IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 15, Issue 1 Ser. II (January 2021), PP 47-54
www.iosrjournals.org

Climate Change and Extreme Climate Events: A Threat to Water Security in Northern Nigeria

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Abstract:
Background *Climate change has significantly impacted on water security and developing countries have severely been affected. Rural communities in northern Nigeria have of recent been exposed to unprecedented impacts of extreme climate events. Flash floods and drought incidences have impacted on the regions water quality and access to water.*
Materials and Methods*: This mini review focuses on the impacts of extreme climate events on water quality, water access and availability within northern Nigeria. It highlights how variations in both temperature and precipitations impacts the regions water security. In addition, it highlights how climate change further undermines the regions sustainable development goal on access to water and how lack of water further undermines the fight against SARs-CoV-2.*
Results*: Findings from the study shows that extreme climate event is continually impacting on water access and quality within northern Nigeria. In addition, rural communities are worst affected due to inequalities amongst and within rural people. Water access and quality have been undermined and the lack of water and wastewater treatment facilities within rural communities will further exacerbate water insecurity which will also undermine the realization of the SDGs.*
Conclusion: *There is therefore the need for a redesign of water programs and projects aimed at addressing water related issues within northern Nigeria. Water managers must begin to collaborate with local residence on the projects that will assist in building adaptive capacity and community resilience.*
Key Word*: Extreme climate events, water security, climate change, northern Nigeria*

Date of Submission: 20-01-2021 Date of Acceptance: 04-02-2021

I. Introduction

Climate change has emerged to become one of the greatest challenge's humans will have to deal with today. Climate change have manifested in diverse of ways which include, heatwaves, flood, drought, storms, hurricanes, sea level rise and pollution. According to the IPCC reports, human induced greenhouse gases are majorly responsible for the changes and variations in our environment[1,2]. Climate change will lead to warming and this is set to continue and will led to unprecedented impacts on the environment[3,4]. These impacts are already having negative effect on sensitive sectors such as agriculture, water, energy, health, environment, national and international security[5,6,7]. The business-as-usual scenario proposed by the IPCC reveals a rising trajectory of GHG emissions which will eventually led to increased frequency, severity, and magnitude of impacts globally.

Changes to the climate of this magnitude will result in a completely different environment[8], and although efforts have been made and are still being made by different countries to reduce emissions and mitigate climate change, climate impacts are still on the increase and are being distributed unevenly[9,10] and felt disproportionately especially by the poor who are already considered vulnerable[11]. These poor and vulnerable people are said to have contributed less to the cause of climate change yet suffer the most from its diverse impacts[10,11,12]. This is the climate related injustice which must be addressed in the cause of mitigating climate change. These injustices are also due to the inequalities that exist between and within countries due to economic, social, and other environmental factors, and climate change will further exacerbate these inequalities thereby exposing vulnerable people to severe environmental threats. According to the Mary Robinson Foundation for Climate Justice, developing nations are already at severe risk to extreme climate events and therefore will tend to suffer the most[12]. For instance, it is already estimated that fallout from climate change kills over 300,000 people annually, including through the spread of diseases and malnutrition[13,14]. Furthermore, developing countries have about 98% of affected people and 99% of all deaths from extreme climate disasters[13], and they bear over 90% of the total economic losses attributed to climate change[14].

Water resources will be one of the worst hit sectors because of climate impacts. It will affect water availability, accessibility and quality and further undermine the fundamental human rights of millions of people

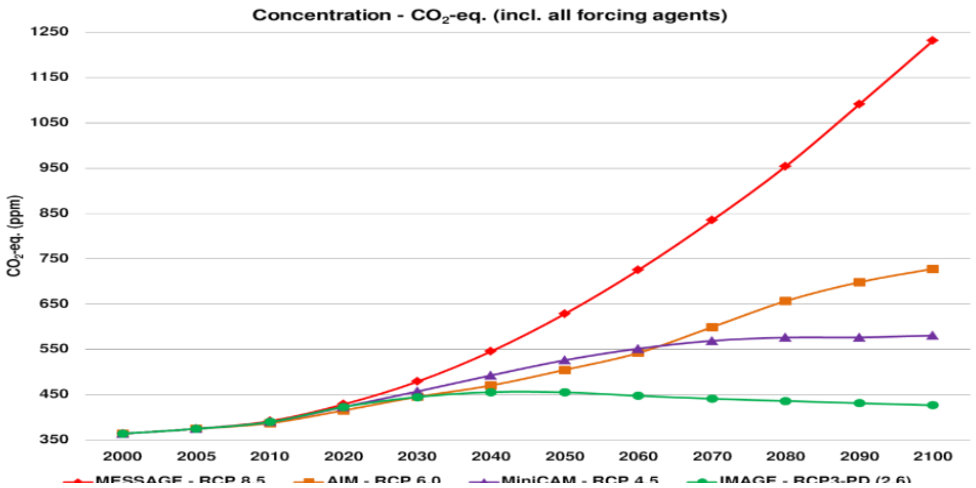
especially those in developing nations. Water supply sources will be polluted, access to safe water will be limited, and majorly, some regions will experience severe water stress[15,16,17]. Climate impacts through the uneven distribution of water resources will further worsen the severity of water security and coupled with the existing inequalities, will led to water justice concerns. For instance, many communities in Northern Nigeria are saddled with climate impacts such as drought, and this has forced women and young girls to spend hours walking several distances (usually more than 2miles) to access water for domestic use in their families. Sultana[18] similarly reported such situation in south east Asia and concluded that women suffer the most from any changes in water accessibility and availability.

Against this backdrop, this review tends to highlight the impacts of extreme climate on water security in Northern Nigeria. It aims to address water availability, accessibility, and quality as the three main approaches to water security and focus on the injustices due to the uneven distribution of water resources and why water justice is the key to attaining sustainable development and adapting to climate change.

II. Climate Change and Extreme Climate Events

The rise in global surface temperature due to increase in anthropogenic greenhouse gasses in the atmosphere has resulted in series of impacts that is being experienced globally[5,19]. Rise in global surface temperature has led to warming, which in turn leads to variation in both temperature and precipitation, resulting in impacts such as sea level rise, heatwaves, hurricanes, storms, drought, and flood. These trends are expected to continue over the next few decades if efforts to mitigate greenhouse gasses are not implemented[7,8]. This is evident in the IPCC AR5 report which clearly indicates the rising trajectory of emissions and suggest the need to cut down emissions if we are to avoid dangerous impacts of climate change[2]. For example, the IPCC projected carbon dioxide ($C0_2$) emissions using different scenarios (Representative Concentration Pathways RCPs) to indicate anthropogenic activities and their contribution to $C0_2$ in the atmosphere. According to the trajectory, impacts will continue to manifest even if emissions are cut and this is because the earth systems will need to stabilize the past emissions as seen in Figure 1 below.

Figure 1: Carbon dioxide Trajectory from 2000 to 2100



The representative concentration pathways (RCPs) developed by the IPCC have given an idea as to what to expect with different efforts made to reduce or mitigate emissions. Consequently, the RCP 2.6 as shown in Figure 1 have been put forward by the IPCC as the possible path to take to avoid further impacts on the environment. Although efforts are being made by many nations to slow climate change, impacts are still on the increase with various magnitudes and frequencies. These impacts will have enormous effect on health, agriculture, water, and other use sectors of the environment. Notably, water resources will have to be managed adequately and people will have to build their capacity to adapt to climate impacts on water especially extreme climate impacts. Water management is key here because, impact on water resource either on availability, accessibility or quality will have a direct or indirect impact on health, agriculture, economic development, and other aspects of governance, development, and the environment.

Extreme climate event (in the context of water resources) is an occurrence or event which is normally rare or unusual that can alter the availability, accessibility, and quality of water well outside the bounds of what is considered normal to a specific region[20,21]. The general understanding of an extreme event assumes that a normal state of climate exists in which any deviation will be termed as rare. Consequently, the state of what is considered normal is generally derived from a temporal series of observed data, events, or conditions over a

considerable period of time[22,23]. For example, the average annual precipitation or temperature may be normal or somewhat uniform over several consecutive years but, a higher or lower variation year would be marked as unusual for that period. The frequency distribution of an observed climate parameter over a considerable period and for a given point or area would be expected to vary around a mean value, as can be seen in Figure 2a. However, an extreme event will be described by a deviation from the mean with a low frequency of occurrence within the period as observed with the second graph in Figure 2b. A deviation from the normal pattern becomes an anomaly and this is recorded when the event is largely outside the general pattern of variation. The incidence of say, a heat wave or an extreme precipitation event will be determined by assessing the climate parameters as part of a statistical analysis and concentrating normally on only three main aspects: the threshold (minimum and maximum), the frequency of occurrence and lastly, the magnitude of occurrence[20,22].

Figure 2a: Idealised frequency distribution for events and distribution shift

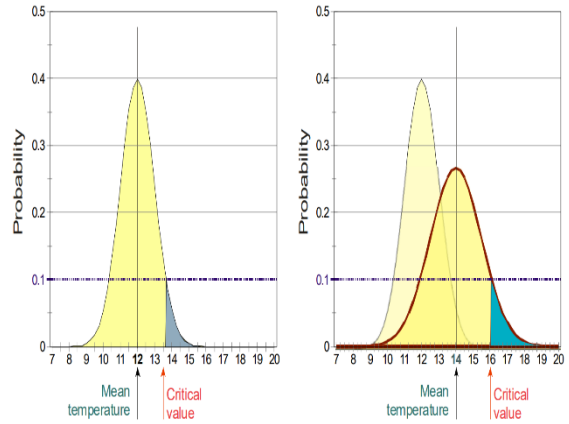
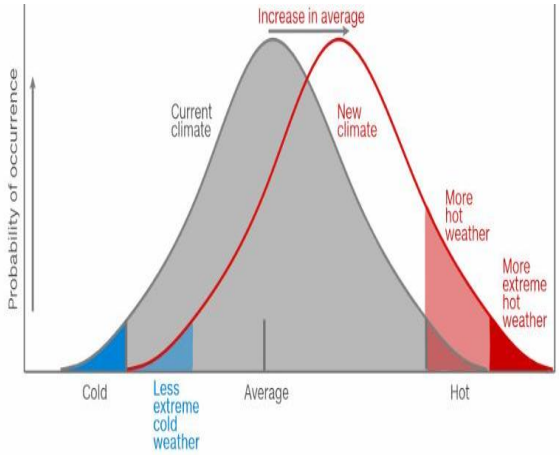


Figure 2b: A shift from normal current climate to extreme climate change



III. Climate Impacts on Global Water Security

Water represents an essential element for the survival of all forms of life and the uneven distribution through alterations in wet and dry periods makes water even more precious. Water is at the center of sustainable development and for socio-economic development, healthy ecosystems and for human survival. It is primarily the medium through which climate change will severely be experienced[24,25]. The availability of water is becoming less predictable in many parts of the world and increased incidences of flood and drought is threatening to destroy water points, sanitation facilities and contaminate water sources especially in rural communities[26]. Incidences of drought are exacerbating water scarcity thereby negatively impacting people's health and productivity[27,28]. In addition, the variation in temperature and precipitation have impacted on water access and quality in many parts of the world. These frequent impacts on water are tending towards water security issues and hence needs to be addressed in order to avoid dangerous impacts globally. Defining water security will vary depending on the perspective from which one views it. For example, according to Water Aid[29], water security is the reliable access to water of significant quantity and quality for basic human needs, small-scale livelihood, and local ecosystem services, coupled with a well-managed risk of water-related disasters. Consequently, the UNEP[30] defined water security as a unifying element which supplies humanity with drinking water, hygiene and sanitation, food and fish, industrial resources, energy, transportation, and natural amenities. Another view of water security is defined by the Global Water Partnership[31], as the access to water at all level by all persons at an affordable cost, to lead a clean, healthy, and productive life, while ensuring that the natural environment is protected and enhanced. All these views give water security an important role in the survival and development of humans, animals, and the ecological system.

The consequences of climate change will compromise water security as vast majority of climate impacts will be directly on the hydrological cycle, resulting in hydrological variability which will in turn have detrimental effects on [society17,32,33]. This will, however, differ regionally and will depends on a number of factors, including geographic location and features, conditions of water availability and utilization, demographic changes, existing management and allocation systems, legal frameworks for water management, existing governance structure and institutions and the resilience of ecosystems[26,34,35]. Climate impacts on the water cycle will threaten existing water infrastructure globally, resulting in communities becoming more vulnerable to extreme water related events and increased water insecurity especially amongst rural communities. Therefore,

water must be at the heart of adaptation to climate change, serving as the crucial link between the climate system, human society, and the environment; and because water is closely linked to the socio-political world, it can serve as a key factor in managing risks such as famine, migration, epidemics, inequalities, and political instability[25,36,37,38,39].

Climate Change and Its Impacts on Water Security in Nigeria

The geopolitical division of Nigeria can clearly reveal the different challenges facing the water sector in Nigeria. The South-South, South-East, and South-West are susceptible to flood, pollution, and contamination as a result of oil exploration, while the North-East, and North-West are exposed to drought, high evaporation and water loss and severe water stress[19,40,41]. According to Abubakar[42], Northern Nigeria is at risk of drought and water scarcity and with the rising temperatures, coupled with variations in both temperature and precipitation as well as current water management practices, the northern region may not be able to cope in the foreseeable future. The drying up of Lake Chad for instance shows the urgent need to address water resources and help salvage the lake which supports the lives and wellbeing of over 30 million people[43,44,45,46].

Water availability and accessibility within northern Nigeria constitute a serious concern. Most communities lack adequate water provisions and water network to supply potable water[47]. This have forced most individuals to provide water for themselves through rainwater harvesting, construction of hand dug wells, and boreholes[48]. Recent variations in weather and climate has seen many northern states to experience flash floods at an alarming rate. The 2012 flood in Adamawa State (Numan and Yola) and Kogi State (Lokoja) are examples of extreme precipitation that affected agriculture and socio-economic development of the regions[49,50]. The occurrence of flood within the northern region is becoming more frequent with detrimental impact on human lives, properties, livelihood, and the environment. Several states within the north western regions have experienced flash floods with losses accounting to millions of Naira and although the Nigerian Meteorological Agency (NiMet) predicted the likelihood of occurrence of these events, there were little or nothing local people could do to reduce or manage the risk. Flood waters washed several contaminants into open hand dug wells and streams. Theses water sources are mostly the only water sources used by locals and with no alternative provisions, communities are left to utilize contaminated water.

Extreme Climate Impacts on Water Access, Water Quality and Sanitation

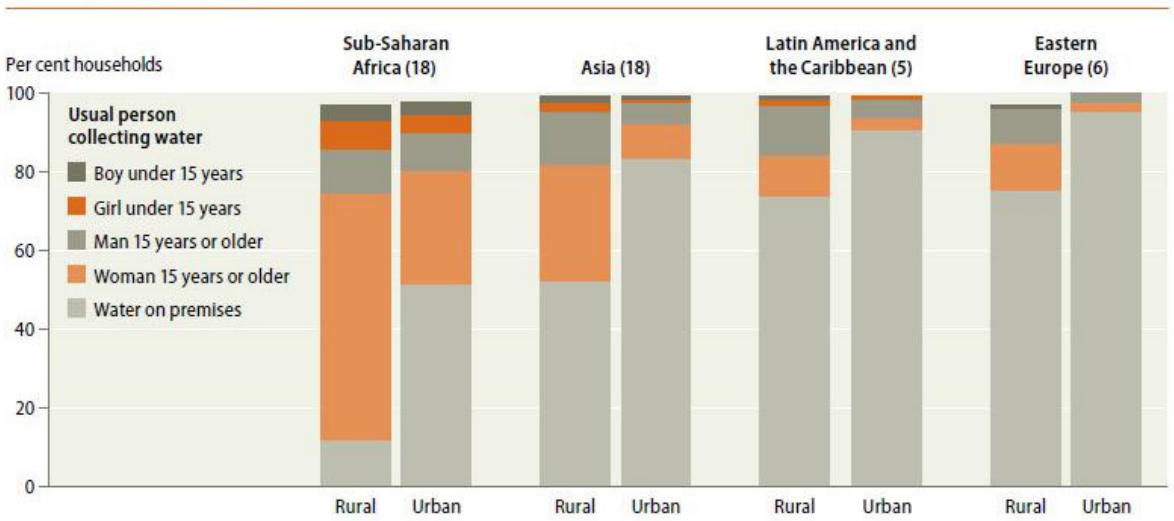
Currently, more than two third of the population in Africa must leave their homes in order to get access to water for domestic and agricultural uses[51,52]. Access to water is paramount for the well-being of humans and animals[53]. Most of rural communities are saddled with water accessibility problems and extreme climate events have further exacerbated water accessibility resulting in health and hygiene problems. The proximity of water sources to people especially in rural areas have been demonstrated to correlate with the frequency of hygiene behaviors[54]. For example, Curtis[55] shows that mothers in Burkina Faso with access to piped water supplies in their homes were three times more likely to perform regular sanitation and hand washing than mothers who must walk out of their homes to access water. This clearly indicates the importance of access to water especially in rural communities who have been considered vulnerable and at risk to variations and changes in weather and climate patterns. Extreme climate events will fuel conflicts over limited water sources especially in rural areas where water scarcity is becoming an issue. Access to water is becoming an inter-generational issue with consequences on sustainable development[18]. Water has also become a gender issue that has affected rural Sub-Saharan African women and young girls the most (See Figure 4). For instance, it is certain that most women in rural areas of Asia and Africa walk long distances to fetch water for their homes[15], this is an arduous task that can lead to young girls dropping out of school and other forms of formal education. Women are also affected and restricted from gaining employment and even leisure due to the time they spend fetching water.

Water quality is a measure of the conditions of water relative to the requirements of any human desires or purpose of use[24]. This however have not been met in many regions globally due to industrialization, agriculture, urbanization, and waste management and of recent climate change. Good water quality is essential to human health, social and economic development, and the ecosystem[25]. However, as the population grows, and natural environment becomes degraded, ensuring sufficient and safe water becomes increasingly challenging. Climate change is also rendering the provision of portable water more difficult as extreme weather events compound already existing challenges of urbanization and pollution. Extreme climate events have had enormous impact on water quality especially in developing countries; this is true because most rural communities of developing countries do not have adequate treatment facilities to remove contaminants from water and this results in health issues especially among children and the elderly. According to Matthew[51], a warming climate is in general, expected to increase water temperature and modify regional patterns of rainfall and these changes usually have direct impacts on water quality. Higher temperatures can enhance microbial activities and give rise to favorable conditions for growth and spread of water pathogens[56]. This can be evident in eutrophication in water sources in humid areas of northern Nigeria. Flash floods can also lead to runoff which may wash off

several contaminants into water bodies thereby altering water quality. Greifenstein[56] in a study on the impact of temperature and storage on chemical in water reveals that higher temperature may likely lead to chemical reactions which can form dangerous reactions that can have a significant impact on water quality and health in general. High temperatures may also release substantial amount of chemicals from other sources such as weathering of rocks, mining and other activities into water thereby impacting on water quality. For example, Morckel[57] shows that heat can play a vital role in releasing lead and other dangerous chemicals from pipes into domestic water supplies. Variations in both rainfall and temperature have shown to impact on water quality and hence rural water supplies need to be assessed and monitored adequately for presence of contaminants that may likely be potential threats to vulnerable people. Bacteriological contaminants exist more in rural areas of developing countries due to poor sanitation, open sewers, and open defecation practices[26,58].

These practices coupled with frequent flood events have the potential to transport bacteriological contaminants from open sewers and defecation sites into water sources, and because rural communities are solely responsible for collection and distribution of their water needs, they often do not treat water but rather use water directly from collection sources. Consequently, the greatest increase in exposure to pollutants are expected to occur in low and lower-middle income earners in developing countries, primarily due to higher population and economic and due to vulnerability to the impacts of climate change[26].

Figure 4: Distribution of persons responsible for water collection, by region and urban/rural areas



Impacts of Water, Hygiene and Sanitation in addressing SARS-CoV-2

The current pandemic has necessitated the need for water to address sanitation and promote hygiene. One of the non-pharmaceutical measures identified by the WHO in reducing the spread of SARs-CoV-2 is handwashing and sanitation[59]. Regularly handwashing and practicing sanitation and hygiene has proved to drastically reduce the likelihood of contacting the virus. This however can only be effective with the provision of water and sanitation facilities. Access to water in most communities especially rural communities have been poor in rural Nigerian communities and Sub-Saharan Africa and climate change have further impacted severely on water resource management thereby denying a considerable number of persons access to this precious resources[60]. The consequences will result in poor adherence to Covid-19 guidelines and deterrent to the fight against the spread of the virus.

The limited or lack of water for sanitation and hygiene services will further exacerbate the already existing difficulties on several communities. In addition to the impacts on water access, the lack of wastewater treatment facilities in most rural communities in Nigeria will likely see a rising trend in the spread of the virus. This is because, several studies have indicated the presence of the virus in sewage and other wastewater[61,62]. Since most rural and some urban communities lack water treatment facilities, there is a concern that water quality will further be impaired, and that the SARs-CoV-2 virus will likely thrive and mutate in water bodies[60]. There is therefore the need to integrate WASH to the SDG 6 on access to water to enable water managers especially within rural communities of developing countries to design water projects that will not only provide access to water but to provide adequate sanitation services that can cater for epidemics and pandemics.

IV. Climate Change and the Sustainable Development Goal on Access to Water

The sustainable development goals were established in 2015 to address specific problems confronting humans and the environment. However, climate change is playing a vital role in reversing the progress made so far in achieving the SDGs in water stressed parts of developing countries[60]. Climate change has undermined the Millennium Development Goals (MDGs) in several developing countries[25] and it can likely undermine the SDGs if concerted efforts to tackle and assist local people adapt to the variations and changes are not implemented. Addressing water insecurity caused by climate change will require a collective effort from every regions of Nigeria and the World. Local people must be carried along in the fight against climate change. They must be made aware of the consequences of actions such as deforestation and bush burning and be provided with cleaner ways to use energy.

Both rural and urban cities have a role to play in addressing the issue of climate change and the sustainable development goal on access to water. Water managers will have to redesign ways to provide potable water to local communities who are experiencing water stress and lack of water. Taking climate actions as stipulated in the SDGs will likely assist other goals to be addressed effectively. This is because climate change has a direct relationship with food production, health, water, ocean, ecosystem, and sustainable development of cities.

V. Conclusion

Water resources has been one of the sectors affected by climate change. The impact of climate change has affected water availability, accessibility, and quality in several regions of the world including northern Nigeria. Flood incidences impact water access and quality by transporting contaminants into drinking water sources thereby resulting in water pollution. Drought incidences deprives local people access to water and in most communities where water sources are lowered, there are likelihood of water contamination. The absence of water treatment facilities (for both drinking water and wastewater) has further exacerbated the water crises in northern Nigeria and with significant variations in weather and climate within the regions, the water crises is projected to deteriorate further in the future. There is the need for government and other non-governmental organizations to on one hand invest in programs and projects aimed at reducing inequalities and building adaptation and resilience to climate change while thriving to mitigate climate change.

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Joshua, W. K. "Climate Change and Extreme Climate Events: A Threat to Water Security in Northern Nigeria." *IOSR Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT), 15(1), (2021): pp 47-54.