Another portion penetrates into the ground until it meets an impervious stratum, thus giving rise to surface water which, in part, through the intermediary of channels, ditches and rivers, flows into lakes or back into the sea (Figures 1 and 2).

More than 50 percent of the World's water appears to be sourced from mountain runoff and snowmelt [12]. When snow and ice collect on mountain-tops, water is released slowly into reservoirs as it melts throughout the Spring and Summer. When rain falls, reservoirs fill quickly to capacity and sometimes results in excess water runoff that can be stored. Thus, in a tropical/warm environment, more precipitation may occur as rain rather than snow. However, since rain flows faster than melting snow, higher levels of soil moisture and ground water recharge are less likely to occur. Hence, areas that rely on snowmelt as their primary source of water may increasingly experience water shortages (i. e. low water supplies towards the end of summer). From the forgoing, the main sources of water are rainwater, surface water and underground water. However, on a smaller scale, water can be manufactured in a laboratory by burning hydrogen and oxygen gases in the proportion indicated by the chemical equation stated above.

Water is by far the most important liquid found on earth and an increasingly precious substance to man, society and ecosystems [13, 22]. Plants absorb nutrients from the soil because mineral salts that sustain plant life dissolve in water. Photosynthesis is the process that combines water and carbon (IV) oxide for the manufacture of plant food [3]. Water is extensively used in virtually every industry/manufacturing process where it serves as solvent. Distilled water is used in the manufacturing of drugs and blood infusions in pharmaceutical establishments. Washing and cleaning of machines and equipment in chemical industries require large amounts of water. Many factories also use large quantity of water to cool their machines [10].

A reliable, clean supply of drinking water sustains health and life. As temperatures rise, people and animals need more water to thrive and maintain good health [12, 22]. The economic activities which require water include agriculture, energy production, construction, navigation, recreation, sewage disposal, transportation, fire protection, laundering, environmental control, and manufacturing. However, the growth in population coupled with rapid urbanisation, changing lifestyles and economic development has led to increasing pressure on water resources especially in developing countries. Presently, more than one billion people do not have access to safe drinking water [14, 22].

Furthermore, in many areas, climate change seems to increase water demand by shrinking water supplies on one hand; while on the other hand, other areas may experience increase in runoff, flooding, or sea level rise (Figure 2). These effects can also reduce the quality of water and damage the infrastructure used to transport and deliver water.

Against this background, the European Union Water Initiative (EUWI) was launched at the Johannesburg Summit in 2002. The EU Council

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resolution of 30th May 2002 endorsed the EUWI and its focus on poverty reduction in underdeveloped countries, highlighted the importance of Integrated Water Resources Management, and also emphasised the need to balance human water needs and those of the environment [15].

Water quality could suffer in areas experiencing increases in rainfall. For instance, an increase in heavy precipitation could cause problems for water infrastructure, as sewer systems and water treatment plants are overwhelmed by the increased volume of storm water. Similarly, heavy downpours can increase the amount of runoff into rivers and lakes, washing sediment, nutrients, pollutants, trash, animal waste, and other materials into water supplies, making them unusable, unsafe, or in need of water treatment (see Figures 1 and 2).

The methods adopted for treating and moving public water supplies require large amount of energy, produced mainly by burning coal, natural gas, oil and other fossil fuels [16]. This contributes significantly to climate change.

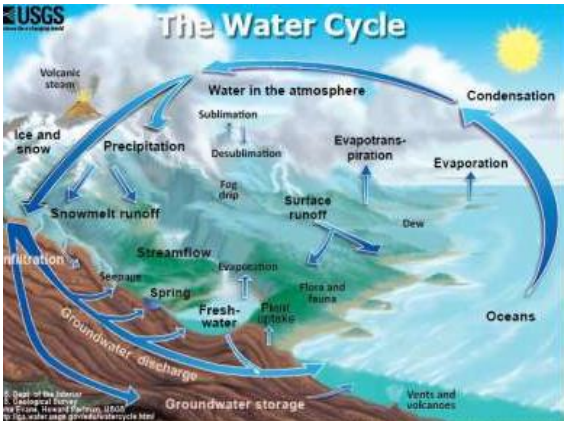

Figure 1. The Hydrologic Cycle [17]

Water is always in movement, and the natural water cycle, otherwise known as the hydrologic cycle (Figure 1), describes the continuous movement of water on, above, and below the surface of the Earth.

The water cycle appears to be a delicate balance of all the steps in-between precipitation and evaporation. Warmer temperatures often increase the rate of evaporation of water into the atmosphere thereby increasing the capacity of the atmosphere to 'hold' water. Increased evaporation may dry out some areas and fall as excess precipitation on other areas (Figure 2).

Changes in the amount of rainfall during storms provide evidence that the water cycle is already being affected. Over the past 65 years, the amount of rainfall during the most intense 1 percent of storms appears to have increased by almost 20 percent [21]. Warming winter temperatures cause more precipitation to fall as rain rather than snow. Additionally, rising temperatures often cause snow to begin to melt early [17]. This definitely alters the timing of streamflow in rivers whose sources are in mountainous areas.

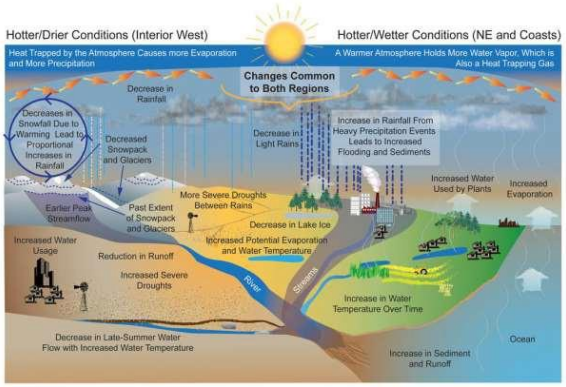

Figure 2. Changes in the water cycle [12]

3. Sustainable drainage systems

Sustainability is a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs [2, 22]. Drainage is concerned with the disposal of surface water together with the discharge from all sanitary appliances installed within a building or facility.

The areas of permeable land where rainwater can soak away appear to be fast diminishing as a result of an increasing built-up environment. Traditional drainage system moves storm water as rapidly as possible to a watercourse or river through gravity pipelines or culverts. Yet, sustainable drainage systems replicate natural drainage patterns, keeping rainwater on site longer and controlling run-off thus helping to reduce the risk of flooding. Sustainable drainage systems include infiltration, trench- style soakaway, attenuation and rainwater harvesting [18].

Infiltration system allows for slow release of water generally into the surrounding soil (Figure 1). As an effective solution to a number of storm-water drainage problems, infiltration systems are generally divided into two categories (depending on whether temporary storage takes place above or below ground level). Above-ground infiltration systems utilise natural or artificial surfaces. Typical examples include porous pavements and paviours or infiltration basins and swales. Below ground or sub-surface infiltration systems are buried structures. The most common example is the conventional soakaway filled with rubbles or broken blocks. Today, more effective alternative options include modular plastic cells wrapped in permeable membrane. Another drainage option is a trench-style soakaway that utilises perforated pipework over a large plan area for dispersal.

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Attenuation consists of the temporary storage of surface water in a suitable chamber below ground level. This chamber may need to be of sufficient size to accommodate the intended run-off during peak periods of rainfall. The stored water is then gradually released in a controlled manner into a surface water or combined drainage system or watercourse, subsequently effectively reducing the risk of flooding. Increasingly, as existing sewer networks approach their capacity, attenuation systems offer a cost-effective solution for accommodating additional catchments without increasing the size of existing sewers.

Rainwater harvesting (collection) is ideal for garden irrigation, flushing sanitary appliances (urinals, water closets, etc.) and can combine infiltration with recycling. Thus, it reduces the demands on drainage systems and can help to reduce flood risk. Many countries are presently enjoying the benefits of water reuse. These include USA, South Africa, New Zealand, Malaysia, Chile, Central America, Canada, Australia, Argentina, France, Belgium, Italy, Czech Republic, Germany, Netherlands, Poland, Spain and the UK [22].

4. Effects of Climate change on Water Services

Climate change is an observable and undeniable fact. Its effect on water services is evident on energy, tourism and recreation, agriculture and health [10]. Water and energy are intimately connected. For instance, water is used for hydro-electric power generation and cooling, while energy is used by the water sector for pumping, treatment and heating. Without energy, there would be limited water distribution, just as there would be limited energy production without water. In this respect, climate change resulting in lower streamflow in areas where hydro-power is generated may reduce the amount of energy that can be produced. Similarly, changes in the timing of streamflow can also have effect on the ability to produce hydro-electricity. In the same vein, low water flow would reduce the amount of water available to cool fossil-fuel and nuclear power plants.

The effect of climate change on water supply and quality may also affect tourism and recreation. The quality of lakes, streams, coastal beaches, and other water bodies that are used for swimming, fishing, and other recreational activities can be affected by changes in precipitation, increases in temperature, and sea level rise. Furthermore, winter sport activities which depend on the production of snow and ice could be limited in the future as temperatures increase.

The role of agriculture in a developing economy cannot be over-emphasised. It is a major contributor to the country's Gross Domestic Product, source of income for a large proportion of the population engaged in the sector, provision of adequate food for the people, supply of raw materials required by the industrial sector, a major foreign exchange earner through export, and provision of employment opportunities for the teeming population [19, 22].

Agriculture involves the cultivation of crops and rearing of animals. These activities depend on vagaries of weather especially in developing countries. Thus, epileptic rainfall and sudden increase in temperature portend serious danger for crop production as key physiological process such as pollination, tasselling of crops may cease after temperature thresholds are reached. The livestock species such as cattle, goat, sheep, poultry and other non-livestock animals such as donkey, horse which provide employment, food, income, farm energy, and transport respectively are also victims of the temperature which affects the animal health and reduce their market value thereby reducing farmer's income.

The fishery business is not immune as heavy rainfall frequently leads to flooding. Agricultural processing is also not spared as the erratic weather condition interferes with operations like sun- drying of crops and smoking of fish etc. [10]. There is no doubt that the impact of climate change may further aggravate the stress associated with subsistence production, such as small farm size, land tenure problem, low level of technology, lack of storage facility etc. Furthermore, the indirect effects of climate change on agriculture include the effects on sporadic pests and diseases as witnessed recently in Southwest Nigeria maize farms that were infected by army worms and ebolatomato case in the Norther part of Nigeria.

Agriculture and livestock depend largely on water. Heavy rainfall and flooding can damage crops and increase soil erosion and delay planting. Similarly, areas that experience more frequent droughts may have less water available for crops and livestock. Given the current concern on the state of agriculture and the effects of climate change on small scale agricultural productivity coupled with dwindling resources from oil, there is an urgent need to embark on climate-smart agriculture which is a system that sustainably increases productivity and resilience (adaptation), reduces or remove GHGs, and support achievements on food security and other developments' goals.

Heatwaves are amongst the deadliest natural hazards, with hundreds of thousands of people dying from preventable heat-related ailments each year [7b, 10]. Heat is a rapidly-growing health risk, due to burgeoning urbanisation, an increase in high temperature extremes, and demographic changes in countries with ageing populations. Recently, death related to meningitis, an extreme heat-related disease became a yearly scourge in the Sahel. Specifically, land surface areas exposed to heat stress and waves killed thousands of people in India and Pakistan in

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2015 [20]. Thus, continued climate change along the present path may have more dire consequences. From the foregoing, the relationship between water, energy, agriculture and climate may fall out of balance, thereby jeopardising food, water, health, and energy security.

5. Research Methodology

This paper examines the causes and effects of climate change, and strategies for climate hope and sustainable water management. The study employs a positivist epistemological positioning approach to capture the views/opinions of stakeholders in the geo-political zones of Nigeria. In all, 240 survey questionnaires were administered to the randomly selected samples of stakeholders i. e. public authorities, business and industry, non-governmental organisations, workers and trade unions, scientific and technological community, indigenous people, children and youth. Of these, 210 completed and usable questionnaires (representing 87.5% response) were retrieved. Secondary data were collected through a critical desktop analysis, synthesis and evaluation of extant literature from peer-reviewed journal articles, refereed conference proceedings, textbooks and technical reports. Descriptive statistical (Relative Importance Index, RII) tool was used along with SPSS version 28 for primary data analysis.

6. Results of the Study

Results from Table 1 show that the subjects to this study are relevant stakeholders in climate change. About 90% of the respondents (Table 1) have more than 10years post-qualification experience in employment and practice. These respondents are samples randomly selected and representatives of climate stakeholders. The underlying assumption that they are competent, experienced and capable of exercising sound judgement is met. Therefore, the findings and conclusions of this study can be generalized.

Table 1. Respondent's characteristics

Characteristics	Frequency	Percentage
Public Authorities	32	15.2
Business and Industry	38	18.1
Non-Governmental Organisations	30	14.3
Workers and Trade Unions	34	16.2
Scientific and Technological Community	40	19.1
Indigenous People, Children and Youth	36	17.1
Total	**210**	**100**

Table 2 shows the relative importance index results for causes and effects of climate change, and strategies for climate hope and sustainable water management.

Table 2. Relative Importance Index results

Variables	SA 4	A 3	D 2	SD 1	NO 0	RII	Rank
Causes of Climate Change							
Burning of fossil fuels (coal, oil, natural gas)	129	81	0	0	0	0.903	5
Concentration of greenhouse gases in the atmosphere	140	70	0	0	0	0.916	2
Changes in the sun's energy output	100	99	0	0	11	0.829	19
Changing position of continental plates	120	90	0	0	0	0.892	8
Rotating axis of the earth	89	121	0	0	0	0.855	16
Acid rain	81	129	0	0	0	0.846	17
Carbon emissions	150	60	0	0	0	0.928	1
Heat wave	98	112	0	0	0	0.866	13
Fire accidents	120	80	0	0	10	0.857	15
Transport emissions	130	80	0	0	0	0.904	4
Bush burning	110	100	0	0	0	0.880	9
Volcanic eruptions	104	106	0	0	0	0.873	11
Ocean currents	109	101	0	0	0	0.879	10
Earth orbital changes	94	116	0	0	0	0.861	14
Solar variation	80	123	0	0	7	0.820	20
Anthropogenic/ man-made causes	121	89	0	0	0	0.894	7
Deforestation	73	137	0	0	0	0.836	18
Coal mining	102	108	0	0	0	0.871	12
Industrial processes	133	77	0	0	0	0.908	3
Agricultural processes	124	86	0	0	0	0.897	6
Food chain and consumption pattern	97	100	0	0	13	0.819	21
Industrial meat production	80	101	0	0	29	0.741	22
Effects of Climate Change							
Rise in sea level/ ocean surge	155	55	0	0	0	0.934	5
Heavy rainfall across the globe	100	98	0	0	12	0.826	23
Extreme drought	92	104	0	0	14	0.809	26
Decline in crop productivity	118	86	0	0	6	0.869	19
Changes in ecosystems	116	94	0	0	0	0.888	14
Hurricanes	89	110	0	0	11	0.816	24
Rise in global temperature/ global warming	160	50	0	0	0	0.940	1
Carbon-iv-oxide acidifies seawater	102	99	0	0	9	0.939	21
Shrinking water supply	122	88	0	0	0	0.895	13
Expanding deserts	126	84	0	0	0	0.900	11
Raging forest fires	145	65	0	0	0	0.922	7
Heat related diseases	100	95	0	0	15	0.815	25
Erosion	106	104	0	0	0	0.876	18
Frequent storms	111	99	0	0	0	0.882	16
Challenges to human habitation	148	62	0	0	0	0.926	6
Challenges to animal and plant life	142	68	0	0	0	0.919	8
Melting of glacial ice/ glaciers	100	110	0	0	0	0.869	19
Flood	127	83	0	0	0	0.901	10
Fluctuating precipitation	108	102	0	0	0	0.878	17
Variation/ changes in weather conditions	157	53	0	0	0	0.936	4
Unpredictable weather patterns	158	52	0	0	0	0.938	3
Food insecurity	128	82	0	0	0	0.902	9
Loss of biodiversity	90	112	0	0	8	0.828	22
Increased hunger	125	85	0	0	0	0.898	12
Increased poverty	114	96	0	0	0	0.885	15
Vulnerability to climate disaster	159	51	0	0	0	0.939	2
Strategies for Climate Hope							
Smart agriculture	96	94	0	0	20	0.792	19
Sustainable drainage systems	95	78	7	0	30	0.747	20
Renewable energy	165	45	0	0	0	0.946	2
Energy efficiency	120	90	0	0	0	0.892	11
Mass transit system	135	75	0	0	0	0.910	7
Inter-modal transport system	110	100	0	0	0	0.880	14
Water efficiency	119	91	0	0	0	0.891	12
Family planning	90	80	10	5	25	0.744	21
Waste reduction, reuse and recycling	141	69	0	0	0	0.917	5
Afforestation	124	86	0	0	0	0.897	10
Green environment	162	48	0	0	0	0.942	3
Sustainable development	154	56	0	0	0	0.933	4
Environmentally friendly (green) technology	109	101	0	0	0	0.879	15
Adaptation techniques	115	95	0	0	0	0.886	13
Electric vehicles	105	105	0	0	0	0.875	16
Elimination/drastic reduction of transport emissions	136	74	0	0	0	0.911	6
Free trade	112	79	5	4	10	0.832	17
Introduction of carbon tax	88	101	6	10	5	0.805	18
Inland waterways development	125	85	0	0	0	0.898	9
Expansion/ modernisation of rail transport system	130	80	0	0	0	0.904	8
Net-zero emissions	170	40	0	0	0	0.952	1

Key: RII = Relative Importance Index, NO = No Opinion, SD = Strongly Disagree, D = Disagree, A = Agree, SA = Strongly Agree.

$$RII = 1\ [\sum i=4\ Wix\ fi]$$

$$4n\ i=0$$

Where Wi is weight given to ith rating; i = 0, 1, 2, 3 or 4, fi = response frequency of the ith rating; and n = total number of responses.

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7. Discussion

Results from Table 2 indicate that all the assessed variables rank very high. Empirical results from this study (Table 2) revealed 'carbon emissions (RII = 0.928)', 'rise in global temperature (RII = 0.940)' and 'net-zero emissions (RII = 0.952)' as the major cause of climate change, major effect of climate change, and the ultimate strategy for climate hope and sustainable water management respectively.

Climate change is a variation attributed directly or indirectly to human activity that alters the composition of the global atmosphere in addition to natural climate variability observed over comparative time periods. Climate change may have significant effects on precipitation, evapotranspiration, and runoff and ultimately on global water supply (Figure 2). The frequency and severity of droughts may increase as a result of a decrease in rainfall as well as more frequent dry spells and greater evapotranspiration. Changes in stream-flows, increased storm surges, and higher water temperatures may negatively affect the health of nations' water supply. Warm air temperature is capable of raising stream and lake temperatures, and can harm aquatic organisms that live in cold water habitats. These changes may vary in different continents and regions of the World with the potential effects of increased flooding and drought, water quality impairment, and salt water intrusion to coastal water supplies. In particular, many countries may face extremely high risks of water shortages as a result of global warming.

Projections from Intergovernmental Panel on Climate Change, IPCC [7aandb] estimated that by year 2100, global surface temperature will probably increase a further 1.5 to 4.8 degrees Celsius. Additionally, by mid-century, annual average river run-off and water availability are projected to increase by 10-40 percent at high latitudes and in some wet tropical areas, and decrease by 10-30 percent over some dry regions at mid-latitudes and in the dry tropics [5, 21]. Millions of people are projected to be flooded every year due to sea level rise by 2080's [5, 7aandb, 21]. The population affected may be largest in the mega-deltas of Asia and Africa; while small Islands might be especially vulnerable. Thus, recent natural disasters in Morocco; Libya; Hawaii; New York; Afghanistan; Myanmar; Ghana; Nepal; Italy; Northern France; Houston, Texas; Florida; Irma; Puerto Rico; Caribbean Islands; Cuba; Tortola; Barbuda; St. Martin; Mexico; China; Sierra Leone; and Nigeria are signs of what to expect in no distant future. Given these, climate scientists estimate that the world must cut its emissions by 80 percent by year 2050 in order to limit global warming to a 2 degree Celsius average rise compared to pre-industrial levels [5], [7b].

More than 100 million extremely poor people in Africa are threatened by accelerating climate change that could also melt away the continent's few glaciers within two decades [21]. By 2030, it is estimated that up to 118 million extremely poor people will be exposed to drought, flood and extreme heat in Africa if adequate response measures are not put in place [21]. Floods can cause death and injury (by drowning), physical trauma, heart attacks, shortage of safe water, illness from infectious diseases, poisoning, and disruption to health services displacement. The extremely poor are those who live on less than $1.90 per day. In Sub-Saharan Africa, climate change could further lower gross domestic product by up to 3% by 2050 [21].

Not only are physical conditions getting worse, but also the number of people being affected is increasing. The respondents to this study reported that temperature-rise in Africa increased in 2020, resulting into accelerating sea-level rise as well as extreme weather events like floods, landslides, and droughts. Between 2010 and 2020, deaths from floods, droughts, and storms were 15 times higher in highly vulnerable regions, compared to other parts of the World [21]. Vulnerable communities bear the brunt of economic, health, and social impacts due to limited resources and increased risks. Displacement, diseases, biodiversity loss, and food insecurity are just a few of the devastating consequences. Climate change deepens existing inequalities and social injustices, threatening fundamental human rights. The top 10% of high GDP households contribute 34 – 45% of global greenhouse gas emissions, while the bottom 50% contribute 13 – 15%. Children and young people, who have not caused the crisis bear the full force of its impacts [21].

Burning fossil fuels drives climate change and causes air pollution that leads to lung cancer, stroke and heart disease [23, 24]. Air pollution causes 13 deaths per minute worldwide, hence climate crisis harms human health [21]. Climate change makes it more likely for droughts and wildfires to happen. Wildfires can cause death and injury (from suffocation), burns and smoke inhalation, trauma impacts on mental health, loss of housing and livelihoods, respiratory and cardiovascular problems from smoke and ashes.

Given that the effects of climate change may differ from one country to another due to how climate factors interact with demographic and socio-economic factors at the local level, it is estimated that about 9.4 million people could become climate migrants in Nigeria by 2050 [21]. This presupposes internal climate migration in West African countries.

The respondents to this study posited the introduction of carbon tax, free trade, and climate justice. Free trade implies more people having access to goods and services at low prices, while carbon tax would reflect the true cost of goods transportation. Thus, free trade and carbon tax may work well together to reduce emissions and enable economic

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development particularly in Africa, Southwest Asia and Latin America. Climate justice is not an end in itself but a path to ensuring equity in the distribution of burdens and benefits in the push towards net-zero emissions. Therefore, countries and industries which have become wealthy by emitting large amounts of greenhouse gases have a responsibility to reduce emissions and support vulnerable communities impacted by climate change.

8. Conclusion

Climate change refers to the long-term changes in the earth's climate, beyond the increase in average surface temperature. It causes weather patterns to be less predictable, affecting the balance of ecosystems that support life and biodiversity. On the other hand, water is a finite resource with provision determined very much by the fickle nature of the weather. All over the world, demand from an increasing population is imposing considerably on this limited resource. Additionally, rising levels of affluence and higher standards of living create expectations for luxury goods such as whirlpool baths, power showers, hot tubs and possibly swimming pools in some high specification modern homes. Promotion of water use efficiency is therefore paramount to management of demand.

The increase of the average temperature on earth (global warming) is the single biggest environmental and humanitarian crisis of our time. Climate-induced changes in water cycle may affect the magnitude, frequency, and costs of extreme weather events as well as the availability of water to meet growing demand. Although the responsibility for the causes of climate change rests with both the developing and industrialised nations, the costs of climate change will ultimately be borne most directly by the poor. The effects of climate change on water availability and water quality may affect such sectors as agriculture, energy production, infrastructure, human health, and ecosystems. Thus, the enabling environment has to be put in place to ensure the reuse and recycling of water especially in developing countries.

A lot can be done to reduce emissions, mitigate climate change and protect threatened water sources. Exploring alternative, non-fossil fuels, especially solar power, which is inexhaustible in Sub-Saharan Africa may be a good start. Avoidance of energy wastage and effective use of power is paramount. For example, electricity lights can be turned off when not required, so also electrical appliances should be switched off when not in use. Additionally, effective thermal insulation of homes in temperate regions can help to conserve heat, while adequate natural cross-ventilation openings in tropical regions would guarantee energy efficiency.

Transport plays an important role in climate change problem, as it consumes about half of the global oil, and contributes one-quarter of total fossil fuel combustion related CO2 emissions of the World. Therefore, investment in mass transit programmes which can move a large number of passengers, goods and services rapidly and safely from point to point with the minimum of disruption to everyday life can no longer be delayed. Thus, the significance of renewable energy cannot be over-emphasised. For example, Brazil, Zimbabwe and the USA produce ethanol as a renewable source of energy for the motor car. Since 1990, 30% of new cars in Brazil can use ethanol and many more use a mixture of petrol and ethanol. Ethanol produces less pollution than petrol. Furthermore, the modernisation and expansion of the rail transport system, as well as the development of water transportation need to be pursued vigorously.

Family planning should be encouraged and rewarded in order to reduce population pressure on scarce resources. Pressure on water resources becomes more intense with expanding urban populations and greater strain on existing infrastructure.

Conserving water, food and other resources is an important step towards reducing overall energy use because virtually everything that is made, transported and thrown away requires the use of fuel and water. In particular, the use of drinking water for non-hygienic purposes constitutes wastage and consequently needs to be discouraged. Additionally, bottled water is a small but real contributor to GHG emissions, because it takes fuel to make plastic bottles and ship them around the World and country. The plastics industry is the fastest growing source of industrial GHGs in the World. Similarly, eating locally grown food and reducing consumption of imported food and other consumer goods can make an impact on curbing GHGs. Locally grown food may help to reduce transportation and guarantee lower energy consumption. Furthermore, going meatless for just one day a week can have a significant impact on environmental resources because industrial meat production is associated with substantial GHG emissions.

Afforestation should be much more than ritual tree-planting exercise in order to curb desert encroachment. Trees can be planted and nurtured in order to mitigate the hazards of global warming and climate change. Planting of trees is very important for creating a green environment because trees provide oxygen, cool the atmosphere, help conserve energy, save water, prevent erosion, reduce the rate of ocean surge, save children from ultra-violet rays, provide food and bring diverse groups together.

The effects of climate change exert extreme pressure on the traditional methods of water supply and dealing with storm-water. Increased or severe flooding and drought demands a different approach to how water is controlled, stored and re-used. This presents the opportunity for recycling initiatives and a

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more sustainable way to manage water.

Climate change poses an obstacle to sustainable development, yet it presents the opportunity to rethink consumption and production patterns, provides prospects for growth that is green, resilient and inclusive. It helps to imagine alternatives to non-renewable sources of energy and to develop new technologies. Alternative and renewable 'green' energy sources are becoming viable solutions to fossil fuels. Renewable energy is effectively free fuel, a natural, constantly replenished alternative energy resource including solar, wind, tidal, geothermal, hydro, biomass, biofuel and hydrogen. The UK government's low carbon transition plan aims at reducing carbon emissions by 34% by year 2020 and by 80% by year 2050. However, IPCC [21] lamented that countries' commitments appear far away from getting the World on track to limiting global warming to 1.50C. The report claimed that while some progress has been made, the required downward trend in emissions is not yet in sight.

It would be recalled that in 2017, President Trump's Executive Order eviscerated the Paris Agreement, discouraged adherence and watered-down sanctions for non-compliance to the international protocol on global warming. But, on assumption of office early 2021, President Biden announced the restoration of America's commitment to the Paris Agreement. Therefore, governments actions need to reflect the level of urgency, the gravity of threats being faced, and the shortness of the remaining time to avoid the devastating consequences of climate change. While the World is standing at the verge of climate disaster, a window for action remains open to avoid the worst climate impacts. To get on track to achieving the Paris Agreement goals, investments in adaptation and drastic emissions cuts are expedient. Consequently, the implementation of national climate plans needs to be accelerated.

Climate change is a security issue which threatens everyone and everything. Though empirical data for this study is drawn from the Nigerian context, the data constructs were developed from extant literature. Given the probability sampling technique employed, this study has significant implication for policy formulators and planners across sectors, individuals, and all-and-sundry to devise strategies that will sustain climate hope and simultaneously meet the water-needs of growing communities, sensitive ecosystems, farmers, ranchers, energy producers, and manufacturers. This may require the adoption of a variety of adaptation practices designed to better conserve water supplies, improve water recycling, and develop alternative strategies for sustainable water management.

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