Influence of Climate Variability and Change on Natural Hazard in Selected States in Northern Nigeria

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Abstract

The study examined the climate variability and change using temperature record (1951-2014) over Kano, Maiduguri, and Sokoto to depict the spatiotemporal influence on natural hazards across the states. Shiroro hydrologic records for thirty seven years (1975-2012) were collected and analyzed in addition, 300 structured questionnaires were administered to the residents of Gurmana downstream settlement for the purpose of generating their responses arising from flooding and its related problems. The result affirmed temperature changes between 1950 - 1981 and 1982 – 2014; it reveals positive changes in April mean, maximum and minimum temperature values of between 0.4 to1.5°C across the study area. Similarly, the observed oscillation and positive trend of inflow and outflow from shiroro reservoir constitute a major and unprecedented shift in stream flow across the downstream communities. Intensified warmer temperature, inflow and discharge trends have continued to aggravate seasonal rainfall related hazards which are threats to sustainability of human livelihood across most rural communities. Consequently, there is need for systematic development and application of policies, strategies and adoption of best practices as pathway towards disaster risk reduction.

Introduction

Technology and urbanization have been significantly escalating the emission of Green House Gases (GHGs) such as Carbondixiode (CO_2) in most urban areas across the country. Christopher *et.al* (2014) stated that Cities are major sources of Green House Gas (GHG) emissions and the effects of mass urbanization upon the environment have now become clear. Concentration of GHGs in the atmosphere is aggravating changes in the world's climate which is a prime factor that determines economic livelihood across most developing countries.

Our planet is sending a powerful message to world leaders to sign and implement the Paris Agreement on climate change and cut greenhouse gases now before we pass the point of no return (Taalas, 2016). Similarly, deforestation of vegetal cover which sequesters and store more carbon than any other terrestrial ecosystem is on increase due to intensification of human thereby escalating the CO_2 concentrations in the atmosphere. Human activities are boosting the concentration of "greenhouse gases" (GHGs) in the atmosphere to dangerous levels (Alice and Gary 2009).

Generally, these changes coupled with increase in human activities are aggravating the intensity of natural hazards which could be disastrous. ICSU (2007) defined natural hazard as a potentially damaging physical event, phenomenon, or human activity that can cause loss of life or injury, damage to property, social and economic disruption, or environmental degradation. Similarly, UNISDR (2009) defined hazard as a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Hazards commonly result to disastrous event across the study area through to destruction properties and loss of live in many incidences. More than 90 per cent of natural disaster related deaths are to be found in developing countries (ISDR 2003). Climate change and human activities are increasingly threatening both intensifying the severity of natural hazard there endangering livelihood and increasing poverty across northern Nigeria. Thus, it is crucial for institutions and relevant stakeholders to identify and take proactive measures that can help in the mitigation of hazards thereby reducing disasters. This could go a long way to improving living standards and opportunities for more fruitful livelihood across the vulnerable Northern Nigeria.

Climate change is a reality globally, its effects are apparent across the country; seasonal flooding across southern Nigeria aggravating soil erosion and drought typical of the northern intensifying soil moisture stress and aridity. In Nigeria, climate is factor key factor exacerbating natural hazards due to high depends on climate sensitive activities for livelihood. Stephen and Tobi (2014) rightly observed that Nigeria's population and economy are linked to climate sensitive activities such as rain-fed agriculture. The high temperature, variability and change that characterized climatic distribution are threat to attainment of sustainable livelihood and prime factor intensifying natural hazards. The Hyogo Framework for Action (HFA) 2005-2015 identified the use of knowledge, innovation, and education for building the culture of safety and resilience at all levels.

Human activities in Nigeria such as deforestation, emission of greenhouse gases, mining and dam construction generally intensify both natural and human-induced hazards thereby threatening sustainable livelihood across the Nigeria.

Temperature values are generally rising in recent times; each of the past several decades has been significantly warmer than the previous one (Taalas 2016 and Hansen *et.al,* 2010). This trend has negative impact on thermal comfort, water, vegetation and agricultural resources and in extreme cases it leads to outbreak of epidemics like meningitis. Africa's climate seems certain to change, with far-reaching implications for water resources and agriculture (Bette et.al 2014). It has been projected that future temperatures will be associated with more extreme and increased variability hence, there is need to understand these changes at micro-levels and the human activities that are exacerbating the intensity of the changes for appropriate adaptation and mitigation measures. Many prevalent human diseases are linked to climate fluctuations for example, cardiovascular disease and respiratory illnesses are associated to heat wave (Jonathan et,al 2005).

Flood is common phenomena in Nigeria that usually affects the riverine communities. This usually occurs when the flow rate exceeds the carrying capacity of the river channel, particularly at the lower course of the river and flood plain. The flood plain areas are generally, national assets across the globe but are highly vulnerable areas in

Nigeria because the response at all levels are mainly reactive rather than being proactive. Nott (2006) correctly points out that a flood event is not considered to be a natural hazard unless it threatens human life and/or property.

Generally, floods constitutes a major hazard in Nigeria because of the high human population densities that inhabit these vulnerable areas, lack of capacity and adverse human activities which are aggravating flood hazard across the country. Okori et.al (2009) affirmed that disasters arising from human-induced and natural hazards are growing globally and threatening millions of people annually, with devastating impacts on vulnerable communities. In addition, Sorensen et.al (2017) concludes that as the planet continues with the warm trend, it is likely that we will see an increase in climate events that will compound the impact of acute and protracted humanitarian crisis.

Consequently, it is fundamental to examine and understand the influence of climate variability and change on the occurrences of natural hazard in northern Nigeria in order to identify and develop proactive measures as well as strategies for Disaster Risk reduction (DRR) and the attainment of sustainable livelihood.

Study Area

Generally, the northern part of Nigeria is located between Longitudes 3^0 to 15^0 East of the Greenwich meridian and Latitudes 9^0 and 14^0 North of the Equator (Fig.1). The climate of Northern Nigeria is influenced basically by two air masses - The Tropical Maritime air mass (South West trade winds) and the tropical continental air mass (North East trade wind). The boundary zone between these two air masses is called Inter-Tropical Discontinuity (ITD) (Adejuwon, 2012). This area has three distinct seasons: The hot dry season from March to May, and the warm rainy season from June to September, and a cool dry season from November to February with an average relative humidity of 36% during the dry season and 79% during the wet season (Yamusa, *et.al* 2015).

The seasonal and latitudinal variations affect diurnal and seasonal temperature ranges, the highest maximum air temperature is recorded in the northern part usually areas north of latitude 9° and occur in March /April and minimum temperatures are recorded in December/January North of latitude 9°N. Kano, Sokoto Maiduguri and Minna are headquarters of four states among the nineteen states in northern Nigeria.

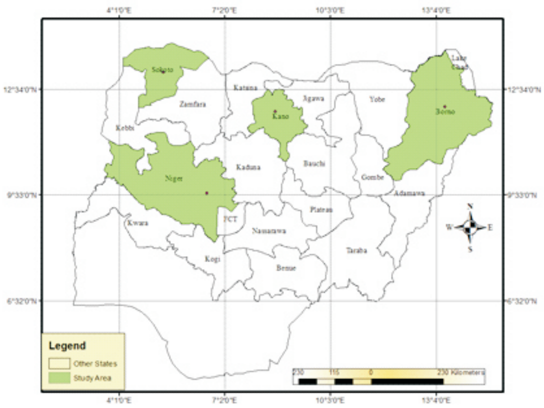

Fig.1 Location of the Study Area

Materials and Methods

This study examines influence of climate variability and change across some selected cities using temperature records and other natural event aggravating natural hazards in northern Nigeria. Maximum and minimum temperature records record (1951-2014) over Kano, Maiduguri, and Sokoto to depict the spatiotemporal influence on natural hazards across the states. Shiroro Inflow and discharge record for thirty seven years (1975-2012) were sourced and carbon dioxide emission at various locations within Minna and its environs were determined. The temperature data were selected from globally reference meteorological weather stations and sourced from Geography Department, Federal University of Technology, Minna.

These were used to investigate spatio-temporal temperature changes in northern Nigeria between 1951- 2014 and its influence on natural hazards. Descriptive and inferential statistics were used to summarize the raw data, analyze and visualize the spatiotemporal changes across the study area. Several trends in weather extremes are sufficiently clear to inform risk reduction efforts (Van Aalst 2006).

In addition, Gasman CO_2 sensor device was used to determine carbon dioxide emission at various locations within Minna and its environs. The mean values were plotted graphically to visualize human activities and carbon dioxide emission within Minna and its environs.

Similarly, inflow and discharge record of the Shiroro dam area was collected for 37 years (1975-2012), summarized and analyzed using inferential statistic to visualized trend in the parameters. Furthermore, 300 questionnaires were administered to residents of Gurmana downstream settlement of the dam in order to examine the community flood risk perception and its impact. The entire data was analyzed using Statistical Packages for Social Sciences (SPSS) 21.

Results and Discussion

The result reveals the spatio-temporal variability, positive trend and changes that are typical of mean temperature values across the study area (fig. 2). In addition, Pearson correlation analysis shows that there are strong positive corrections between the temperature values of the three locations; Maiduguri and Kano .69, Sokoto and Maiduguri .62 and Kano and Sokoto correlation coefficient is .51.

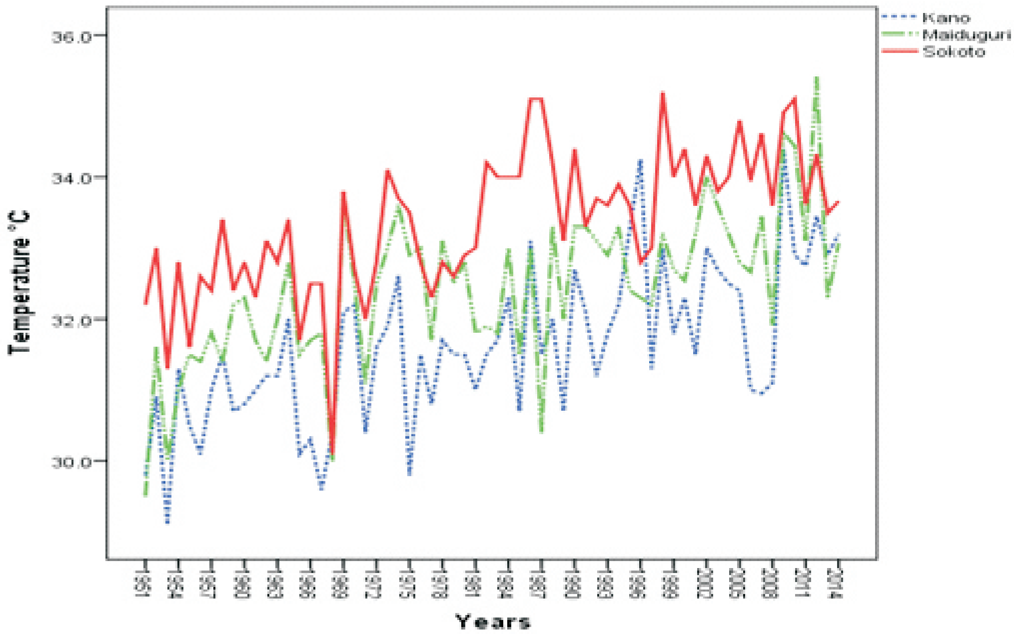

Fig.2 Mean Temperature Value (1951-2014)

The differences in mean temperature values between 1951 to 1982 and 1983 -2014 confirmed the observed gradual temperature changes (Table 1). It indicates that temperature changes are .99 in Maiduguri, Sokoto 1.28 and Kano 1.2. This affirms the projection of IPCC (2007) projection that by 2050, average temperatures in Africa are would increase by 1.5 to 3°C, and will continue further upwards beyond this time. Carlowicz (2010) stated that one-degree *global* change is significant because it takes a vast amount of heat to warm all the oceans, atmosphere, and land by that much. By implication, this percentage change seems small but could have adverse impact on man and the physical environment. In addition, the decadal rate of change is higher in Sokoto and Kano (.41 and .39) than Maiduguri (.32) and this affirm decadal changes in mean temperature values across the zone where agriculture is primary occuation. Oladipo (2008) concluded that large rural population that is directly depending on the natural resources for their subsistence and livelihood which are climate-sensitive are highly vulnerable.

Table 1: Mean Temperature changes between 1951-1982 and 1983-2014.

Station	Annual Mean Temperature	Decadal Rate of Change
Maiduguri	.99	. 32
Sokoto	1.28	. 41
Kano	1.2	. 39

Similarly, the January mean minimum and maximum temperature values also unveils the spatio-temporal variability and gradual changes in January mean temperature values which is the coldest month in the region. The mean minimum and maximum temperature values across the study area are generally characterized by high variability, as figures 3 and 4 signals gradual temperature changes. The mean minimum temperature changes are apparent than the maximum values which is an indication of decline in temperature range and a warmer temperature trend.

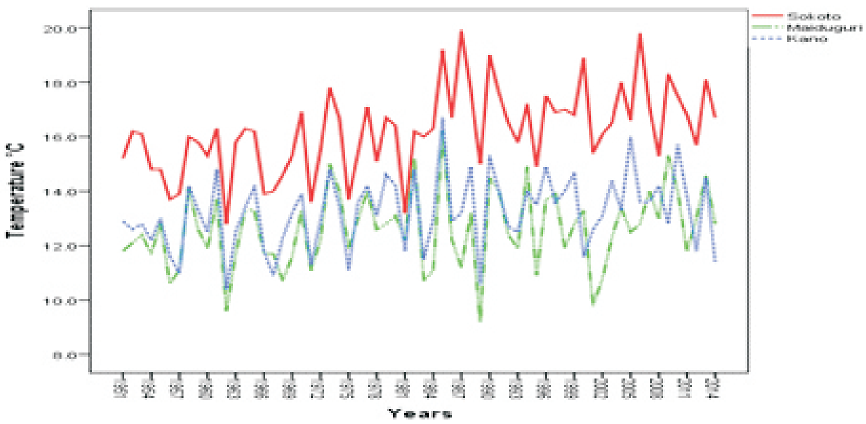

Fig.3 January Minimum Temperature

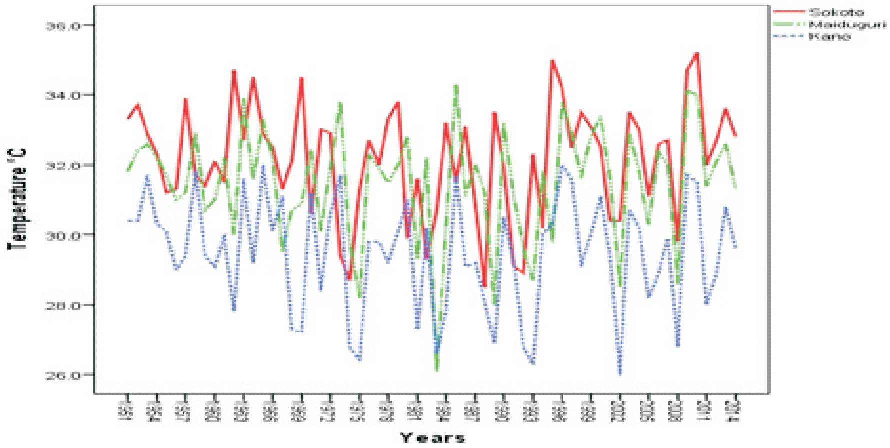

Fig.4 January Maximum Temperature

The April mean minimum and maximum temperature values also shows the variability and gradual changes typical of temperature values across the study area (Figure 5 & 6). The figures signal a warmer temperature across the study area. IPCC (2007) reported that by 2020, between 75 and 250 million people in Africa are projected to be exposed to increased water stress due to climate change.

As high temperature values aggravate aridity, moisture stress and reduced thermal comfort as already apparent in most part of the study area. (NCDC 2017), reported outbreaks of meningitis in five States (Zamfara, Katsina, Kebbi, Niger and Sokoto) in Northwest and Northcentral zones of Nigeria, that as of 3rd April 2017, a total of 2,997 cases with 336 deaths reported with 146 of cases being laboratory confirmed. By implication, this extreme and change weather condition does not only affect the rural livelihood but also lead to outbreak of epidemics like that of cerebrospinal meningitis.

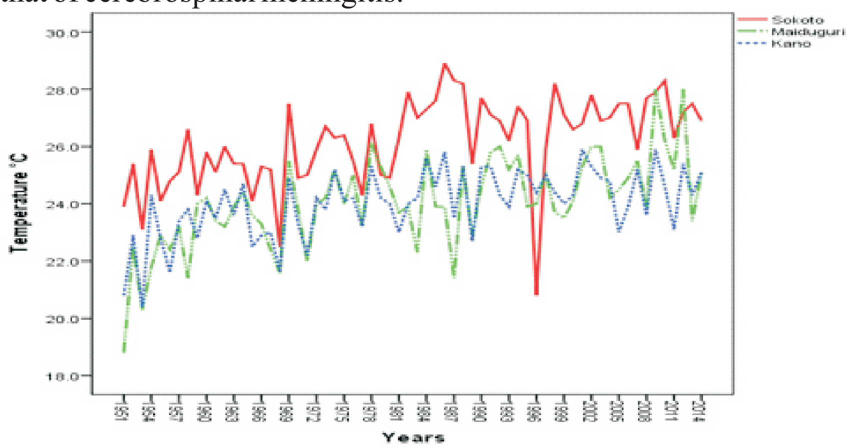

Fig.5 April Minimum Temperature

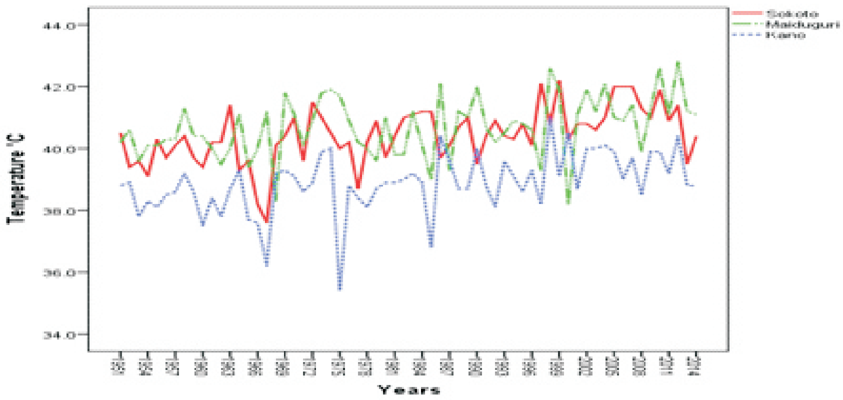

Fig.6 April Maximum Temperature

The observed changes in minimum and maximum temperature values were confirmed between 1951 - 1982 and 1983 – 2014 as evident in January and April values (Table 2). Positive changes in April mean maximum and minimum temperature values were between 0.4 and 1.5°C across the study area. The negative changes in range (-0.4 to -1.5) is an indication of warmer temperature since the margin between maximum and minimum temperature is declining. FAO (2008) forecasted that for each 1°C rise in average temperature, dry land farm profits in Africa will drop by nearly 10%. These increments in average temperature values will aggravate moisture stress and environmental stress in a region where large proportion of the population are dependent on environmental resources. Consequently, these have continued to aggravate poverty, famine as well as food, socio-economic and political insecurity across the region. Furthermore, Nick et.al (2005) indicated that the most vulnerable nations are those situated in sub-Saharan Africa and those that have recently experienced conflict.

Table 2: Temperature changes between 1951-1982 and 1983-2014.

Stations	Jan max	Jan min	Jan mean	Jan range	April max	April min	April range
Maiduguri	-0.1	0.2	0.1	-0.3	0.6	1.4	-0.8
Sokoto	0.2	1.4	0.5	-1.7	0.4	1.5	-1.5
Kano	-0.6	0.8	0.1	-1.3	0.8	1.2	-0.4

Similarly, there was increasing carbon emission with increase human activities; from 200 at the outskirt to 600 and 700 ppm at central areas and location of small scale industries (Figure7). The alarming rate of change we are now witnessing in our climate conditions as a result of greenhouse gas emissions is unprecedented in modern records (WMO 2015). As the over reliance on fossil fuel; increased use of automobile in recent times is escalating emission of GHGs across the country.

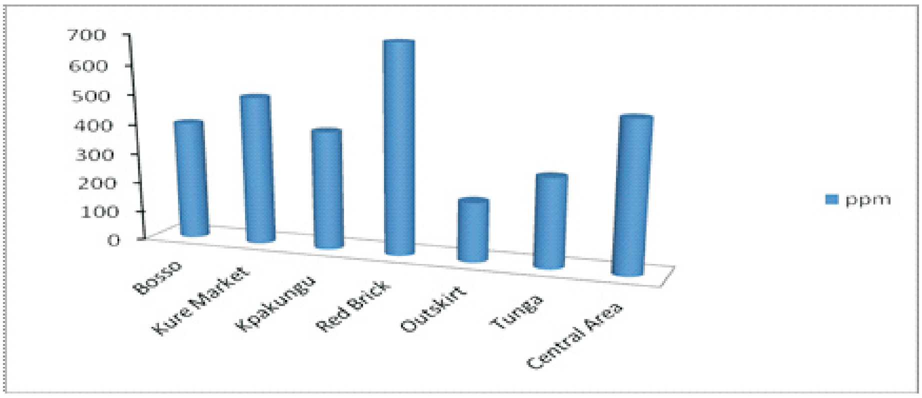

Figure 7: Carbondioxde Emission at Various Locations in Minna

By implication, the ongoing population growth, urbanization and socio-economic development signal higher rate of emission and significant impact on future climate. While climate change is now considered by many to be the most pressing challenge facing the human society today, total anthropogenic GHG emissions have continued to increase (Kevin, 2014). It added that about 78% of the total GHG emission increase from 1970 to 2010 was due to CO2 emissions from fossil fuel combustion and industrial processes. This trend is hazardous to human livelihood particularly in a region where large proportion depends on environmental resources coupled with low capacity will certainly escalating vulnerability. Consequently, Akinwande (2014) identified carbon tax as policy instrument and canvassed for the reduction of greenhouse gases (GHGs). Implementing this will reduce emission, mitigate climate change, and enhance sustainable livelihood and resilience to climate change as well as climate-related hazards.

The annual inflow and outflow is generally characterized by variability and positive trend in recent times which is aggravating flooding downstream (Figure 8). These oscillation and positive trend of inflow and outflow from Shiroro reservoir constitute a major environmental hazard downstream across the riverine communities. Thornton et.al (2014) states that changes in the frequency and severity of extreme climate events and in the variability of weather patterns will have significant consequences for human and natural systems. Also, the years of high discharge were in 1984, 1987-1989, 1991, 2001, 2003-2005, 2010 and 2012, these high discharge have been escalating downstream flooding. Changes in extreme weather and climate events are among the most serious challenges societies are faced with living in a changing climate (John *et al.*, 2016). Thus, intensifying seasonal climate related hazards that threaten livelihood of the exposed and vulnerable community. Specifically, over 70% of the riverine community strongly agree that floods pose a great threat to them and their farmlands. Families living nearer to the river seem to have fewer opportunities to engage in multiple economic activities which make them more vulnerable to natural disasters and may keep them trapped in a poverty cycle (Brouwer, *et al.*2007).

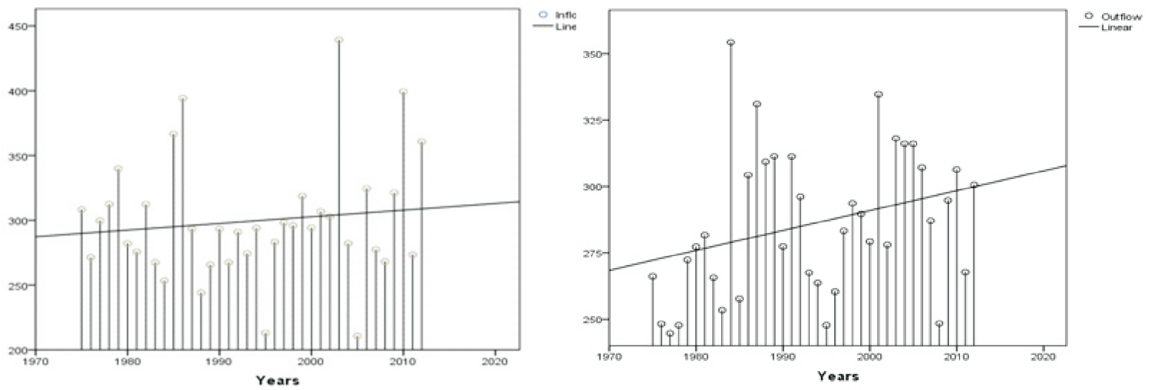

Figure 8: Annual Inflow and Outflow into and from Shiroro Dam (m^3/s)

Furthermore, questionnaire analysis shows that large proportion of the population are poor and depends on natural resource for livelihood and this increases community vulnerability as 92% of the population are mainly farmers. Correspondingly, about 82% of the respondents strongly agree that flood is an annual phenomenon that poses a great threat to their farmlands and livelihood. Thus, the high level of perception and awareness of the recurring hazards does not deny the community from being at risk because of the exposure of the physical structures, economic resources (farm land) and even life and property that could be injury or damage. Malte (2015) concludes that impacts of extreme weather events are relevant for regional economies. Community dependence on natural resource base, climate sensitive livelihood, low capacity to respond and adapt to extreme weather conditions whether dry or wet affect and threatens rural livelihood and the country's sustainable livelihood at large. Consequently, there is need to identify these changes, develop and take proactive measures for mitigating the changes and adapt best practices that will enhance livelihood resilience against seasonal hazard as pathway towards disaster risk reduction.

Conclusion

This study shows that it is crucial to understand climate variability and change that aggravate the intensity of natural hazards across the country. Temperature trend across the study area signal increase higher temperature variability and values are expected in the future as well the inflow and outflow trend unveils the high uncertainty that have continued to the aggravates the perennial downstream flood. The knowledge of these is important for enhanced understanding and monitoring of local conditions that will guide identification and development of effective adaptation strategies. Globally, climate change and variability has been on increase thereby increasing the intensity of natural hazard and climate related disasters across the world. These generally pose numerous changes to vulnerable communities hence, the need to develop precise and sufficient understanding of these natural changes and adopt best practices for enhance livelihood.

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