Chapter 20
Climate Change and Rural Water Supply Planning in Nigeria

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Abstract This paper is aimed at providtsaveing a synthesis of what we currently know about climate change, especially its potential impacts on rural water availability in Nigeria. This is because climate change is known to have impacts on the quantity of water available as well as the geographical and seasonal distribution of this water through its significant impact on precipitation amount, its distribution and duration, as well as the rates of water loss by evaporation. This paper also joins others before it to call for more research on climate change and water resource availability for the sake of our rural population, who are the most vulnerable to climate change phenomena when it comes to water shortages. Finally, this paper gives recommendations on how this trend should be averted locally through educating the rural people that they are partly the construct of their misfortunes, mainly through bush burning and deforestation.

Keywords Climate change · Rural · Water supply · Planning

Introduction

Throughout much of the developing world (including Nigeria), freshwater usually comes in the form of seasonal rains. Although there is variability and unreliability in its occurrence with time (temporal) and with space (spatial), it is still the only source of annual recharge for both surface and sub-surface water storages.

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W. Leal Filho (ed.), *Climate Change and the Sustainable Use of Water Resources*, Climate Change Management, DOI: 10.1007/978-3-642-22266-5_20,

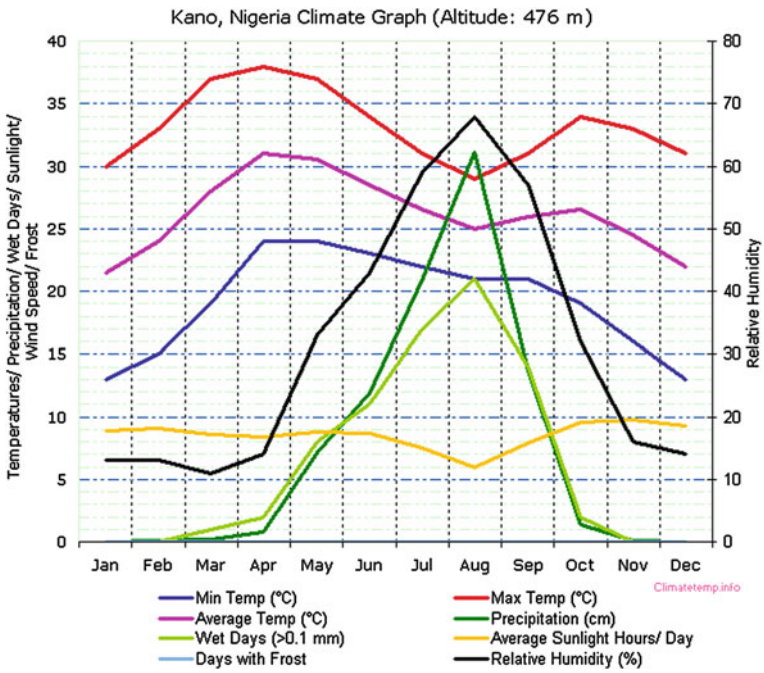

Fig. 1 Climate conditions in Kano, Nigeria (2009, NIMET)

This happens through the processes of runoff, streamflow and infiltration, since the falling precipitation ultimately sinks into the ground (as soil moisture and groundwater recharge) or runs off (as surface sub-surface flow) into the oceans, seas or some inland lakes, or is intercepted and temporarily stored (as interception and surface storage) before being eventually evaporated and transpired (as evapotranspiration), as is clearly demonstrated in the process of the water cycle (Ayoade 1988).

Because of this increased variability in precipitation, resulting in floods in humid areas, and decrease in precipitation resulting in drought in the savannah and semi-arid areas, the characteristics of the component of the hydroclimatological systems in the different ecological zones is altered, with their consequences on the availability of water resources. In its recent annual rainfall prediction, the Nigerian Meteorological Agency (NIMET) said that rainfall is expected to fall slightly below its normal level over a large portion of the country in 2009. This is likely to create water shortage in lakes, dams and rivers. The annual rainfall is expected to vary from 400 to 1200 mm in the northern half of the country to an increase from 1200 to 2800 mm in the southern half, implying high surface runoff (NIMET 2009) (Fig. 1). These conditions would eventually lead to changes in management strategies in order to balance water supply and demand through conservation efforts (Briscoe et al. 1990). This statement is especially true among the rural Nigerian population who were living under the tyranny of water resource scarcity.

Table 1 Population distribution type

Population distribution type	Community size	Population (million)	% of total
Urban	> 20,000	45.0	38
Small towns	5,000 to 20,000	40.0	33
Rural	< 5,000	35.0	29

Source. Field study, 2010

Population

Nigeria is the most populous country in Africa with an estimated population of 120 million and average density of about 130 persons per km^2. The population has been growing at an estimated average of 2.9% per annum (Table 1). The best estimate of the population's distribution is given in Table 1.

Climate Change

It is important to point out that the global climate, or climate of any part of the Earth for that matter, has never been static. Variability is an inherent attribute of climate. What is crucial is the degree of variability that climate is subjected to, as well as the duration of such variability. Minor fluctuations or variations constitute not more than a noise in climatic series and humans can easily adapt to such minor variations. However, when fluctuations in climate constitute significant departures from the normal climate or become prolonged to constitute a new climate state, then there are problems of adjustment and the environment, and humans and their socioeconomic activities become very vulnerable.

Climatic variations occur on various temporal scales, varying from a few decades to millions of years. Different nomenclatures are used to describe climatic variations depending on the timescales within which such variations occur. Thus, we have such terms as climatic trends, climatic cycles and climatic change. There are also general terms such as climatic fluctuations and climatic variability, which emphasizes the inherently dynamic nature of climate.

Climate change is therefore a situation when climatic variations or fluctuation over a long period of time occur to produce a shift or a change in the type of climate prevailing over an area. In other words, climate change represents a significant difference between two mean climatic states or climatic normals with a significant impact on the ecosystem (Ayoade 2003; Smith 1996).

Changes in weather and climate have been known to profoundly affect water resources, and thus increase human vulnerability to infection. Climate change will bring overall less rainfall and also heavier individual rainfall events in a single day. We depend on water for drinking, washing and cleaning, for agricultural needs (such as irrigation), for industrial needs (such as food processing), and for transportation, fishing and recreation. Pre-existing problems will only get worse with climate change.

Fig. 2 Point of rural water sources

Nigeria's low-lying coastline makes the country prone to sea-level water intrusion into coastal freshwater resources as climate change brings with it a rise in sea level that will seriously affect our coastline. Coastal erosion and flooding is not uncommon, and contributes to the "polluting" of freshwater systems. Nigerians do not enjoy an adequate water supply. This problem is more prominent and devastating in the northern areas of the country with their limited sources of water and harsh weather conditions (Fig. 2).

Water Availability and Sources

About 70% of the Earth's surface is water, but most of that is ocean. By volume, only 3% of all water on Earth is freshwater, and most of this is largely unavailable because about three-quarters of all freshwater is locked away in the form of icecaps and glaciers located in polar regions far removed from human habitation. The water found in lakes, rivers and those at shallow underground level are the easily accessible freshwater and are only 1% of the total water on Earth. Only this amount is regularly renewed by precipitation and its sustainability is threatened by the alarming climate change phenomena. Therefore, in all, only one-hundredth of one per cent of the world's total water supply is considered accessible for human use (Barabas 1986).

Globally, between 12.5 and 14 billion m^3 of water are deemed available for human use on an annual basis. This amounts to about 9000 m^3 per person per year, as estimated in 1989 (Alaba 2001).

By the year 2025, global per-capita availability of freshwater is projected to drop to 5100 m^3 per person, as another 2 billion people join the world's population. Even then, this amount would be enough to meet human needs if it

were to be distributed equally among the world population. But the availability of freshwater supply is not distributed evenly around the globe throughout the season or from year to year, usually because of the inherent variability of climate coupled with the topical climate change issue that aggravates these disparities. In some cases, water is not where we want it, nor in sufficient quantities. In other cases, we have too much water, in the wrong place, and at the wrong time (Malin 1989, 1991).

For instance, about 20% of the global average rainfall each year is accounted in the Amazon basin (a vast region with fewer than 10 million people: a tiny fraction of the world's population). Similarly, the Congo river and its tributaries account for about 30% of the entire African continent's annual runoff, but the watershed contains only 10% of Africa's population. However, the disparities are starker when it comes to access to water (Postel 1997).

Freshwater Resources and Their Management

By the middle of the century, annual average river runoff and water availability are projected to increase by 10–40% at high latitudes and in some wet tropical areas, and decrease by 10–30% over some dry regions at mid-latitudes in the dry tropics, some of which are presently water-stressed areas. By 2020, around 75 million people are projected to be exposed to increased water stress due to climate change. If coupled with increased demand, this will adversely affect livelihoods and exacerbate water-related problems (Working Group 11 Fourth Assessment Report, IPCC 2007).

Rural Water Supply Planning

Water supply is the provision of water for drinking, domestic uses and irrigation; its availability is controlled by global water distribution (Oteze and Foyose 1998).

Water supply planning, therefore, is the collection, analysis and interpretation of hydrologic and geohydrologic data, followed by field reconnaissance surveys, geophysical investigation supported by test drilling and physical examination of cores samples (Oteze and Foyose 1998). These were done to isolate the water-bearing horizons (or aquifers), estimate their water resources potentials and establish the quality of the groundwater: water for rural people in the developing world should have easily applicable, minimum possible treatment. The types of treatment for water purification depend on the physical, biological and chemical characteristics of the water to be used. In rural areas where a population of 5,000 or more is spread over relatively short distances, and in villages with over 500 households, a small-scale safe water supply should be provided. To ensure convergence between water scarcity, demand availability and supply of water to the

rural population, drinking water directly from its source should be treated before supplying and or distributing it to various locations according to population demand criteria, since untreated water may contain many bacteria, causing diseases such as typhoid fever, dysentery, gastroenteritis, hepatitis and amoebic dysentery.

The whole idea of water supply planning depends on the availability or amount and sources of water, which is directly controlled by hydrological cycle—by extension the climatic system and processes that dictate where and when rain will fall. Thus, water resource planning is aimed at achieving an orderly development of water resources to meet present and future demands.

Rural Water Supply and the MDGs

There are still at least 1.1 billion people across the world who do not have access to safe drinking water. Many of these people live in rural areas and are among the poorest and most vulnerable to be found anywhere in the world. In sub-Saharan Africa, 300 million people have no access to safe water supplies—approximately 80% live in rural areas (Fig. 2). Therefore, significantly increasing the coverage of rural water supply in Africa is fundamental to achieving many of the internationally agreed Millennium Development Goals (MDGs). Without safe water near to dwellings, the health and livelihoods of families can be severely affected; children's education suffers as the daily tasks of survival take precedence over all other concerns (MacDonald et al. 2010).

Facing Up to the Water Crisis

Water is the defining link between climate and agriculture. But even without climate change, we are in serious trouble. Competing demands combined with mismanagement of this critical resource means that water availability has become an urgent issue facing rural people (and other users) the world over. And typically, the most extreme shortages are experienced by those least able to cope with them—the most impoverished inhabitants of developing countries. Climate change will exacerbate an already critical situation. Water is already a critical limitation for many poor people (Moorhead 2009).

Impacts of Climate Change on Rural Water Supply

The hydrological cycle, driven by solar energy, involves water changing in form and moving from one storage to another. Consequently, climate change will lead to the intensification of the global hydrological cycle with consequences for the

major world's water storages. The changes in the volume (magnitude), timing and distribution of water resources would necessitate changes in management strategies in order to balance water supplies and demand, since the hydrological cycle comes with no guarantees for humankind (Postel 1998).

Various methods have been employed to assess the impact of climate change on hydrology and water resources at various geographical scales varying from the globe to the river catchments. They include the following, among others:

- Statistical analysis of long-term concurrent variation in runoff and meteorological elements, especially air temperature and precipitation over past periods.
- Studies of the hydrological consequences of past periods of very warm or cold, wet or dry conditions.
- The use of methods of water balance over a long period of time to assess the impact of increased temperature and decreased precipitation on run off and soil moisture storage.
- The use of General Circulation Models (GCMs) of the atmosphere to obtain changes in the climatic and hydrological characteristics of a large area using different greenhouse gas emission scenarios.
- The use of deterministic hydrological conditions using input of climatic data including outputs from GCMs.

The methods above have their strengths and weaknesses when used to assess the impact of climate change on hydrology and water resources (see IPCC 1990b).

From the result of several studies conducted using the above approaches, here are the extracts that correspond to Nigeria's situation:

River catchments will be very sensitive to even small changes in climatic conditions, especially those in arid and semi-arid regions where the annual runoff is highly variable, as is the case in our river catchments in the Sudano-Sahelian region of Nigeria, which, according to Olofin (1987) stretches from 12 N to the international boundary of the Niger Republic (Fig. 3a, b).

Global warming is likely to lead to changes in runoff extremes both high and low. In other words, there are likely to be very high flows and very low flows within the year (Fig. 4).

There will be increases in the rates of evaporation/evapotranspiration, which will lead to reduced soil moisture storage and reduction in the total annual volume of runoff, particularly in areas where precipitation remains unchanged or decreases in amount or fails to increase in amount large enough to offset the increases in the rates of evaporation (IPCC 1990a).

There may be a decrease in infiltration rates where raindrop size increases or rainfall intensities increase, with consequent adverse effects on soil moisture, groundwater recharge and groundwater levels.

There will be changes in demand for water resources both domestic and agricultural; water consumption will increase with increasing dryness and/or heat, all things being equal. The radiational index of dryness RW/LP (where RW is the net radiation of a wet surface, P is precipitation and L is the latent heat of

Fig. 3 **a** Political map of Nigeria **b** Map of Nigeria showing the drainage pattern

condensation) provides an indirect measure of water consumption. The greater the value of the index the higher the water consumption rate (IPCC 1990b).

Regions that depend on unregulated river systems (as the case with most of rural Nigeria) will be more vulnerable to hydrological changes induced by climate change (IPCC 1990c; Umolu 1995).

With these impacts of climate change on water availability and distribution, the need for water supply planning especially in rural areas has arisen if the water supply crisis is to be averted. The current population growth has also exacerbated the problem of water scarcity. Over the years, access to clean water has been a key indicator of measuring the quality of life in nations across the world. Access to clean water has been proven to have a strong relationship with longevity, since clean water does not only reduce incidence of waterborne diseases, but is also a vital requirement in attaining high standards of sanitation.

Fig. 4 Impact of climate change on rural rivers

Conclusion

Water resource planning essentially resolves into three issues: the extent of available water resource, the future requirements of water for various purposes, and how these can be met. The most fundamental thing is water's availability: how can the diminishing resources be conserved or improved? This calls for action on what causes climatic change, especially the contribution wade by rural dwellers, whether deliberate or accidental. One such activity is deforestation, which reduces the most essential tropospheric sinks of carbon (the vegetation), which is the highest contributor of greenhouse gas concentration (50–60%). Today, carbon concentration in the troposphere is approaching 400 ppm and it is predicted to reach 450 ppm by the year 2050 if we do not cut down emissions at local, national, regional and international levels (Umar 2000).

At the rural (village) level, what is significant to note is that most rural dwellers were unaware of the danger of their actions and inactions. For instance, locally, the rural farmers were of the habit of setting fire to the bush thereby contributing to atmospheric carbon concentration and at the same time aggravating species attrition.

Besides bush fire, the activities of the rural dwellers to cut down trees recklessly (deforestation) may be poverty driven, but even then they should have been replaced or reforested, for the fact that vegetation ameliorates the microclimate, stabilizes soils, plays a role in interception and, above all, absorbs excess carbon that contributes immensely to global warming. This warming intensifies heat and encourages evaporation and at the same time contradicts rainfall reliability as a result of this change in climate. The Intergovernmental Panel on climate change indicates that in the 1980s, deforestation alone accounted for about 1.6 billion tonnes of carbon emissions (Umar 2000). It has been stated elsewhere that "man is

the architect of his environmental misfortune", as this climate change is partly the result of human activities at various geographic locations.

Recommendations

Nigeria in general and rural areas in particular need a "blue revolution" in the first instance to conserve and manage the little available water resource in the face of growing demand. In another outlook, factors affecting climate, especially negatively, should henceforth be stopped (e.g. bush fire and deforestation as commonly practised by the rural populace). Besides this broad recommendation, the local, state and federal authorities should:

- Educate rural households to use water wisely and about the dangers involved during water shortages.
- Provide a legal framework to guide the activities of industries sited in rural areas so as to ensure no toxic waste contaminates water bodies.
- Punish non-law abiders through taxes.
- Involve qualified companies while awarding contracts on rural water supply, i.e. those capable of assessing, harnessing and distributing the available water accordingly.
- Educate the rural people about the significance of climate change on water resource availability, temporally and spatially.
- Improve upon the available water supply system, such as dams, reservoirs, inter-basin transfer for both single and dual purposes.
- Educate the rural people about the danger of their local actions such as bush burning and deforestation, which contribute immensely to changes in climate as we know it.
- Involve the supply of water through desalinization of ocean water and saltwater for public consumption, especially in the rural coastal population.
- Improve water re-use systems, especially where industries are located in rural areas. This involves sequential water use (e.g. household → industrial → agriculture).

Acknowledgments We are very grateful to Dr (Mrs) R. J. Muhammad for her support and encouragements at all times, directly or indirectly, Muhammed A. Muhammed, Musa Sule and the entire Management of Federal College of Education Kano, who have in one way or other contributed to the success we have achieved nationally and internationally. We are greatly indebted to the Education Trust Fund (ETF) for funding to attend an International Conference in Cairo and F. C. E. Kano in Nairobi to mention but a few. Thanks also to Associate Professor A. I. Tanko, Department of Geography, Bayero University Kano, Nigeria, Professor S. U. Abdullahi (former VC A. B. U. Zaria) Ibrahim Ahmad Gundutse Jamilu Gambo, Murtala Muhammed Adogi, Dr M. L. Mayanchi. All errors and omissions, and all views expressed, remain solely our responsibility.

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