EFFECTS OF CLIMATE CHANGE ON ARTISANAL FISHERY ALONG A SECTION OF JAMA'ARE RIVER BAUCHI STATE, NIGERIA

BY

DAHUWA, Alhaji Abdullahi

(M SC/GEY/15/0326)

NOVEMBER, 2019

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A THESIS SUBMITTED TO THE DEPARTMENT OF GEOGRAPHY SCHOOL OF ENVIRONMENTAL SCIENCES MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY, YOLA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE IN GEOGRAPHY (CLIMATOLOGY)

NOVEMBER, 2019

DECLARATION

I hereby declare that this thesis was written by me and it is a record of my own research work. It has not been presented before in any previous application for a higher degree. All references cited have been duly acknowledged**.**

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DAHUWA, Alhaji Abdullahi **Date**

DEDICATION

This thesis is dedicated to my delightful parents, my wife and my sons and Daughters. May Allah continue to sanctify and reward them with Al-Jannah Firdaus.

APPROVAL PAGE

This thesis entitled "Effects of Climate Change on Artisanal Fisheries Along a Section of Jama'are River Bauchi State, Nigeria" meets the regulations governing the award of Masters of Science of the Modibbo Adama University of Technology, Yola and is approved for its contribution to knowledge and literary presentation.

____________________	____________________
Prof A. A. Zemba Supervisor	Date
____________________	____________________
Prof A A. Adebayo Internal Examiner	Date
____________________	____________________
Prof I. H. Jimoh External Examiner	Date
____________________	____________________
Professor A. A. Zemba Head of Department	Date
____________________	____________________
Prof. A. A. Adebayo Dean, School of Postgraduate Studies	Date

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ABSTRACT

Understanding climatic changes and variability becomes very vital not only for solving the problems of climate change implications for fisheries but to initiate how the fishing industry can adapt to climatic change and take a lead in informing fishers and policy makers about the likely consequences of climatic changes for fisheries. This study looks at the climatic trends along a section of Jama'are river located at Latitude 12°00'N to 12°30'N and Longitude 9°00'E to 11°00'E and associate it with river water availability and fisheries. Data were collected from five sampled fishing points/ communities in the area i.e. Zigau, Disina, Jama'are, Walai and Sakwa which are located between Fago and Katagum along the Jama'are river valley. Data on climatic elements were from the Nigerian Meteorological Agency (NIMET) and AminuSaleh Collage of Education Azare Weather Station. The research was quided by questions such as, what are the of key climatic elements and decadal variance over the years along Jama'are River, what perception does fishermen have about the effect of water volume on fish catch, what has accounted for the changes in the volume of fish species and fishing activities along Jama'are River as well as what are the Adaptation measures to be taken to cope with the problems affecting fishing occupation along Jama'are River. The study examines the effects of climate change on Artisanal fishery along Jama'are River and part of its strong objectives and have the view to trace changes in rainfall and temperature with their decadal variance over 30 years' period, find out the perception of fishermen on the effects of water volume on fish catch, see trends and magnitude of changes in fish species and fishing activities and to assess artisan fisher's adaptation strategies. A psychometric scale was used in designing questionnaire to obtain participant preference or degree of agreement with a statement or set of statements. A total of 224 questionnaires were administered to 224 fishermen at the five (5) randomly selected fishing points/communities for the study, but only 219 questionnaires were retrieved and five are missing. The data were collected by the use of interview and structured set of questionnaire with open and close ended questions. The study also employed trend analysis and to be specific linear trend which are subset of monotonic trends for series of observation over time on rainfall and temperature. This research also used descriptive and inferential statistics. The descriptive involved the use of tables, percentages and simple mean, while the inferential statistics used were chi-square and Analysis of variance (ANOVA). The result shows fluctuating trend and decreasing pattern in rainfall and an increasing pattern in temperature which vary slightly. The result also goes on to show association between water level in a river and a fish-catch volume and at the same time shows that there is little variation in the decline of fish species and fishing activities between the sampled fishing points/communities. The study recommends more weather station, relevant climate monitoring platforms and advice all stake holders to make use of researches as part of measures to adopting changes in climate. The study also recommends diversification by fishers as well as encourages enlightenment and sensitization campaigns on climate change and extreme weather events. Lastly it recommends the need for fish seeds to farmers for sustainable development.

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CHAPTER ONE
INTRODUCTION

1.1Background of the Study

The threats of climate change to human society and natural ecosystems have been elevated to a top priority since the release of the fourth Assessment Report of the Inter-Governmental Panel on Climate Change (IPCC) in 2007. While the importance of fisheries is often understated, the implications of climate change for these sectors and for coastal and riparian communities in general are difficult to ignore. At the same time, fisheries do contribute to greenhouse gas emissions, although in a relatively minor way, and present some opportunities for mitigation efforts.

Food and Agricultural Organization (FAO 2008) observed that from local to global levels, fisheries play important roles for food supply, food security and income generation. Some 43.5 million people work directly in the sector, with the great majority in developing countries. Adding those who work in associated processing, marketing, distribution and supply industries, and the sector supports nearly 200 million livelihoods. Aquatic foods have high nutritional quality, contributing 20 percent or more of average per capita animal protein intake for more than 1.5 billion people, mostly from developing countries. They are also the most widely traded foodstuffs and are essential components of export earnings for many poorer countries. The sector has particular significance for small island States, who depend on fisheries for at least 50% of their animal protein (FAO 2008).

Climate change is projected to impact broadly across ecosystems, societies and economies, increasing pressure on all livelihoods and food supplies, including those in the fisheries sector. Food quality will have a more pivotal role as food resources come under greater pressure and the availability and access to fish supplies will become an increasingly critical development issue.

The fisheries sector differs from mainstream agriculture and has distinct interaction and needs with respect to climate change. Aquaculture Complements and increasingly adds to supply and, though more similar to agriculture in its interactions, has important links with capture fisheries.

The Food and Agricultural Organization (FAO) Fisheries and Aquaculture Department held an Expert Workshop on Climate Change Implications for Fisheries and Aquaculture, from 7 to 9 April 2008, in order to provide the FAO Conference with a coherent and high quality understanding of the fisheries and aquaculture climate change issues. This Workshop provided inputs into the High-Level Conference and also constituted a response to the request from the twenty-seventh session of the FAO Committee on Fisheries (COFI) that "FAO" should undertake a scoping study to identify the key issues on climate change and fisheries, initiate a discussion on how the fishing industry can adapt to climate change, and for FAO to take a lead in informing fishers and policy-makers about the likely consequences of climate change for fisheries".

Similarly, the Food and Agriculture Organization (FAO) of the United Nations, in recognizing the likely changes to come and the interactions between fisheries and aquaculture, agriculture and forestry and these changes, held a High-Level Conference on World Food Security: The Challenges of Climate Change and Bio-energy at FAO headquarters in Rome from 3 to 5 June 2008. This conference addressed food security and poverty reduction issues in the face of climate change and energy security.

In general, warm-water species are being displaced towards the poles and are experiencing changes in the size and productivity of their habitats. In a warmed world, ecosystem productivity is likely to be reduced in most tropical and subtropical oceans, seas and lakes and increased in high latitudes. Increased temperatures will also affect fish physiological processes; resulting in both positive and negative effects on fisheries and aquaculture systems depending on the region and latitude.

Differential warming between land and oceans and between polar and tropical regions will affect the intensity, frequency and seasonality of climate patterns (e.g. El Niño) and extreme weather events (e.g. floods, droughts and storms). These events will impact the stability of related marine and freshwater resources. Sea level rise, glacier melting, ocean acidification and changes in precipitation, groundwater and river flows will significantly affect coral reefs, wetlands, rivers, lakes and estuaries; requiring adaptive measures to exploit opportunities and minimize impacts on fisheries and aquaculture systems. In recent years' numerous long-term changes in physical forcing have been observed at global, regional and basin scales as a result of climate and other anthropogenic changes.

Impacts of these on biological processes supporting fish and fisheries production in marine and freshwater ecosystems have already been observed and may be used as proxies to estimate further global climate change impacts. These physical factors include atmospheric circulation, intensity and variability patterns, ocean currents and mixing, stratification, hydrological cycles and seasonal patterns.

The International Panel on Climate Change (IPCC) has examined the implications of projected climate change for freshwater systems. Overall, it concludes that freshwater resources are vulnerable to, and have the potential to be strongly impacted by climate change *(Bates et al., 2008)*. Expected changes include *(*Kundzewicz *et al.*, 2008): decreases of between 10 and 30 percent of average river runoff at mid-latitudes and in the dry tropics by mid-century, but increases of 10–40 percent at high latitudes and in the wet tropics (Milly *et al.*, 2005); shifts in the form of precipitation from snow to rain and a consequent change in the timing of peak river flows; and changes in flood and drought frequency and intensity. The IPCC assessment also concluded that the impacts of climate change and effective adaptations will depend on local conditions, including socio-economic conditions and other pressures on water resources *(Kundzewicz et al., 2008)*. Patterns of temperature change for inland waters are expected to follow the changes over land areas which are warming at greater than global atmospheric annual means because there is less water available for evaporative cooling and a smaller thermal inertia as compared to the oceans (Christensen *et al.*, 2007).

Increases in temperature, change in salinity regime, and increased precipitation and storm events also affect coastal areas. Many coastal organisms are already exposed to a wide range of temperatures and salinity because these physical variables are naturally more variable due to large tidal cycles and freshwater runoff from land. Therefore, additional pressures from climate change such as sea level rise and increased storm events will drive changes to an already stressed environment. Many inland fisheries are threatened by alterations to water regimes that, in extreme cases, cause whole lakes [e.g., Lake Chad] and waterways to disappear. Climate change has direct effects, through reduced precipitation and greater evaporation, and indirect effects when more water is used for irrigation to offset reduced precipitation. Threats to aquaculture arise from stress due to increased temperature and oxygen demand and decreased pH, uncertain future water supply, extreme weather events, increased frequency of diseases and toxic events, sea level rise and conflict of interest with coastal defenses, and an uncertain future supply of fishmeal and oils from capture fisheries. Reducing fishing mortality in the majority of fisheries, which are currently fully exploited or overexploited, is the principal feasible means of reducing the impacts of climate change.

1.2 Statement of the Problem

1-A number of climate threats to both artisan fisheries and aquaculture are identified, but we have low confidence in predictions of future fisheries production because of uncertainty over future global aquatic net primary production and the transfer of this production through the food chain to human consumption (Brander 2007).

2-Recent changes in the distribution and productivity of a number of fish species can be ascribed to high confidence to regional climate variability, such as the El- Nino –southern Oscillation. Future production may increase in some high-latitude regions because of warming and decreased ice cover, but the dynamics in low –latitude regions are governed by different processes. Production may decline as a result of reduced vertical mixing of the water column, hence, reduced recycling of nutrients. There are strong interactions between the effects of fishing and the effects of climate because fishing reduces the age, size, and geographic diversity of populations and the biodiversity of marine ecosystems, making both more sensitive to additional stresses such as climate change (Brander 2007). Additionally, Inland fisheries are threatened by changes in precipitation and water management. The frequency and intensity of extreme climate events is likely to have a major impact on future fisheries production in both inland and marine system.

3-Fishing and climate change are strongly interrelated pressures on fish production and must be addressed jointly. Loss of fish species and their reduced number due to climate and fishing result to greater sensitivity about fish stocks and marine ecosystems (Brander 2007). Conversely, climate change can reduce (or in some cases enhanced)the productivity of stocks through effects on net primary production (NPP), reproductive output, growth and survival. Sustainable levels of fishing (often expressed as reference levels for biomass and fishing mortality) must therefore be adjusted to take into account climate-induced changes in productivity.

4-The semi-arid and dry sub-humid areas of tropics are generally said to be characterized by high inter-annual and intra-seasonal rainfall variability (Usman and Abdulkadir 2013). Northern Nigeria is a region of significant Rainfall variability on a temporal and special scales and prone to serious drought and flood events which is understood to have impact on Agriculture and other related occupations. This creates a great need for continued monitoring, provision of accurate and timely report on the Rainfall phenomenon.

5-The Nigerian Meteorological Agency (2012) affirmed that the climate of Nigeria has shown considerable temporal and special shifts in its variability and change since the late 1960s and early 1970s. This has resulted to weather and climate events such as drought, flood, ocean surges e t c and have become more regular (Abaje Sawa and Ati, 2014). Therefore, individual communities and Nations have coped with and adapted to climate variability for centuries, but the changes may be of a magnitude and speed that overstretch traditional adaptive capacities (Brooks 2006).

Therefore, appropriate research most be undertaken to provide information on the effects of climate change on fisheries as well as providing a better understanding of coping strategies to climate change among the fishing communities.

1.3 Research Questions

The following questions were formulated to guide the study

1. What are the trends of key climatic elements and decadal variance over the years along Jama'are River?
2. What perception does fishermen have about the effects of water volume on fish catch?
3. What has accounted for the changes in the volume of fish species and fishing activities along Jama'are are river?
4. What are the adaptation measures to be taken to cope with the problem affecting the fishing occupation along Jama'are River?

1.4 Aim and Objectives of the Research

The aim of this study is to examine the effect of climate change on artisanal fisheries along Jama'are River with the view to trace changes in rainfall and temperature with its decadal variance over 30 years' period, find out about the perception of fishermen on the effects of water volume on fish catch, see trends and magnitude of changes in fish species and fishing activities as well as assessing artisan fisher's adaptation strategies.

But more specifically, the study seeks to:

1. Analyze rainfall and temperature trends and decadal variation over the period of 30 years along Jama'are River Valley (1986 to 2015),
2. Examine the perception of fishermen about the effects of water volume on fish-catch
3. Asses trends and magnitude of changes in the volume of fish species and fishing activities along Jama'are River
4. Identify adaptation strategies for coping with fishing problems along Jama'are river.

1.5 Significance of the Study

Fresh water fisheries are susceptible to a wide range of climate change impacts. The ecological systems, which support fisheries, are already known to be sensitive to climate variability. For example, in 2007, the International Panel on Climate Change (IPCC) highlighted various risks to aquatic system from climate, including loss of coastal wetlands, coral bleeding and changes in the distributions and timing of freshwater flows and acknowledged the uncertain effect of acidification of oceanic waters which is predicted to have profound impacts on marine ecosystems (Orr *et al.,* 2005). Poverty in fishing communities or other forms of marginalization reduces the ability to adapt and respond to change; increasingly globalized fish markets are creating new vulnerabilities to markets disruption which may result from climate change. Related to this trend is the tendency for inland fisheries to be conducted by people who do not define themselves as fishers, but rather engage with seasonal fisheries alongside other livelihood options (smith *et al.,* 2005). Ecosystem overfishing has occurred as the species assemblage is fished down and fishers use smaller nets to catch smaller and less valuable species. According to Allan *et al.,* (2005) the aquatic ecosystems have been profoundly altered by fishing, with a generalized trend of fishing down the food web as fish from higher tropic levels decline, leading to lower tropic levels of harvest and a range of ecosystems effects, including disturbance of sensitive habitats by destructive gears such as explosives, poisons and heavy bottom trawling equipment. Extinctions of large fish species, even marine species with high reproductive outputs, are thought to be possible which constitute a loss of aquatic biodiversity.

However, there is an increasing awareness of the need to develop the ornamental fish farming industry in Nigeria. This development arises from the realization of the role the sector could play in the overall socio-economic development of the country. Nigeria is blessed with a diversity of fish species most of which are of ornamental value and most of the artisanal fishermen do not know the importance/value of these fishes. As a result, they have not been able to play any meaningful role in the conservation and development of these species. Consequently, the national institute for freshwater fisheries research has now risen to the challenges and a national survey of the different ornamental fishes available in Nigeria has been initiated with the view to providing the base line information for ornamental fisheries resources management and development as well as reference sources for future monitoring activities. This would no doubt facilitate the development of the sector so as to make meaningful contribution to the national economy in the area of non-oil foreign exchange earnings.

Nevertheless, there is strong evidence that the fisheries sub-sector of Agriculture is experiencing major challenges and some of these challenges are directly linked to climate change. Therefore, the study will investigate fish farmer's perception of climate impact on fisheries along Jama'are River. The study will also look into how fishing communities perceived climate change factors such as evaporation rate and rainfall fluctuations. Furthermore, it will also uncover how lost fish species may be considered consequence of the negative of impact climate change. All these will help proffer a need for the active involvement of stakeholders in developing policies relating to climate change mitigation and beneficial response strategies to global warming.

1.6 Scope of the Study

The study covered only a section of Jama'are river valley in northern part of Bauchi state, and particularly covered five (5) fishing point as samples along the river valley. The research was conducted between 2016 – 2018 and used rainfall and temperature data for a thirty-year period that is from 1986-2016.

The researches specifically study the effects of climate change on artisanal fisheries along the river valley.

1.7 Description of the Study Area

1.7.1Jama’are River Valley

River Jama’are is a part of the Hadejia-Jama’are-Komadugu-Yobe basin (HJKYB) that drains a catchment of approximately 84,000km2 in northeast Nigeria, before discharging into Lake-Chad. Politically it covers five northern states of Kano, Jigawa, Bauchi, Yobe and Borno state. Over 15 million people are supported by the basin through agriculture, fishing, livestock rearing and water supply. (Geos,2001)

The two major rivers of the basin are the Hadejia/Jama’are, both of which met in the Hadejia-Nguru wetlands to form Yobe. The river Jama’are also known as Bunga river in its upper reaches, begins in the highlands near Jos plateau state, Nigeria and flows northeast through Bauchi and Yobe state, before joining Hadejia river to form the Yobe river. There has recently been controversy over a plan to build the Kafin Zaki Dam on this river with concerns over the effects on seasonal flooding and the water table.

The two principal rivers of the basin are Hadejia (Tributaries-Kano, Challawa Watari) and Jama’are river(Headwaters are in the (Jos-plateau). These uplands are underline by the impermeable Basement Complex, which comprises Precambrian granitic and high-grade metamorphic strata. The terrain is hilly with steep slopes. Deposits, which are especially notable in interdune depressions, consist of sands gravels and clays. The dunes have had a major impact on the development of the basin’s drainage pattern. The Hausa term for these seasonally flooded areas is *fadama*. The *fadamas* of the wetlands consist of levees, back swamps, point bars, meander scrolls and ox-bow lakes.

1.7.2 Location and Extent

The Jama'are River Valley is located in the North/East zone of Nigeria and situated between Latitude 12°00’N to 12°30’N and Longitude 9°00’E to 11°00’E. The River has its source from the highlands of the Jos Plateau which flows in the north-east direction, forming the main drainage system in the western and northern parts of Bauchi State (Figure 1.1). The river flows from an area of high rainfall into an arid region as the other rivers of the Chad Basin. These rivers have seasonal and sluggish flow, and lose much of their waters on route by evaporation and percolation so that little water eventually reaches the lake (Iloeje, 1981).

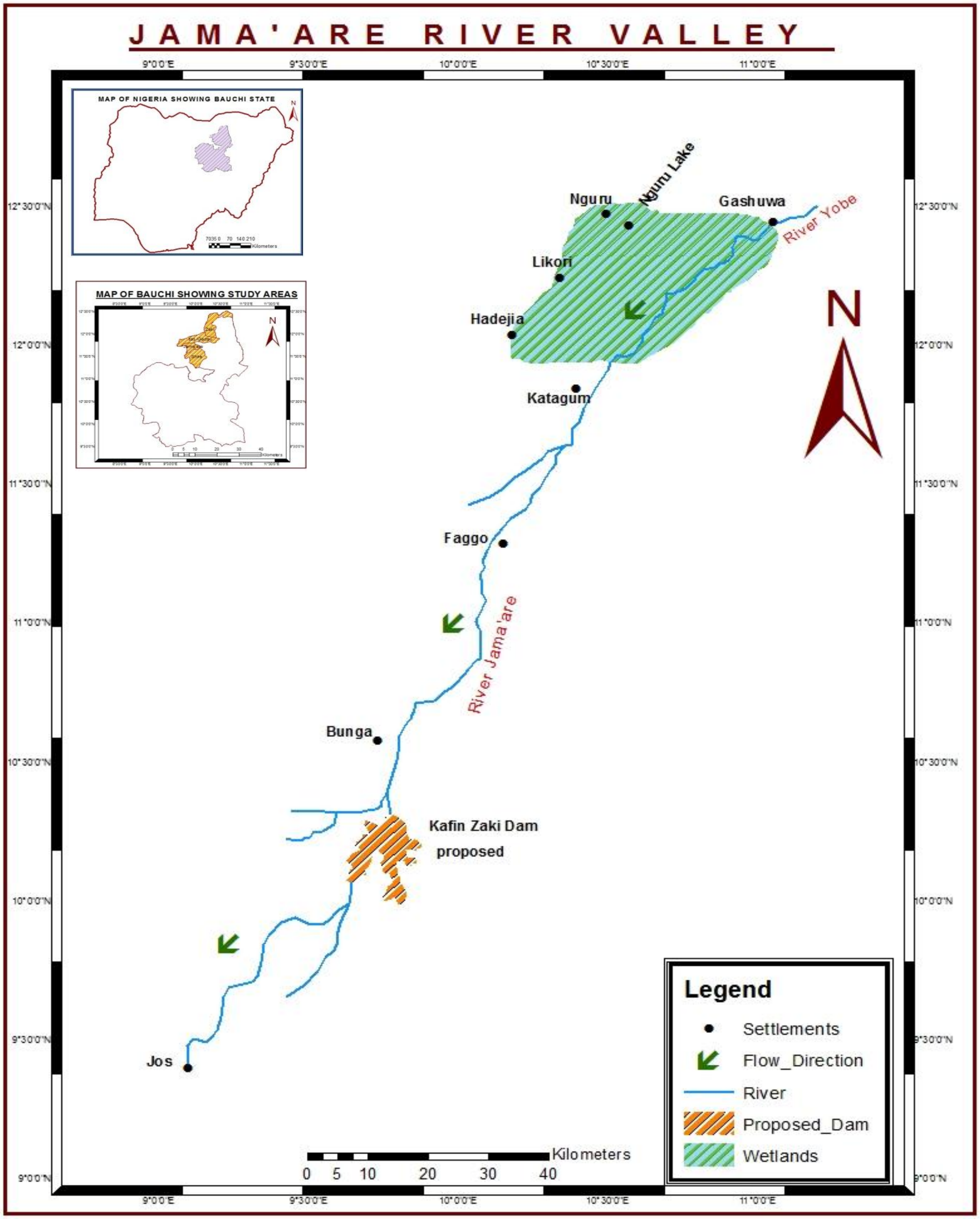

Figure 1.1 JAMA'ARE RIVER VALLEY

1.7.3 Climate

The zone has two distinct climatic patterns, a wet and dry season and aunimodal peak with annual ranges of between 500mm to 1000mm characterizes the wet season. All the rain in the zone falls within 5 months' period. It begins by June and ends in October. The Inter-Tropical Convergent Zone (ITCZ) controlled by two prevailing air masses determines the two seasons: The Northeast Trade Winds, which brings the harmattan, and the South West trade winds, which brings rainfall. Relative humidity is highest during the wet rainy season and lowest in the cold harmattan periods. Average sunshine for the area is 8 hours while temperatures are highest in April/May (ranging between $32^{\circ C}$ and 40°C). Whereas it is lowest, in December/January (ranging between 12°C and 17°C). All the conditions of rainfall, temperature, and relative humidity are very markedly different from the South of the zone to the North.

The climatic regime of the Sahel area, which is closer to the study area, is characterized by a single long dry season followed by a shorter wet season. In the Sahel, mean annual rainfall is less than 500mm and may range between 500-800mm while in the northern part of the region, it is between 1000mm to 800mm. the number of wet months is about 4 months in the northern part of the area to less than 1 moth in the Sahel zone.

The mean annual temperature is 26^{0c} increasing toward the Sahel zone, humidity is very low throughout the dry season (Nwaka, 1985). Potential evapotranspiration exceeds rainfall.)

The mean annual rainfall rages from over 1,000 mm in the upstream Basement complex area to approximately 400mm in the middle part of the basin and less than 300 mm near lake. However, climate variability has resulted in these mean annual rainfall values been unrepresentative for different periods (Hess *et al.,* (1995) calculated in average deduce in annual rainfall of 8mm year 1 between 1961-90 for the north-eastern arid zone of Nigeria (i.e. the middle and lower part of the basin) since the grid- 1990's the decreasing trend in annual rainfall seems to have been reversed.

I .7.4 Vegetation

The vegetation of the zone varies from the Southern part to the northern part according to intensity and duration of rainfall. Generally, the area falls within the Sudan Savannah characterized by short grasses and deciduous trees. The most common trees are: *Butyro* *spermumparadoxum* (Shea butter), *Macla albeda* and *Combretum micranthumspp.* Annually, during the dry season, bush fire burns out most of the grasses.

The density of trees and grasses decreases north words responding to climatic conditions. Increase rainfall variability climate change and increase human activities have been and will continue to adversely modify the natural resources and the environment as a whole. Desertification of the region has been severely altering the traditional climate and eco-climate zones resulting to recurring crop failure, giving rise to short increase in the prices of agricultural products, hunger, sickness, malnutrition, starvation and livestock death in extreme cases (Abdulkadir A. *et al.*, 2013).

1.7.5 Soils

There are four (4) major soil types in the zone. The first type is the ferruginous tropical soils found around the north guinea Savannah area that extends into the southern part of the zone. The second is the weakly developed soils comprising Regosols, brown soils and reddish-brown soils with desert origin. These groups of soils are found further north of the first group discussed earlier on. The third type is ferrisols while the fourth is hydromorphic soils. Generally, the soils of the zone are well drained, however some sections are considered poorly drained and strongly leached (Abdulkadir A. *et al.,* 2013).

1.7.6 Hydrology

The region is drained by Jama'are the major river system and its tributaries and together with Hadejia River constitutes large wetlands along their channels. From these, many water bodies and lakes have been formed. In addition, intense draw down agriculture is done in these area Ground water is already utilized to some extend and there is even some concern about over-utilization in the area. The area is especially prone to droughts and floods, and which is a classic illustration of the reality that far more food is produce from flood place in agriculture, which is dependent upon ground water recharge {Abdulkadir A, *et al*., 2013}.

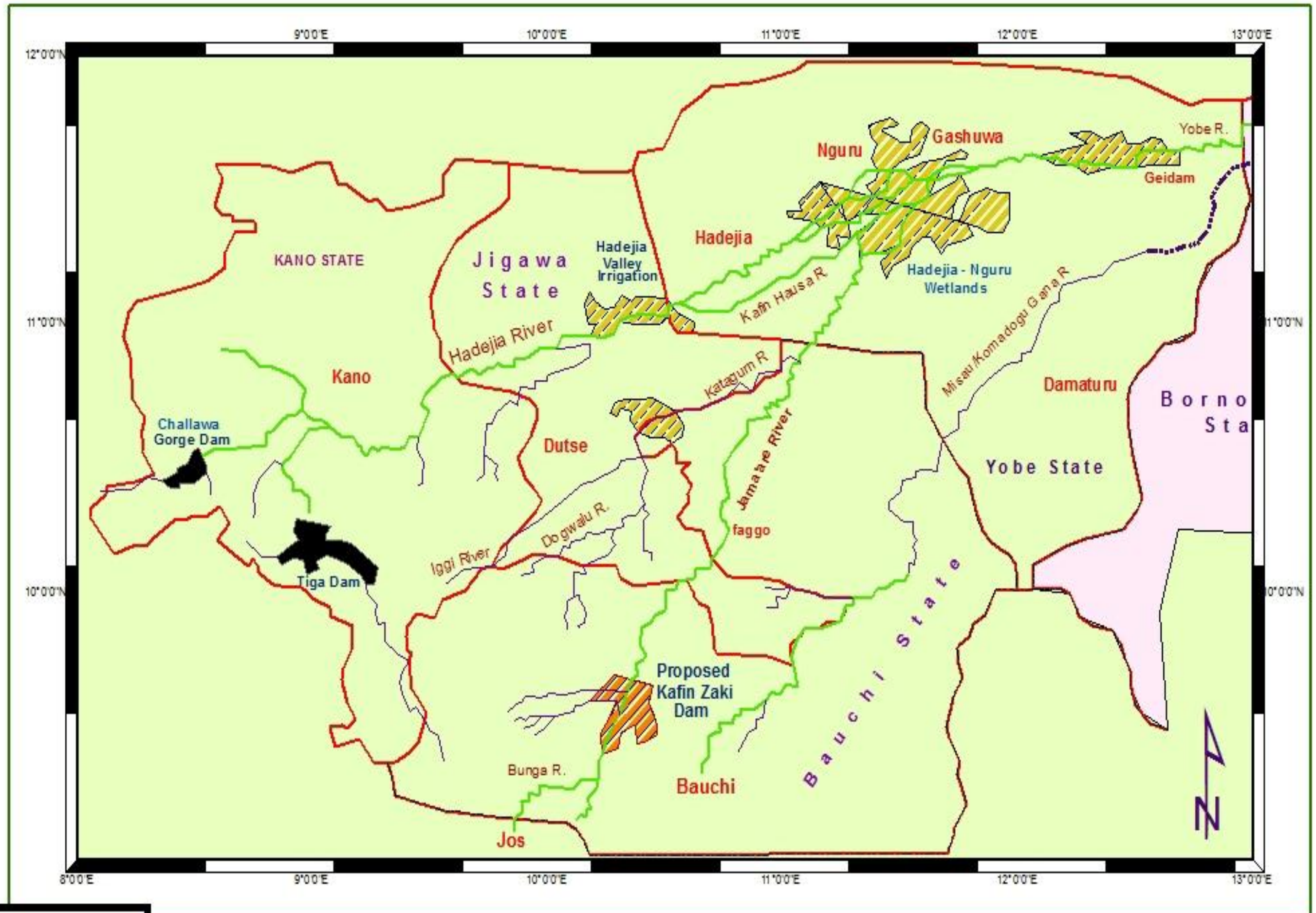

Figure 1.2

HADEJIA - JAMA'ARE RIVER SYSTEM (H-JRS)

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Related literature have been reviewed in this chapter, on the effects of climate change on artisanal fisheries in relation to variability concerning climatic elements such as temperature, rainfall, sunshine humidity, wind, pressure, etc. The climate change as it affects fish-catch and loss-fish species as well as the contribution of individuals pertaining adaptation strategies to the problem in question.

2.2 Climate Change and Climate Variability

Fisheries have always been affected by variable climate, including rare extreme events such as upwelling failures, hurricanes and flooding. Rather than a steady increase in temperature, climate change is likely to be experienced as an increased frequency of extreme events. Therefore, it is valid to analyze how fisheries react and adapt to existing climate fluctuations. This assumption, that future climate change will be manifested in form of increasing severity of familiar phenomenon, may be appropriate to guide policy and action for near-term climate impacts, but it should be borne in mind that thresholds, or "tipping points" may exist, with shift SES into qualitatively different conditions and present novel problem for fisheries sustainability and management (Dawet. *et al.*, 2009). However, Allison *et al.*, (2005), observed that whilst the discharge rates and flooded areas of many rivers in south and south-east Asia may increase, their dry season flows are often predicted to decline and exploitable biomass is more sensitive to dry, than flood season conditions. In a similar vein Shanker, *et al.*, (2004) noted that Changes to the hydrological regime and the risk of droughts and flooding may create further incentives to invest in large-scale infrastructure projects like flood defenses, hydropower dams and irrigation scheme, which are already known to have complex (and often negative) interactions with fisheries.

Existing climate trends will increase over the next century (IPCC, 2007) and are expected to impact more severely on aquatic ecosystem and, directly and indirectly on fishing sectors, markets and communities' loss of corals though bleaching is very likely to occur over the next 50 years, with consequent impacts on the productivity of reef fisheries and potentially on coastal protection as reefs degrade. Sea level will continue to rise and by 2100 will have increased by a further 20 to 60cm, leading to elevated extreme high sea levels greater flooding risk and increased loss of coastal habitats.

Climate change may therefore, result in sudden, surprising and irreversible changes in coastal systems (Nicholls, 2007). The infamous collapse of the Northwest Atlantic Northern cod fishery provides a (non-climate related) example where chronic overfishing led to a sudden, unexpected and irreversible loss in production from this fishery. This existing observation of linear trends cannot be used to reliably predict impacts within the next 50 years.

Sharp (2003) considered future climate change effect on region fisheries by examining historical climate changes and evaluating the consequences of climate related dynamics on evolution of species, society and fisheries variability. The author ranked the impacts of climate changes on regional fisheries and recognized the following fisheries as most responsive to climate variables (in descending order of sensitivity).

1. Fresh water fisheries in small rivers and lakes in regions with larger temperatures and precipitation change; fisheries with exclusive economic zones (EEZ), where access regulation mechanism artificially reduce the mobility of fishing groups and fleets and their abilities to adjust to fluctuations in stock distribution and abundance.
2. Fisheries in large lakes and rivers
3. Fisheries in estuaries particularly where there are species sans migration or spawn dispersal paths or in estuaries impacted by a sea level rise or decreased river flow.
4. High seas fisheries furthermore, it was pointed out that large scale production sea fisheries are not under immediate imported impacts by climate change and those that are most impacted are the ones affected by human interventions such as dams, diminished access to up or dawn –river migration and other issues related to human population growth and habitat manipulation.

Ficke, *et al.,* (2007) posited that the general effects of climate change on fresh water systems will occur through increased water temperature, decreased oxygen levels and the increased toxicity of pollutants. In addition, it was concluded that altered hydrological regimes and increased ground water temperatures would impact on fish communities in lotic systems.

2.3 Increased Environmental Temperature

According to Franklin et al (1995) increasing global temperature can affect individual fish by altering physiological functions such as thermal tolerance, growth, metabolism food consumption, reproductive success, and the ability to maintain internal homeostasis in the face of a variable external environment. Furthermore, Fry (1971) opined that temperature tolerance ranges are specie-specific and include both stenothermal (narrow thermal range) species such as Arctic Charr (selvelinus alpinus), and eury thermal (wide tolerance range) species such as common carp (cyprinuscarpio).

In another development, Moyle and Cech (2004) argued that all freshwater fishes are exotherms that cannot regulate their body temperature through physiological means and whose body temperature are virtually identical to their environmental temperatures. It is also said that fishes may thermo regulate behaviorally, by selecting thermally heterogeneous microhabitats (Brett 1971), but they are constrained by the range of temperatures available in the environment. Because bio chemical reactions rates vary as a function of body temperature, all aspects of an individual fish's physiology, including growth, reproductions, and activity are directly influence by changes in temperature. Fish populations that are faced with changing thermal regimes may increase or decrease in abundance, experience range expansions or contractions, or face extinction.

2.4 Hydrologic Regime as a Function of Precipitation

According to Wood, *et al.,* (2002) Local hydrology is a function of land use, precipitation, soil moisture, and evapotranspiration. However, Allan *et al.,* (2005) opined that it is difficult to predict the effects of climate change on the hydrologic regime of individual streams, and quantitative estimates of the effects of climate are few. In the words of Annear *et al.,* (2004) the hydrological regime of a stream involves the timing of flows of different magnitudes. Flood or peak flows and low flows vary regionally and by watershed with respect to duration, frequency, magnitude and inter-annual variability. Fishes living in lotic systems have adapted to a specific set of hydrologic conditions, changes in these conditions can result in increased success of invasive species.

Welcomme (1979) said that in most major river system worldwide, the size of the seasonal flood is determined by precipitation. Most large river systems are pulse dominated, the extend and duration of the seasonal flood determines the success of the systems fisheries. Meisner 1992 opined that tropical fishes and artisanal and commercial fisheries are adapted to this “feast or famine” cycle and are equipped to deal with conditions that vary with season. Because fish are often adapted to a certain level of hydrologic variability (Poff and Allen 1995), a change in this variability could have negative effects on fish populations. In the North American Mic/West, fish community composition depends upon degree of hydrologic stability in a given stream. Streams characterized by extreme variability (such as those of the North American Great Plains) contain generalist fish species that are able to exploit a wide array of resources and tolerate changing environmental conditions.

2.5 Evaporation and Evapotranspiration

In tropical systems, Evaporation and Evapotranspiration often already exceed precipitation in the dry season (Irion *et al.,* 1997). It is also unknown if increased water loss to the atmosphere will be offset by the rising precipitation rates (Hulme 1994). Also Melack (1996) observed those evaporation rates are a driving factor in tropical lakes. Lakes Malawi and Tanganyika are endorheic, their only “outlet” is to the atmosphere. Therefore, changes in their water chemistry are largely driven by inflows, evaporation and precipitation. Small changes in water levels will eliminate these crucial habitats, forcing these fishes to use areas devoid of their vital habitat structures. This change would likely lead to population declines and might set off a cascade of new inter-specific interactions.

2.6 Ultraviolet Light (UV-B)

Climate change will result in increased ultraviolet light penetration into bodies of water (Lodge 2001). UV-B affects survival of primary producers, the bioavailability of dissolved organic carbon, and the survival of zooplankton species (Header *et al.,* 1998). Although the effects of UV-B have been documented, the interaction between acidification or pollution, UV-B penetration, and eutrophication has been little studies and is expected to have significant impacts on lake systems (Allan *et al.,* 2005). A pair of laboratory and outdoor studies of ceriodaphnia Dubia concluded that increased exposure to UV-B light increased the crustacean’s sensitivity to arsenic (Hansen *et al.,* 2002). Synergy between increased UV-B and the bioavailability of zinc has also been documented is natural systems (Kashian *et al.,* 2004). These studies both suggest that this phenomenon may negatively affect natural systems, and it warrants further study.

2.7 Climate variability and its effects on Fish Production

An inland example of the consequences of a change Net Primary Production (NPP) come from Lake Tanganyika, where the decline in pelagic fish catches since the late 1970s has been ascribed to a climate induced increase in the vertical stability of the water column, resulting in reduced availability of nutrients Brander (2007).

However, the harvest of anchovies is extremely variable because of population fluctuations induced by warm modes of the El Nino – Southern Oscillation (ENSO), commonly known as El Nino. El Nino event reduce up welling along the Peruvian coast, thereby impacting on the natural process that provide nutrients for the anchovies and causing a significant decrease in anchovy biomass. During the 1998 El Nino the anchovy Biomass was estimated at 1.2 million tones, the lowest in the 1990's. (Niquen and Bouchon 2004). Climate variability in pery is not always synonymous with negative effects for the fishmeal industry, La Nina events (cooling of sea surface temperatures) have led to increased catches of anchovies and revenues for the industrial sector (Ordinola, 2002).

Following a temperature induced mass coral mortality event in 2000, and damage to corals from crown of thorns starfish outbreaks in 1999, it might be exported that fisheries and local communities who used those reefs would be directly impacted. However, a socio-economic survey conducted in the area in 2006 found that, while some fishes were aware of the bleaching and starfish phenomena, few identified them as a threat to fish populations. Most fishers had not perceived a decline in fisheries and none had adjusted their fishing practices as a result. Despite the remoteness of these communities and the presence of subsistence farming, the major change in livelihoods and the islands appeared to have been driven by an export market opportunity (carving ceremonial wooden bowl) rather than the ecological impacts from the climate mediate bleaching and starfish outbreak.

This case is based on a relatively small survey of a particular island group and so should not be generalized, but it illustrates how assumptions about the prominence of biophysical and ecological drivers in subsistence fisheries can be misleading (Turner *et al.,* 2007).

2.8 Anthropogenic climate change

Evidence indicates that the Earth is currently going through an unprecedented and accelerated, period of global warming (IPCC 2007a). Global climate scenarios examined by the intergovernmental panel on climate change (IPCC) forecast global mean temperature increase of 1.1□C to 6.4□C by 2100 (IPCC 2007a). Increase in anthropogenic emissions of gases (e.g. carbon dioxide, methane) into the atmosphere, and a resultant enhanced greenhouse effects, have been shown to be the major driving forces behind the observed trend of accelerated global warming that has taken place over the last century (IPCC 2007a).

2.9 Sea temperature

Since the peak of the last ice age, about 20,000 years ago, the global mean air rise temperature has risen 4^{0c} to 7^{0c}, leading to an increase in sea surface temperature (sst) in most of the world's oceans (IPCC 2007b). The rate of increase of coastal sea surface temperature in the gulf of maine is similar to the rise in global mean sst of about 0.7^{0c} over the last century (Trenberth *et al.*, 2007; Shearman 2010). However, the rate of increase has accelerated in recent years and regional studies that sea surface in this region have increased by about 0.23^{0c} from 1982 to 2006 (Belkin 2009), while there is variability in temperatures from year to year, coastal temperatures have increased steadily over the last 40 years, but are not necessarily higher than they were in the 1950s.

2.10 The Importance of fisheries

Fish and other aquatic resources of inland aquatic system are beneficial, especially in Developing countries, but remain largely undervalued and poorly taken into account in water related policies. Recent publication underlines the high potential of small scale fishing activities for Economic Development at local and National Levels. However, they also highlight how poorly their true Economic value is reflected in official statistics, food security and livelihoods appraisals (Cowx *et al.*, 2004; Neiland and Bene, 2006).

In Africa, which provide about 25 percent of the world's inland fisheries landing, there is such a lack of Data that FAO had to provide estimate of the total catch for half of the African Countries where inland fishing is known to take place (FAO 2007). Better Data are needed if fisheries are to be adequately accounted for in water allocation/conservation policies and they escape in vicious circles generated by the present situation since competition for water and modification of aquatic habitats are the main threats to fisheries resources, the water productivity approach may prove useful to formulate adequate water allocation policies for sustainable fisheries and aquatic ecosystems (Sugunan *et al.*, 2007).

2.11 Global inland fisheries and aquaculture

Global inland fisheries and aquaculture (including China) contributed 9.6 and 28.9 million tones, respectively of fresh weight in 2005 amounting to about 27 percent of the world's total marine and inland production (FAO 2007). If China's figures are excluded in 2005 inland capture and aquaculture produced 7.0 and 8.8 million tonnes respectively, the contribution of fish to total animal protein intake is significant (about 20 percent) and probably higher than indicated by official statistics given the unrecorded contribution of subsistence fisheries. An estimated 68 percent of the total landing from inland fisheries occurs in Developing countries, where they contribute significantly to the livelihoods of many rural households. National statistics are usually considered as underestimates, since part of the catch is either not commercialized or delivered through informal channels, where data are "reconstructed" however, evidence suggests small scale fisheries are important in the developing world.

2.12 Multiple Impacts on Inland Fisheries

Inland fisheries ecology is profoundly affected by changes in precipitation and run-off, which may occur due to climate change. Lake fisheries in Southern Africa for example, will likely be heavenly impacted by reduced lake levels and catches. In basin where run-off and seasonal inundation of river flood plains such as those in the Ganges Basin South Asia, fish yields may increase as larger of ephemeral spawning and areas are exploited by lateral migrant species. In Bangladesh, a 20 to 40 percent increase in flooded areas could raise total annual yields by 60,000 to 130,000 tones (Allison *et al.*, 2015).

However, whilst the discharge rates and flooded areas of many rivers Southeast. Asia may increase their dry season flows are often predicted to decline and exploitable biomass is more sensitive to dry than flood season condition (Halls, Kirkwood and Poyne, 2001). Any increase in yield arising from more extensive flooding may therefore be affected by dry season declines. In addition, changes to the hydrological regime and risk of droughts and floowding may create further incentive to invest in large scale infrastructure projects like Flood defenses, hydropower dams and irrigation schemes which are already known to have complex (and often negative) interactions with fisheries (e.g. Shanker, Halls and Barr, 2004).

An estimated 68 percent total landings from fisheries occurs in developing countries, where they contribute significantly to the livelihoods of many rural households. National statistics are usually considered under estimates, since part of the catch is either not commercialized or delivered through informal channels, where data are “reconstructed,” however, evidence suggests small-scale fisheries are important in the developing world, Neiland and Bene (2003) for instance, have produced tentative but never the less informative estimates of the importance of actual and potential basin-wide fisheries in West and Central Africa, from Senegal to Congo-Zaire. Although some of their figures for actual catch may be underestimates (e.g. Lake Chad and Lake Volta), they also show that the potential catches derived from general relationships described later in this study, is expected to be much higher than the actual estimated catch in most basins.

2.13 Fish Responses to New Challenges

Fish faced with a changing environment must adopt, migrate, or perish. Fish population, especially large or widely distributed ones often have high heterogeneity that varies within their geographic range (Laikre *et al.,* 2005). For example, genetic loci is the European hake (merluccius merluccisus) (Cummaruta *et al.,* 2005) and the mummichog fundulus heteroclitus (Smith *et al.,* 1998) vary along a latitudinal cline. The current rate of climate change rivals or surpasses all other rates recorded in the fossil record (Allan *et al.,* 2005), so it is likely that the changing climate will outstrip the ability of some fish populations to respond to new selective pressures. Historic and fossil records indicate that animal and plants tend to shift their range in response to climate change indicating that some genetic traits are relatively intractable (Thomas 2005). The ability of species to adopt will depend upon their genetic plasticity and degree of specialization. Specialists adapted to local conditions will be more likely to go to extinct than generalists (Allan *et al.,* 2005).

Because global climate will shift the ranges of temperate fishes towards higher latitudes, it could have potentially serious impacts on some streams fishes, fishes in geographically isolated environment, and fish in lentil systems. Migration towards the poles may be an option for some species, but fishes in east west oriented stream systems e.g. the southwestern United States

(Matthews and Zimmerman 1990), eastern Africa Allan *et al.*, 2005), and New Zealand (McDowall 1992) would be prevented from moving to higher latitudes by excessive distance and physiological barriers like the ocean. Though some fishes in streams with an east west orientation could migrate toward high elevation head waters in search of cooler temperature they would likely be faced with an entirely new set of environmental challenges such as smaller stream size and unfamiliar habitual (e.g. higher gradient, larger, substrate, changes in turbidity). Similarly, fishes force to seek optimal temperatures in north south oriented system would probably also. Have to cope with a new physical environment. The magnitude of these differences world depends upon factors such as the extent of the range shift and the size and longitudinal profile to the stream. Furthermore, physical barriers to migration will prevent colonization of new habitats. Worldwide, streams and lake chains have been fragmented by man-made barriers such as dams, water diversions and flood control structures (Porto *et al.*, 1999). These alterations will hinder the ability of the fishes to move to new habitat. Fish population is geographically isolated systems such as springs and lakes will be essentially trapped and therefore faced with extinction (Lodge 2001).

2.14 The role of institutions in Adaptation

Institutions in the broadest sense, mean formal and informal traditions, rules, government, systems habits, norms and culture. A technical approach to Adaptation can underestimate the importance of institutions (especially informal) to facilitate or limit adaptation. For example, traditional practices or links with alternative livelihoods can be drawn on to adapt to declining field yields, while culture identities, connected with fishing may limit adaptation in terms of leaving fisheries, that fisher folk are willing to consider (Coulthard 2009). However, in the face of increasing climate change impacts they can also be a barrier to the flexibility needed for adaptive management (Coulthard).

2.15 Gaps in knowledge about vulnerability

The ability to identify those most vulnerable to climate change is limited by the lack of high resolution data at appropriate scale and by uncertainty as to the processes that make people and places vulnerable. The IPCC fourth Assessment highlighted that, in terms of impacts and adaptation, knowledge, monitoring and modeling of observed and future impacts is skewed towards developed Nations (IPCC 2007).

2.16 Adaptation of Fisheries to Climate Change

Adaptation to climate change is defined in the climate change literature as an adjustment in ecological, social, or economic systems, in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities. In other words, adaptation is an active set of strategies and actions taken by people in reaction to, or in anticipation of, changes in order to enhance or maintains their wellbeing. Adaptation can therefore involve both building adoptive capacity to increase the ability of individuals, groups or organizations to predict and adapt to changes, as well as implementing adaptation decisions i.e. transforming that capacity into action. Both dimensions of adaptation can be implemented in preparation for, or in response to impacts generated by a changing climate. Hence, adaptation is a continuous stream of activities, actions; decision that informs decisions about all aspects of life and that reflects existing social norms and processes. Smith et, al, (2000) noted that classification of adaptation can be summarized based on their purpose, mode of implementation, or on the institutional form they take.

Coulthard (2009) highlights the difference between adaptation in the face of resources fluctuations that involve diversifying livelihoods in order to maintain a fishery based livelihoods, and those which involve "hanging up our nets", existing fisheries for a different livelihood source. Another response often observed during the development of a fishery to cope with reduced yield is to intensify fishing by investing more resources into the fishery. This can be in terms of increasing fishing effort (by speeding more time at sea), increasing fishing capacity (by increasing the number, size or efficiency of hears or technology) or fishing further or deeper than previous. Such adaptation responses obviously have potentially negative long term consequences if over exploitation is a concern in the fishery. The state of many worlds is fisheries offer little opportunity for sustainable intensification of fishing as an adaptation strategy.

Inevitably, adaptation strategies are location and context specific. Indeed, Motion (2004) argues that both impacts of an adaptation to climate change will be difficult to model and hence predict, for smallholder or subsistence agricultural systems. This is because of factors such as integration of agricultural and non-agricultural livelihood strategies and exposure to various stressors, ranging from natural stressors to those related to policy change. The same condition is likely to prevail in the subsistence fisheries sector, though this has not been researched in the same manner as marginal and subsistence agricultural systems. Faced with this complexity, there have been various suggestions and typologies of how adaptation actually occurs for such livelihoods.

2.17 Examples of Adaptation in Fisheries

Fisher folk and their communities around the world are already constantly adapting to various forms of change (Coulthard, 2009). Thus, much can be learned by examining how fishers have adopted to climate variability such as El Nino and non-climate pressures and stocks such as lost market or new regulations. Responses to direct impacts of extreme event on fisheries infrastructure and communities are believed to be more effective if they are anticipatory as part of long term integrated coastal and disaster risk management planning (Nicholls 2007) Adaptations to sea level rise and increase storm and surge damage include hard (e.g. sea walls) and soft (e.g. Welland rehabilitation or managed retreat) defenses, as well as improved information systems to integrate know ledge from different coastal sectors and predict and plan for appropriate strategies.

Cultural and socio-economic aspects limit people's adaptive capacity in apparently unpredictable ways. In Pulicat Lake in India, for example, access to fish and prawn fisheries is mediated by caste identities. The non-fishing caste members do not have traditional hereditary rights of access and subsequently tend to be economically poorer and more marginalized. However, in the face of declines in catches, these non-fishing caste fishers were more adaptable to do jobs outside of the fisheries sector. Hence, they had a greater adoptive capacity and were in many ways less vulnerable to annual fluctuations in stocks (Coulthard 2006).

2.18 Adaptation of Fisheries Management

Much fisheries management is still loosely based on maximum sustainable yields or similar fixed ideas of the potential productivity of a stock. For example, North Sea ground fish fisheries have recently been managed in order to receiver cod to a target biomass of 150,000 times. Although climatic influences on cod productivity are recognized (Anonymous, 2007), there is currently do formal strategy by which environmental processes can be incorporated into management targets and measures. As climatic change increases environmental variation, more fisheries managers will have to explicitly consider such variations and more beyond static management parameters for particular stocks. Such changes create an additional imperative to implement the ecosystem approach to fisheries (EAF), a holistic, integrated and participatory approach to obtain sustain able fisheries (FAO, 2006).

CHAPTER THREE
METHODOLOGY

3.0 Introduction

This chapter deals with research methodology. It encompasses types and sources of data, sample frame, sampling Technique, questionnaire design/method of data collection, and statistical analysis.

3.1Types and Sources of Data

The data type used in this research were primary and secondary data which were sourced from quantitative and qualitative sources the qualitative and quantitative types of data otherwise known as primary types of data were gathered by the researcher which include in-depth/unstructured interviews, semi structured interview, structured questionnaires, observation field notes/technical fieldwork notes, photographs and other type of visual material. The primary data was obtained through questionnaire, administered to fishers along Jama'are River. The primary data results obtained from climatic data for thirty years was use d for trend analysis and decadal variance result to determine the increase or decrease of climatic element and their decadal variation. While the data obtained from the questionnaire was analyzed using statistical package for social sciences (SPSS) and the result arrived at include; socio cultural characteristic of the respondent, such as the sex, age, educational qualification, and community and fishing experience. Other result from the data includes annual fish catch in kg, fish size ranges and reasons for fish size reduction.

Also from the data are result of water level effect on fish catch volume as well as association between them, changes in the volume of fish species and fishing activities and result of changes in temperature/rainfall and their effect on fishing, distance covered by fishermen and finally responses about adaptation strategies.

The secondary data were obtained from government publication, bulletin, journals, books, magazines and data from the Hadejia/Jama'are river basin development authority (HJRBDA) headquarters in Kano as well as its branches in in Jama'are and Katagum, the headquarters of Zaki local government, Bauchi state. On the other hand, the secondary data is the data that have been collected and recorded by someone else and readily available from other sources.

3.2 Sampling Frame

This study covers four local government areas in northern part of Bauchi State through which River Jama'are flows. The Local Government areas include Shira, Jama'are, Itas/Gadau and Zaki respectively. Each of this Local Government has 2 to 3 major fishing communities or points, making the total number of 10 fishing points/communities and total population of 889 as indicated in table3.1 below (Fieldwork 2016). The table 3.1 contained the 10 fishing communities or points with their population from which the research five (5) randomly selected samples were derived using lottery for the study. The population figures however were collected or obtained during fieldwork in 2016 from the fisher's head leaders of each community for the purpose of this research.

Table 3.1 Fishing Communities and their Population

S/N	LGA	Fishing communities/points	Population of fishermen
1.	Shira	• Zigau • Disina • Faggo	72 90 88
2.	Jama'are	• Jama'are • Gongo	107 86
3.	Itas/Gadau	• Melandige • Walai • Gadau	94 102 90
4.	Zaki	• Sakwa • Katagum	78 82
			TOTAL 889

Source: Fieldwork 2016

However, the research sampled five (5) fishing communities/point out of the total number of 10 fishing points. The data were collected through visiting the fishing points/communities and questionnaire administered.

The study was conducted along a section of River Jama'are which touches five sampled out of ten fishing points/communities at four Local Government Areas in Northern part of Bauchi State.

The local governments include Shira/Yana, Itas/Gadau, Jama'are, and Zaki which are all situated within latitude 12°00'N to 12°30'N and Longitude 9°00'E to 11°00'E (see figure 1.1). The five sampled fishing points/communities i.e. Zigau, DisinaJama'are, Walai and Sakwa are located between Faggo and Katagum along the Jama'are river valley.

A sample size of 50% (Half a population of each fishing community) was considered in the selection of respondents from the sampled five out of the ten fishing communities available for the research. The sampling has followed the Yount's (2006) rule for setting sample size (for a population size of 0 – 100, 101 – 1000, 1,001 – 5000, 5,001 – 10,000+) to be respectively represented by a sample size of 100%, 10%, 50%, 30% and 1%. The selection of 50% sample size in the research followed the Cochran formula which allows you to calculate an ideal sample size given a desired level of precision, desired confidence level, and the estimated proportion of the attributes present in the population. In Cochran's opinion a sample of any given size provides more information about a smaller population than a larger one. The Cochran formula is

n 0= (z square# p q/ e square).

Note that a proportion of 50% indicates a greater level of variability than either 20% or 80%. This is because 20% and 80% indicates that a large majority do not or do, respectively have the attributes of interest and because a proportion of 5 indicates the maximum variability in a population.

Table 3.2 sampled fishing communities

S/No	Fishing Communities	Population	Sample at 50%
1.	Jama'are	107	53
2.	Disina	90	45
3.	Zigau	72	36
4.	Walai	102	51
5.	Sakwa	78	39
	Total	449	224

Source: Fieldwork 2016

3.3 Samples and Sampling Technique

Simple random sampling as a procedure of probability sampling techniques was applied to identify fishing points/communities used in the study. In the selection of sample points, lottery was employed and achieved where each member of the population of (10) fishing communities/ponts in the study area was given a unique number code, that is to say each member of the population of ten fishing points was numbered serially from 1-10. The researcher wrote each number 1-10 on a separate piece of paper folded and shuffled thoroughly and then blindly drew one at a time until the sample of five (5) fishing points was selected.

3.4 Questionnaire Design/Method of data collection

A psychometric scale was used in designing questionnaire to obtain participants preferences or degree of agreement with a statement or set of statements. Further to that Likert scale as a non-comparative sealing technique and uni-dimentional (only measure single built) in nature. Respondents were asked to indicate their level of agreement with a given statement by way of an ordinal scale. The 5-point scale ranging from a "strongly disagree" on one end to strongly Agree" on the other. Each level on the scale is assigned a numeric value or coding starting of one (1) and incremented by one for each level.

1= SA (strongly agree), 2= A (agree), 3= N (neither), 4= D (disagree), 5= SD (strongly disagree).

A total of 224 questionnaires were administered to 224 fishermen at the five (5) randomly selected fishing point/communities for the study, but only 219 questionnaires were retrieved and 5 are missing. Individual fishermen were contacted at various places such as their residences, fish selling points as well as the river valley where they carry out fishing festivals; therefore, fishermen formed the entire respondents of the study.

The data were collected by the use of interview and structured set of questionnaires with open and close-ended questions. The information obtained through the administration of the questionnaire included educational background, age, gender, fishing communities, estimated catch, fish size, top captured fisheries, association between water level and fish catch volume, decline in fish species and fishing activities etc. SPSS statistical package was utilized in carrying out the analysis of the questionnaire.

3.5 Statistical Analysis

The climatic data needed for the research were specifically the temperature and rainfall record for the period of thirty (30) years ranging from 1986 to 2015 which has to do with the first objective of the research

The study employed trend analysis and to be specific linear trend which are subset of monotonic trends for series of observations over time on rainfall and temperature, the trend analysis which is a process that determine whether values are going up, down or staying the same and can be applied to all the variables. Broadly, speaking trends occur in two ways: a gradual change over time that is consistent in direction (Monotonic) or an abrupt shift at a specific point in time (step trend). Effective trend analysis requires a fairly long sequence of data collected at a fixed location, collected by consistent methods, with few long gaps. It has been suggested that five years of monthly data are the minimum monotonic trend (continuous rate of change, increasing or decreasing).

The research develop time series plots in the process of exploratory data analysis using excel spreadsheets and displayed trend line in time series scatter plots with adjustable averaging

This research used descriptive and inferential statistics. The descriptive statistics involved the use of tables, percentage and simple mean, while the inferential statistics used were Chi- square and Analysis of variance (ANOVA), to determine the level of association between two variables that is water and fish catch volume along the river valley. The study also calculates mean of rainfall and temperature (max and min) to see whether it is decreasing or increasing and lastly compare the mean of the three decades to find out the level of variation between them.

The Chi -square which is a test of association between two or more variables was used in the study to measure the degree (magnitude) and the nature of association between water levels in the river and the volume of fish catch. The analysis of variance (ANOVA) was used also to test variation in the changes of the volume of fish species and fishing activities between and within the five selected fishing points/communities along the river valley.

The statistical package for social sciences (SPSS) was utilized in carrying out the analysis of the data from the questionnaire and Microsoft word excel 2010 was used for the calculation of the trend analysis for the climate data from 1986-2015 (30 years) and Decadal mean and Anova analysis 1986-2015i.e climatic decades' data was arrived at using also the (SPSS).

Rainfall data was collected and aggregated into pentad and analyzed, and were computed using Microsoft excel 2010 on the pentad by pentad bases and arrived at derived onset and cessation date as well as the lengths of rain.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Climate Trend

The climate trend along the Jama'are river valley was investigated and the results were presented according to the following sub-headings.

4.1.1: Rainfall Trend along Valley of River Jama'are

The rainfall trend shows that, there are variations with much irregularity in the pattern; the main aim here is to analyze the pattern. At the beginning of the decade that is around 1986 the rainfall was high with an annual precipitation of about 946 mm, the following year it reduced with about 200 mm, then in 1992 the rainfall amounted to over 1200 mm. It was observed that the annual rain drops, keeps fluctuating until 2001 when it records more than 1300 mm. Moreover, 2009 and 2010 witnessed the peak years where rainfall was at its maximum of between 1400 mm to 1500 mm respectively, hence it reduced significantly to about 800 mm in 2011, rose to about 1100 mm in 2012, and keeps decreasing to below 1000 mm until 2015, where the annual rainfall was about 856 mm. This was illustrated in figure 4.1, with a trend line, which reveals a sloping towards the right side of the graph indicating a falling trend.

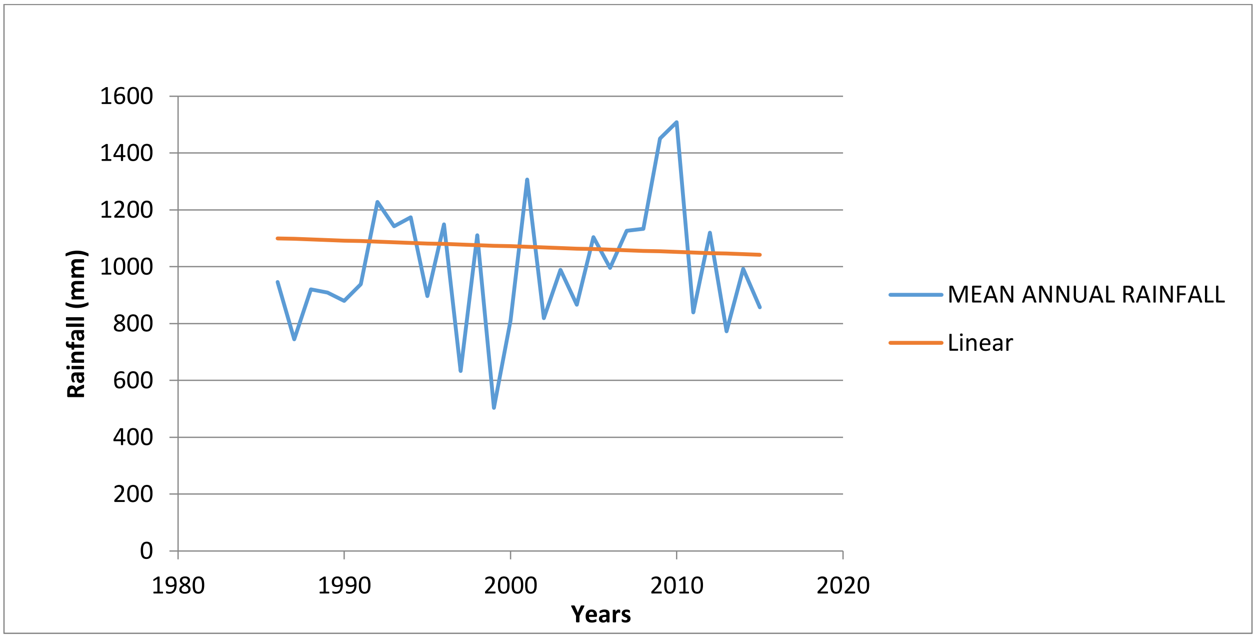

Figure 4.1: Rainfall Trend along Jama'are river valley 1986-2015.Source: laboratory work, 2017.

4.1.2 Length of Rainy Days, Onset and Cessation Dates

The length of rainy days, onset and cessation date scan be seen in fig. 4.2 and in table 4.1; where the highest length of rainy days was in 1988 with 234 days, while the lowest was in 1997 with only 90 days of rainfall. This is an indication of drought year. While onset dates were very fluctuating especially considering the fact that March and April are the most pronounced months with some shifting to May and lastly to June in 2015. However, the cessation dates remain October with the rain usually ceasing within the first or second week of the month.

Table 4.1: Length of Rainy Season 1986-2015 around Jama'are River valley.

YEAR	ONSET DATE	CESSATION DATE	LENGTH OF RAINYDAYS
1986	Mar-29	Oct-26	211
1987	May-18	Oct-05	140
1988	Feb-09	Oct-01	234
1989	Apr-16	Oct-15	182
1990	Apr-17	Oct-12	180
1991	Mar-14	Oct-22	222
1992	Mar-18	Oct-15	211
1993	Apr-17	Oct-19	185
1994	Apr-03	Oct-27	207
1995	Apr-15	Oct-06	174
1996	Apr-09	Oct-13	187
1997	Jun-30	Sep-27	90
1998	Apr-22	Oct-13	174
1999	Jun-01	Oct-15	136
2000	Apr-20	Oct-10	173
2001	Apr-01	Oct-04	186
2002	Apr-06	Oct-13	190
2003	Apr-04	Oct-14	187
2004	Mar-04	Oct-28	208
2005	Apr-28	Oct-18	173
2006	Mar-21	Oct-04	189
2007	Apr-06	Sep-21	168
2008	May-01	Oct-15	166
2009	Apr-21	28-Oct	190
2010	Apr-15	31-Oct	199
2011	Mar-22	Oct-07	198
2012	May-26	Oct-11	140
2013	Apr-22	Oct-18	178
2014	May-28	Oct-11	136
2015	Jun-23	Oct-15	114

Source: Laboratory Work, 2017.

The length of rainy season which otherwise is also known as growing season is not uniform. This uninformed length leads to variability in the amount of water per season per year. The slope from fig 4.2 clearly reveals a declining and increasing trend, which indicates reduction and rising in the number of days with rainfall in the thirty years' duration from 1986-2015. The highest rainfall occurred in 1988 with over 230 days of rainfall, from there on the length of rainy days kept declining up to a point in 1997 when typical drought was witnessed. Since then rainy days kept diminishing below 200 days until 2004 when it reached a little above 200 days then decreased again to even 114 days in 2015.

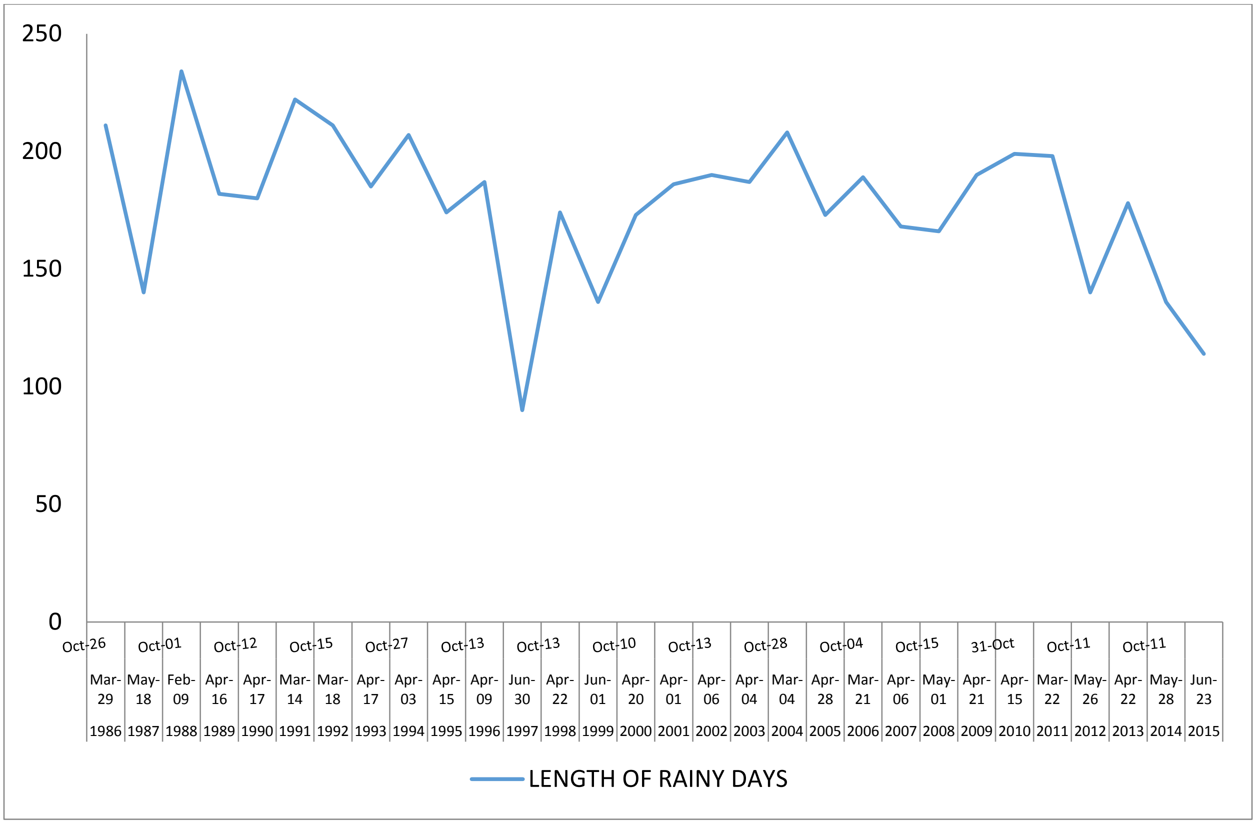

Fig 4.2 Length of Rainy season 1986-2015.

Source: laboratory work, 2017.

4.1.3 Trend on maximum temperature

The Data on maximum temperature reveals a trend that is nearly uniform, considering the graph in Fig 4.3 It is not much noticeable but the temperature seems to be slightly increasing even though the difference shows no much variation, as the slope is almost straight.

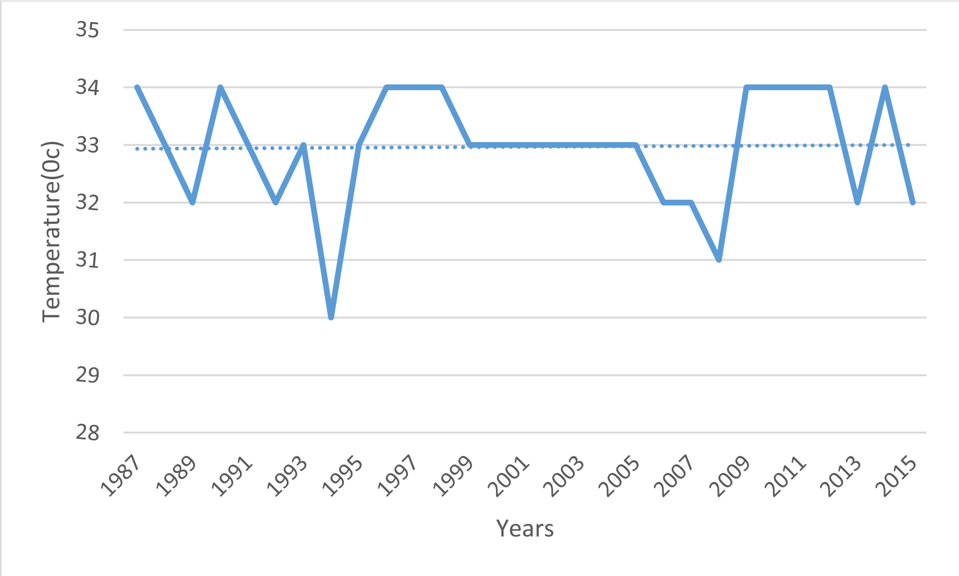

Fig 4.3 Mean Maximum Temperature 1986-2015

4.1.4 Trend on Minimum Temperature

The minimum temperature like the maximum temperature with low variation has also shown and increasing trend. Figure 4.4 shows a slope which inclined towards the right and this indicates that there is increase in minimum temperature and the maximum range between the maximum and minimum record of temperature is 12□C.

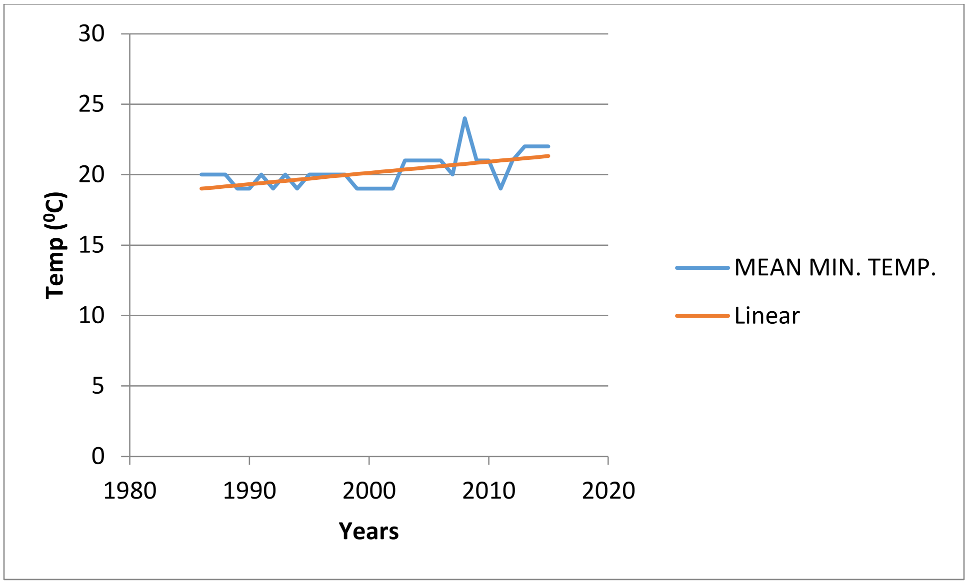

Fig.4.4: Mean Minimum Temperature 1986-2015

Source: laboratory work, 2017.

4.2 Decadal variation of Climatic variables

The decadal average rainfall data from 1986-2015 is divided into 3 decades; 1986-1995, 1996-2005 and 2006-2015. This analysis provides an insight into the decades for possible analysis of rainfall position on Fisheries production since there is a strong relationship between the climatic elements and water in the rivers and lakes.

Table 4.2 Decadal Rainfall Record along Jama'are River Valley

RAINFALL (MM)	DECADE 1	DECADE 2	DECADE 3
YEARS	1986-1995	1996-2005	2006-2015
1	946	1149	966
2	745	633	1127
3	921	1110	1133
4	909	503	1451
5	880	811	1509
6	938	1307	840
7	1228	819	1119
8	1142	989	733
9	1174	866	992
10	897	1105	856
MEAN	978	929.2	1072.6

Source: Fieldwork 2016

4.2.1 Decadal Rainfall (mm) along Jama'are River Valley

The annual rainfall along Jama'are river shows a fluctuating pattern when the rainfall amount within the three decades is taken into account. It was observed that in the first decade 1992 has the highest rainfall amount of 1228 (mm) and the lowest was recorded in 1990 with the value of 880 mm. The highest rainfall amount of the second decade was in 1996 which recorded up to 1149 (mm) and the lowest was 503 (mm). The third decade however, has 1509 (mm) recorded in 2011.

Similarly, the mean decadal rainfall also shows a fluctuating trend, as 978(mm) and then decreases in the following decade to 929.2 (mm) and later in the 3rd decade increases to about, 1072.6 (mm) respectively.

Hence, the data in the table above has been subjected to analysis of the variance (ANOVA) to test for variation as presented in table 4

Table 4.3 Analysis of Variation of Decadal Rainfall

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	106314	53157	1.07	0.358
Error	27	1343204	49748		
Total	29	1449518			

The mean decadal rainfall of the three (3) decades has F value of 1.07 with P value 0.358 which is greater than 0.05 level of significance, thereby accepting the null hypothesis that there is no significant variation between and within mean decadal rainfall along Jama'are River.

4.2.2 Decadal mean maximum temperature of Jama'are river valley

The maximum temperature of the 1st decade (1986-1995) shows a variability pattern, having 34^0C as the highest within the decade in 1990 and 30^0C as the lowest in 1994. However, in the 2nd decade it fluctuates between 33^0C to 34^0C and in the 3rd decade 34^0Cis also the highest and 31^0C the lowest. The mean decadal maximum temperature increases very slightly as the 1st decade has 32.6^0C, 2nd decade 33.3^0C and 32.2^0C for the third decade. The difference between the 1st and the 2nd decade is 0.7^0C and that of the 2nd and third is 0.1^0C respectively.

Table 4.4 Decadal Maximum Temperature of Jama'are River Valley

MAXIMUM TEMPERATURE (0C)	DECADE 1	DECADE 2	DECADE 3
YEARS	1986-1995	1996-2005	2006-2015
1	33	34	33
2	33	34	33
3	33	34	31
4	32	33	34
5	34	33	34
6	33	33	34
7	32	33	34
8	33	33	32
9	30	33	34
10	33	33	33
MEAN	**32.6**	**33.3**	**33.2**

The data from table 4.4 above was subjected to analysis of variance (ANOVA) to find out the level of variation between the decadal maximum temperatures of the three decade as presented in **Table 4.5**

Table 4.5 Analysis of Variation of Decadal Maximum Temperature

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	2.867	1.4333	1.75	0.193
Error	27	22.100	0.8185		
Total	29	24.967			

The F value of the ANOVA is 1.75 with 0.193 p-value which is greater than 0.05 level of significance, hence accepting the null hypothesis that there is no significant variation between and within mean decadal maximum temperature along Jama'are river valley. As such, it can be deduced that there is no significant variation between 1st, 2nd and 3rd decadal mean maximum temperature along Jama'are river valley.

4.2.3 Decadal mean minimum temperature of the Jama'are river valley

Minimum decadal temperature shows a pattern of movement between 20□C as the highest minimum temperature recorded and 19□C as the lowest within the 1st decade. In the 2nd decade however, the movement is between 19□C, 20□C respectively. By and large in the 3rd decade, the year 2008 recorded as high as 24□C, while there are years with, 19□C, 20□C 21□C as well as 22□C. The mean minimum decadal temperature increase from 19.6□C in the 1st decade to 19.9□C in the 2nd decade, and finally to 21.3□C

Table 4.6 Decadal Minimum Temperature of Jama'are River Valley

MINIMUM TEMPERATUE (0C)	DECADE 1	DECADE 2	DECADE 3
YEARS	1986-1995	1996-2005	2006-2015
1	20	20	21
2	20	20	20
3	20	20	24
4	19	19	21
5	19	19	21
6	20	19	19
7	19	19	21
8	20	21	22
9	19	21	22
10	20	21	22
MEAN	**19.6**	**19.9**	**21.3**

Similarly, the data from table 4.6 above have been subjected also to the analysis of variance (ANOVA) to test for variation between and within the three decade as presented in table 4.7 below.

Table 4.7 Analysis of Variation of Decadal Minimum Temperature

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	16.47	8.2333	8.75	0.001
Error	27	25.40	0.9407		
Total	29	41.87			

The F value is 8.75 which yielded 0.001 p-Value which is less than 0.05 level of significance, hence rejecting the null hypothesis meaning that there is significant variation between and within mean decadal minimum temperature along Jama'are river valley. Therefore, it can be deduced that there is significant variation between 1^{st}, 2^{nd} and 3^{rd} decadal mean minimum temperature along Jama'are river valley. This result confirmed that minimum temperature is increasing in the study area in the last 30 years.

4.3 Socio-Cultural characteristics of the respondents:

This section looks at the sex of the respondents as well the age ranges of individual who participate in fishing occupation along Jama'are river valley.

Table 4.8 socio-cultural characteristics of the respondents:

Item	Response	Frequency	Percentage (%)
Sex	Male	219	100
	Female	0	0.00
Age	15 – 20 years	20	9.1
	21 – 30 years	47	21.5
	31 – 40 years	51	23.3
	41 – 50 years	38	17.4
	51 – 60 years	49	22.4
	61 years and above	14	6.3
Educational Qualification	Primary	47	21.5
	Secondary	79	36.1
	Higher	18	8.2
	Arabic	75	34.2
Community	Jama’are	44	20.1
	Zigau	50	22.8
	Disina	46	21.0
	Sakwa	38	17.4
	Walai	41	18.7
Fishing Experience	Less than 10 years	39	17.8
	11 – 20 years	71	32.4
	21 – 30 years	49	22.4
	31 – 40 years	36	16.4
	41 years and above	24	11.0

Source: Fieldwork, 2016.

The socio-cultural characteristics of the fishermen are depicted in Table 4.8. Male respondents had a frequency of 219 representing 100% and therefore showed the total respondents were all male by sex, hence, the name fishermen. The children and old, within the range 15-20 and 61 and above years, least participates in fishing occupation and accounted for 9.1 and 6.3% of the respondents. This may be due to tender and old age, as they could no longer engage more in fishing. Those within the age ranges of 31-40, 41-50 as well as51-60years participate more actively in fishing occupation constituting 23.3%, 17.4% and 22.4% respectively.

The figures in table 4.2 also showed that more than 90% of the respondents attended one level of education or another; as such they would be able to understand the importance of adaptation strategies as remedy to the consequences of changing climate which is affecting fish production, and Only very few (8.2) felt they should attend higher education and this will help in the occupation as they could introduce innovations in the production due to their educated faculties.

The figures in Table 4.2 also showed that Zigau fishing community has the highest number of fishermen with 22.8% which is indicating that more people will be vulnerable to the changes in fish stock, followed by Disina (21.0%) then Jama'are (20.1%) Walai (18.7%) and lastly Sakwa (17.4%) respectively. The population of people in this traditional occupation, constitute both full and part-time fishermen as the water flows through their communities unlike others who don't have this advantage of being near to a River

Plate 1: Zigau River Valley during Rainy Season.

Furthermore, it was observed that the fishermen in the area were in this occupation for a very long time (32.4%) (22.4%) (16.4%) and (11.0%) have fishing experience of 11-20years, 21-30years, 31-40years and 41 and above years respectively. On the other hand, only 17.8% have less than 10 years fishing experience. Fishing occupation in all the communities is as old as the community, this is due to the reason that the communities are located where they are, as a result of the presence of the river flowing. (See plate 1)

4.4 Effects of water level on fish catch volume along Jama'are River

This is where the effects of water level on fish catch volume along the river valley where the respondents show a level of agreement with a statement or otherwise.

Table 4.9: **Effects of water level on fish catch volume along Jama'are River**

Question	**Response**			
	Agree	**%**	**Disagree**	**%**
High water level increases fish output	216	98.6	3	1.4
Low water level decreases fish output	213	97.3	6	2.7
Change in river flow affects fish availability	190	86.8	29	13.2
River water flow considerably decreases	188	85.8	31	14.2

Source: Fieldwork, 2016.

Result from Table 4.9 shows that 98.6%, 97.3%, and 86.8% agreed that water level can increase or decrease fish output in a river, and 85.8% opined as well that river water flow has decreased considerably. (See plate 2)

However, the study use data on Table 4.9 to compute chi-square and found out the association between water level and fish-catch volume along Jama'are river and the ressult presented in table4.11

Plate 2. River Jama'are in Jama'are Town

Source: Field Work, 2016

4.4.1 Association between water level and fish catch volume along Jama'are River

In this section the data from table 4.9 has been subjected to chi-square and the result presented in table 4.12

Table 4.10: **Chi-square of Association between water level and fish volume catch along Jama'are River**

Chi-Square Tests				**Calculated Value**
	Value	df	Asymp. Sig. (2-sided)	17.25
Pearson Chi-Square	41.328[a]	3	.000	
Likelihood Ratio	46.562	3	.000	
N of Valid Cases	876			

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 17.25.

From Table 4.11 the calculated chi-square yielded a value 17.25 while the critical value at 5% level of significance is 7.82, which is lower than the calculated value. This indicated that there is an association between water level and fish catch volume along Jama'are River. However, to support the above assertion Allison et al., (2007) observed in the shallow, highly productive lake Chilwa in Malawi that rainfall variations have led to periodic drying out of the entire lake and time-series demonstrate that the productivity of the fishery is strongly tied to the amount of water in the lake. During drought periods, some fishers diversified their livelihoods to farming, pastoralism and other occupations, while some wealthier, more specialized fishers, and migrate to fisheries in other lakes in the region.

4.4.2 Fish Catch Volume along Jama'are River

This section introduces annual fish catch in kg, fish size ranges as well as the reasons for fish size reduction

Table 4 .11: **Responses on Fish Catch volume along Jama'are River**

Item	**Response**	**Frequency**	**Percentage (%)**
Annual fish catch	200 - 299Kg	21	9.6
	300 - 399Kg	39	17.8
	400 - 499Kg	38	17.4
	500 - 599Kg	34	15.5
	Above 599 Kg	87	39.7
Total		**219**	**100**
Fish size ranges	Big(30 cm long and above.)	32	14.6
	Small (0-12 cm long)	55	25.1
	Medium (13-30 cm long)	44	20.1
	All sizes (combinations)	86	39.3
Reasons for fish size reduction	Reduced water flow	87	39.8
	Fishes food inadequacy	16	7.3
	Rampant fishing	40	18.3
	Deforestation near river bank	7	3.2
	Fishing grounds turn to farms	3	1.4
	Reduced flooding	3	1.4
	White spot diseases	15	6.8
	Poor river control	7	3.2
	Climate change	41	18.7

Source: Fieldwork, 2016.

Table 4.11 showed yearly catch estimates of the respondents in kilograms (kg). The catch estimate comprises of 15.5% and 39.3%, which have 500kg, and above as their yearly catch, while 17.4%, 17.8%, and 9.6% have annual fish catch estimate of 400kg, 300kg and 200kg respectively. However, from the percentages above, the first category uses to have ½ a ton quantity and more or in another angle they have annual fish catch equivalent to ten 50kg and above bags of rice yearly each, and the second segment use to have between 8 to 4 bags of rice yearly.

Also from Table 4.11, we have fish catch size ranges that comprises of big, small, medium and combination of all sizes. About 39.3% were catching all sizes combined, while 14.6%, 25.1%, and 20.1% usually catch big, small, and medium which is the combination of all sizes.

4.4.3 Changes in temperature and rainfall and the distance travelled/covered as it affects fishing and water volume among fishing communities along Jama'are River.

This section discusses changes in temperature, rainfall and the distant covered as it affects fishing and water volume which are presented in table 4.12

Table 4.12: Changes in temperature and rainfall and the distance travelled/covered as it affects fishing and water volume among fishing communities along Jama'are River.

Item	Response	Frequency	Percentage (%)
Changes in temperature	Increase	180	82.2
	Decrease	29	13.2
	Unchanged	10	4.6
Total		**219**	**100**
Changes in rainfall	Increase	54	24.7
	Decrease	155	70.8
	Unchanged	10	4.5
Total		**219**	**100**
Effects of temperature and rainfall on fishing	Reduced fish volume	76	34.7
	Reduced water volume	21	9.6
	Reduces our income	32	14.6
	Low catch	19	8.7
	High Temperature kills fishes	9	4.1
	Fishing activities decreases	20	9.1
	Drying of water	16	7.3
	Increased Temperature and reduced rainfall	26	11.9
Distance covered for fishing	Less than 1 km	7	3.2
	1 - 2 km	114	52
	3 -4 km	38	17.4
	More than 4 km	60	27.4
Effect of climate change on water volume for fishing	Increased water volume	50	22.8
	Decreased water volume	122	55.7
	Fluctuating water volume	47	21.5

Source: Field work, 2016.

From table 4.20 82% of the respondents were of the view that temperature of the area increases while only about 13% held a contrary opinion, 5% indicates that the temperature remains unchanged. However, the above responses of the fishermen show clearly that temperature in the study area increases and this will affect fishing in the sense that rate of evaporation will increase which will also affect water level in the river, hence fishing activities will as well be affected.

More so, responses showed that rainfall amount decreases as 71% of the respondents agreed with the view while 25% opined that rainfall amount increases and that only 5% viewed it to be unchanged. Here, the responses of the fishermen indicated that there was reduction in rainfall amount which will definitely result to reduction in the water volume in the river which will in the long run affect fishing activities.

In addition, 35% were of the view that the changes in Temperature and Rainfall reduces fish volume in the river, while 15% said it reduces the income of the fishermen, 11.9% observed that increased temperature and reduced rainfall affects fishing and another 9% held the same view. While 8% of the respondents admitted that, the changes lead to low fish catch, 7% viewed the changes as been responsible for drying of the river valley and lastly 4% noted that high temperature usually kill fishes.

Further to that, the table also showed the distance covered or travelled. 3% of the respondents covers less than 1km, about 39% travelled 1-2kms to the fishing ground, 22% covered 2-3kms, 17% travels 3-4kms, while 27% travels more than 4kms respectively. The above discussion shows that some fishermen travels more kilometers than others and therefore, the higher the number of kilometers covered by the fishermen, the higher will be the effects on their performance in fishing and hence the entire fish production in the all fishing communities has been affected. Furthermore, table 10 talked about the effects of climate change on water volume in the river. From the table, 56% of the respondents were of the view that the change decreased water volume, while 22.8% said as a result of the change, the water volume increases and 21.5% are with the view that the volume fluctuated. From these outcomes, it can be deduced that Jama'are River water volume decreases.

4.5 Decline of fish species and fishing activities

In this section, reasons for changes in dominant fish species have been given with their percentages as in table 4.13.

Table 4.13: **Reasons for the Decline of Fish Species and Fishing Activities along Jama'are River**

Items	Response	Frequency	Percentage (%)
Reasons for changes in dominant fish species	Size and Population	78	35.6
	Proximity to lake Chad	3	1.3
	No enough food	38	17.4
	No breeding grounds for fishes	5	2.3
	Influence of fishermen	7	3.2
	Temperature fluctuation	21	9.6
	Decreased water volume	67	30.6

Source: Fieldwork, 2016.

Table 4.13 showed Responses on the decline of fish species and fishing activities along Jama'are River. Respondents observed with reasons that there have been changes in dominant fish species between 2010 – 2015. About 35.6% said they have seen changes in the size and population of the fishes along Jama'are River. Similarly, 30.6% were positive about decrease in the volume of water in the river valley. Other reasons given for changes in the fish species include, inadequate food, lack of breeding ground for the fishes and proximity to Lake Chad, which have the following percentages. (17.4%, 9.6%, 3.2%, 2.3%, and 1.3% respectively).

4.5.1 Dominant Fish Species between 2010 -2015 along Jama'are River

This section shows dominant fish species between 2010-2015 along river Jama'are which are presented in table 4.14

Table 4.14 Dominant Fish Species between 2010 -2015 along Jama'are River

Items	Response	Frequency	Percentage (%)
Dominant fish species between 2010 -2015	*Bagrosbayad (Masko)*	13	5.9
	Auchenoglanisspp (Burdo)	3	1.4
	Clariasspp or Cat fish (Tarwada)	65	29.7
	Leviourspp (Lulu)	11	5.0
	Tilapia spp (Karfasa)	75	34.2
	Brycinusspp (Kawara)	41	18.7
	S. Schall (Karaya)	7	3.2
	Hydrocynusspp (Tsage)	2	0.9
	Tilapia oreocrumis (Madde)	1	0.5
	Citharinusspp (Falfal)	1	0.5
Total		**219**	**100**

Source: Fieldwork, 2016.

Table 4.14 also showed the dominant fish species between 2010-2015 as the presently top captured in the valley. KARFASA (Tilapia spp.) with 34.2% is the most dominant specie between 2010-2015, followed by tarwada (Clariasspp or Cat fish) 29.7%, Kawara (Brycinusspp) 18.7%, lulu 5.0%, karaya (S. Schall) 3.2%, burdo (Auchenoglanisspp) 1.4%, Tsage (Hydrocynusspp) 0.9%, madde (Tilapia Oreocrumis) and falfal (Citharinusspp)with 0.5% respectively.

4.5.2 Dominant Fish Species between 80s and 90s along Jama'are River

This section contained fish species available between 80's and 90's along Jama'are River as presented in table 4.15

Table 4.15 Dominant Fish Species between 80s and 90s along Jama'are River

Items	Response	Frequency	Percentage (%)
Dominant fish species between 80s and 90s	*Rainbow trout oncorhyncusmykiss (Kanzai)*	9	4.1
	Mormyrusspp (Sawaya)	2	0.9
	brown trout (Tata)	22	10.0
	rainbow trout (Kurta)	7	3.2
	Leviousalaganasis (Saro)	6	2.7
	Synodontisspp(Kwambami)	14	6.4
	Hydrocynusspp or Tiger Fish Tsage)	5	2.3
	Common carp (Kausa)	15	6.8
	Bagrosbayad (Masko)	5	2.3
	S. Schall (Karaya)	5	2.3
	Brycinusspp (Kawara)	7	3.2
	Perchspp (Lausa)	2	0.9
	Auchenoglanisspp (Burdo)	4	1.8
	Tilapia spp (Karfasa)	16	7.3
	Heterotisniloticus (Bargi)	11	5.0
	Clariasspp or Cat fish (Tarwada)	14	6.4
	Gymnacusspp(Zawo)	5	2.3
	Prince gymnacus (Yauni)	23	10.5
	Tilapia Oreocrumis(Madde)	2	0.9
	Marinespp(Jari)	7	3.2
	Niloticaspp (Barya)	38	17.4
Total		**219**	**100**

Source: Field work, 2016.

Table 4.14 shows the available fish species between 80s and 90s different species are the first ranking which follows this order. Barya (Nilotica) the highest most dominant taken 17.4%, followed by Yauni (Prince Gymnacus) 10.5%, Tata (brown trout) 10.0%, Karfasa (Tilapia spp) 7.3%, Kausa (common carp) 6.8%, Kwambami and Tarwada (Clariasspp or Cat fish) 6.4%, Bargi (Heterotisniloticus) 5.0%, Kanzai 4.1%, and a host of others with lower percentages.

4.5.3 Top Captured Species along Jama'are River

This is where the presently top captured fish species are displayed as in table 4.16

Table 4.16 Top Captured Species along Jama'are River

Items	**Response**	**Frequency**	**Percentage (%)**
Top Captured Species	*Auchenoglanisspp (Burdo)*	8	3.7
	Levioursppp(Lulu)	18	8.2
	Tilapia spp (Karfasa)	62	28.3
	Brycinusspp (Kawara)	43	19.6
	Tilapia oreocrumis (Madde)	2	0.9
	Petrocephalusspp (Faya)	1	0.5
	Clariasspp or Cat fish (Tarwada)	58	26.5
	Mumyrusspp (Sawaya)	2	0.9
	S. Schall (Karaya)	8	3.7
	Bagrosbayad (Masko)	13	5.9
	Malaple-urusspp or electric cat fish (Minjirya)	3	1.4
	Levioursalaganasis (Saro)	1	0.5
Total		**219**	**100**

Source: Fieldwork, 2016.

Table 4.15presently the top captured fishes include Karfasa (Tilapia spp.) with 28.3%, Tarwada (Clariasspp or Cat fish) 26.5%, Kawara (Brycinusspp) 19.6%, lulu (Leviour) 8.2%, Masko (BagrosBayad) 5.9%, Burdo (Auchenoglanisspp) and Karaya (S. Schall)3.7% and many others with lower percentages.

4.5.4 Determining the changes in the volume fish species along Jama'are river valley:

From table 4.14, available fish species between 2010-2015, table 4.15 fish species available between 80s and 90s and table 4.16 the presently top captured fish species along Jama'are river valley have being presented in table 4.17 to determine the absence or presence of a particular species at a particular time. The research used a criteria of symbols plus and minus signs to find out whether a specie is present or absent to determine the increase or decrease in the volume of the fish species and fishing activities.

Table 4.17 Observed changes in the volume of fish species along Jama'are river valley.

Serial number	Available fish species	80-90 species	2010-2015 species	Presently Top Captured species
1	*Rainbow trout oncorhyncusmykiss (Kanzai)*	+	-	-
2	*Mumyrusspp (Sawaya)*	+	-	+
3	*brown trout (Tata)*	+	-	-
4	*rainbow trout (Kurta)*	+	-	-
5	*LeviourSalaganasis (Saro)*	+	-	+
6	*Synodontisspp (Kwambami)*	+	-	-
7	*Hydrocynusspp or Tiger Fish (Tsage)*	+	+	-
8	*common carp (Kausa)*	+	-	-
9	*BagrosBayad (Masko)*	+	+	+
10	*S. Schall (Karaya)*	+	-	+
11	*Brycinussp (Kawara)*	+	+	-
12	*Perch spp(Lausa)*	+	-	-
13	*Auchenoglanisspp (Burdo)*	+	+	+
14	*Tilapia spp (Karfasa)*	+	+	+
15	*Heterotisniloticus (Bargi)*	+	-	-
16	*Clariasspp or Cat fish (Tarwada)*	+	+	+
17	*Gymnacusspp (Zawo)*	+	-	-
18	*Prince Gymnacus (Yauni)*	+	-	-
19	*Tilapiaoreocrumis(Madde)*	+	+	+
20	*Marine spp(Jari)*	+	-	-
21	*Niloticaspp(Barya)*	+	-	-
22	*Leviour (Lulu)*	-	+	+
23	*S.Schall (Karaya)*	-	+	-
24	*Citharinusspp (Falfal)*	-	+	-
25	*Petrocephalusspp (Faya)*	-	-	+
26	*Malaple-urusspp or electric cat fish (Minjirya)*	-	-	+
Total	**26**	**21**	**10**	**11**

Key

+ = Present

- = Absent

4.5.5 Findings from table 4.17

From table 4.16 above, it is observed that the species available along Jama'are river valley which are 26 species in number from the data of the research, 21 fish species are available between 80s and 90s, while 10 species are available between 2010 – 2015 and 11 species are the presently top captured. This is an indication that there is change in fish species and definitely a change in fishing activities along the river valley as a result of a strong relationship that exist between climate, fish stocks, fishing and water ecosystem as indicated in figure 4.5 below:

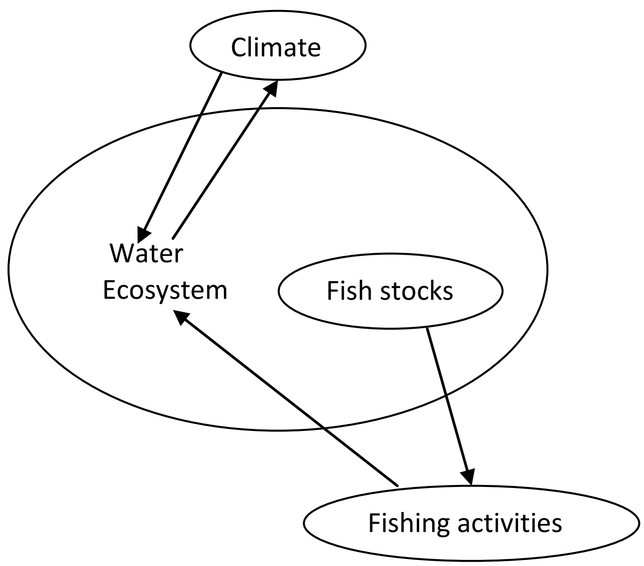

Figure 4.5 System connectivity

As such the livelihood 0f small-scale fishers are vulnerable to changes in fish stock and distribution as the species fluctuates and declined, which has serious impact on income as the fisher so much depend on fish and fishing as the main source of their livelihood. Fishers are also affected by direct climate impacts on processing and trade of their products. Heavy rain prevents rural fishing communities from accessing their usual market and reduces their income as a result of reduction in catch during drought periods.

The small-scale fisher is as well particularly exposed to direct climate change impact because they tend to live in the most Riverside communities and thus at risk from damage to property and infrastructure from multiple direct impact such as flood, increasing storm intensity and frequency and changes in weather pattern may disrupt fishing practices that are based on traditional knowledge.

In addition, any increase in yield arising from more extensive flooding may therefore be offset by dry season declines. In addition, changes to the hydrological regime and the risk of drought and flooding may create further incentive to invest in large-scale infrastructural projects like flood defenses, hydropower dams and irrigation scheme which are already known to have complex and often negative interactions with fisheries

4.5.6 Reasons for Decline in Fish Catch Volume between 2000 and 2015

This is where reasons for changes in fish catch volume between 2000 – 2015 have been given as in table 4.18

Table 4.18 Reasons for Decline in Fish Catch Volume between 2000 and 2015

Items	**Response**	**Frequency**	**Percentage (%)**
Reasons for decline in fish catch volume between 2000 and 2015	Low water level	66	30.1
	Reduced floods	24	11.0
	Many people in fishing occupation	48	21.9
	Reduced water flow	22	10.0
	No flood plains	7	3.2
	More Temperature more output	11	5.0
	Rainfall fluctuation	28	12.8
	No breeding ground for fishes	13	5.9

Source: Field work, 2016.

Table 4.18 are reasons given for the decline in fish catch volume between the period 2000-2015 which include low water level with 30.1%, more people in the fishing occupation 21.9%, and rainfall fluctuation 12.8%, reduced floods 11.0%, and reduced water flow 10.0%, lack of breeding grounds for fishes 5.9%. Others include more temperature and reduced floodplains respectively.

Plate 3: Kawara (Brycinusspp) the third most dominant specie.

Source: Field Work, 2016

4.5.7 Reasons for decline of fish species and fishing activities along Jama'are River

This is where changes in the volume of fish and fishing activities along Jama'are have been displayed as in table 4.19

Table 4.19: Reasons for decline of fish species and fishing activities along Jama'are River

Question	Response			
	Agree	**%**	**Disagree**	**%**
Decrease in fish species is connected to increase in temperature	175	79.9	44	20.1
Sand deposits affects fish availability	136	62.1	83	37.9
Recent climate variability reduces fishing activities in 15 - 20 years back	188	85.8	31	14.2
Declined fish catch/activities resulted from climatic variability over the years	179	81.7	40	18.3
Over exploitation resulted to collapse of fish production	171	78.1	48	21.9

Source: Fieldwork, 2016.

About 80% of the respondents agreed that there is decrease in the number of fish species and it is connected to the following:

a} temperature increase

b} sand deposit along the river valley

c} climatic variability

d} over-exploitation

4.5.8 Diversification of livelihood

In response to catch decline the fishers go for small-scale or subsistence Agricultural systems. This is because of factors such as the integration of Agriculture and non-agricultural livelihood strategies and exposure to various stressors ranging from natural stressors to those related to policy change. Adaptations in fisheries are dominated by diversification or flexible livelihoods in response to climate-mediated fluctuations in yield.

The data in Table 4.19 were further subjected to ANOVA in order to test for variation among fishing communities in the decline of fish species and fishing activities along Jama'are River. The results were presented in table 4.20.

Plate 4. Sand Deposit along Jama'are Valley

Source: Field Work, 2016

4.5.9 Variation in declining fish species and fishing activities along Jama'are River

This is where the data from table 4.19 have been subjected to analysis of the variance (ANOVA) to test for variation in the changes of the volume of fish species and fishing activities along Jama'are River and it has been presented in the table 4.19

Table 4.20: **ANOVA result for variation in declining fish species and fishing activities along Jama'are River**

	Source of variation	Sum of squares	df	Mean square	F ratio	Level of sig
Decline of fish species and fishing activities	SSA	6.423	1	6.423	3.215	10%
	SSE	2183.577	1093	1.998		
	SST	2190.000	1094			

Source: Field Work, 2016.

The calculated F value (3.215) is significant at 10% level of significance, therefore null hypothesis that said, "There is no variation in the decline of fish species and fishing activities between fishing communities along Jama'are River" is rejected. This indicates that there is little variation in declining fish species and fishing activities between fishing communities and hence a decrease in the number of fish species because of increased temperature in all the fishing communities and at the same time, it is agreed that presence of sand deposit along the river valley, climatic variability and over-exploitation affects fish availability and production.

Similarly, the above scenario can be supported with what is happening in Lake Chad basin. The characteristics and performance of the Lake Chad fisheries is associated with the regional hydrological regimes and the distribution of water. This is mainly determined by climate and human activities such as irrigation dams Over the last 60years lake Chad has change from a stable shallow lake to a more unstable, marshy or swamp environment with some open water body in the Southern basin (Neiland *et al.,* 2004). In the 1970s and the 1980s dams constructed on river Yobe and river Lagone led to further alteration of the hydrological regime in the basin. This resulted in the loss of 200,000 hectares of floodplains critical for fish breeding and nursery areas. The 1982-1984 drought further reduced the water flow and by 1990 the lake chad covered less than 2,000 km^2while the swampland came down to only 4,000km^2 so the characteristics of river Jama'are also vary on intra-annual seasonal basis.

4.6 Opinions about Adaptation Strategies among Fishing Communities along Jama'are River

In ideal situation, the fishers are to adapt the following strategies

-The interval hanging of fish- catch nets.

-The use of specific suitable nets for fishing.

-Compliance to the enacted conservation laws.

But this section discusses opinions of individual fishermen about adoptable strategies among fishing communities along Jama'are River as displayed in table 4.21

Table 4.21: Respondents 'opinions about Adaptation Strategies among Fishing Communities along Jama'are River

Question	Response			
	Agree	**%**	**Disagree**	**%**
Extreme weather events adopted strategy is interval hanging of fish catch net	1. 182	2. 83.1	3. 37	4. 16.9
All kinds of nets are rampantly used in fishing	5. 207	6. 94.5	7. 12	8. 5.5
Small size nets are mostly frequented by fishermen	9. 183	10. 83.6	11. 36	12. 16.4
Fishermen freely perform fishing with no regulation for conservation	13. 135	14. 61.6	15. 84	16. 38.4
HJRBDA enact fisheries conservation laws	17. 124	18. 56.6	19. 95	20. 43.4

Source: Field work, 2016.

The opinion of respondents about adaptation strategies among fishing communities along Jama'are River were sampled and the results were depicted in table 4.21. From the table however, about 83% did not comply with the interval hanging of fish catch net as a strategy to reduce the impact of extreme weather events. Similarly, the table shows that 95% uses all kinds of nets rampantly, which also go against the conservation measures. About 83.6% were of the view that small size nets are mostly used by fishermen. Whereas only about 62% opined that fishermen freely perform fishing with no regulation for conservation, despite the fact that 57% indicated that the Hadejia/Jama'are River Basin Development Authorities have enacted conservation laws. With these outcomes, it can be deduced that there are no signs of adaptation strategies by the fishermen in response to the extreme weather events, hence the need for proper compliance to the enacted laws so as to ensure the conservation of fisheries along the river valley.

In connection to the responses on adaptation, it is clearly seen that developing countries in tropical regions including the study area are usually assumed to have lower adaptive capacities than countries with high levels of economic and human development. This is because of lower availability of resources and institutions necessary to facilitate adaptation. The national level analysis of vulnerability of 132 economies to climate change impacts on fisheries predicted climate change, the sensitivity of each economy to disruption to fisheries and adaptive capacity, as indicated by statistics on development and G. D. P. (Allison *et al.,* 2005). According to the resultant index, countries in western and central Africa including Nigeria because of low levels of development and high consumption of fish, northwest south America {due to very large landing} and four Asian countries were most vulnerable.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of major findings

The analysis of climatic trend in the study area revealed that fluctuating precipitation and the varying mean annual rainfall indicating a filling trend, Onset rainfall dates are also fluctuating as March and April are the most pronounced months, but the cessation dates remains October with the rain ceasing within the first or second week. The length of the rain days or rainy season is not uniform leading to variability in the amount of water per season per year. However, length of rainfall matters much as it so impacted on the soil moisture to reach certain level of saturation which also affect water holding capacity to be long enough for aquatic habitation and the dates shows reduction in the number of days with rainfall in the thirty years' duration from 1986-20015 average maximum temperature trend is nearly uniform as there is no much difference, but it seems to be fluctuating. The minimum temperature also shows low variation and has more fluctuating trend. The range between maximum and minimum temperature is $5^{0c.}$On the decadal climatic trend, the decadal average rainfall trend from 1986-1995 shows a decreasing pattern, that of 1996-2005 shows an increasing trend and decadal annual average rainfall from 2006-2015 also shows a decreasing trend as in total, 6 years out of 10 years have rainfall below 1000mm, while only 4 years have rainfall above 1000m.

Decadal temperature both minimum and maximum varied between 1986-1995 the minimum temperature range is recorded as low as 1^{0}c which means the variation is very small compared to that of rainfall over this decade. The average maximum temperature also shows a rising trend, but unlike maximum, the variation is high which is 2^{0}c.Maximum and minimum temperature between 1996-2005 showed an increasing trend, but the mean maximum also has reveals a variability pattern with temperature rising and falling. Temperature of 2006 – 2015 also showed variability pattern and in the majority, the decade witnessed a shift upward.

Also from the study responses of the fishery communities indicated that total sample was all male as the name fisherman implies and those within the age range 31-40, 41-50 and 51-60 are the active participants in fish production. Similarly, the overall picture of educational qualification is that more than 90% of the fisherman attended one level of education or another.

The study also showed that Zigau fishing communities have the highest number of fishers who have been in the occupation for a very longtime as occupation is as old as the communities.

Also in the study, it is indicated that the fisherman uses to have maximum annual fish-catch estimate equivalent to ten 50kg and above bags of rice yearly each and the sizes of fishes in the river ranges between Big, medium and small sizes.

The fishermen confirmed as well that the fishes witnessed reduction in their sizes, and several reasons were attributed to the reduction which include among others, low water volume in the river, rampant fishing, fish food in adequacy and so on. They opined also that river water flows have considerably decrease, it was also found that there is an association between water level and fish catch volume along Jama'are River.

It was observed with reason that there have been changes in dominant fish species when the present time species were compared with the species available during the 80s and 90s along the river valley. Furthermore, the result of the study also showed that there is no variation or difference in the decline of fish species and fishing activities between and within fishing communities along Jam'are river which indicates that there is a decrease in the number of fish species as a result of increase in temperature, presence of sand deposit, climate variability and over-exploitation in all the fishing communities.

5.2 Conclusion

The research carried out trend analysis and finally concluded that between the highest and lowest mean annual rainfall there is about 19% variation. Rainfall onset dates appeared mostly in April and March and all the cessation dates are in October, while there is little fluctuating trend in the onset dates, there is no statistically significant decreasing trend in the termination dates. Temperature in the region or area is generally high when the temperature of 33.0^{0c} of 1992, 1993 and 1994 are compared with 22.4^{0c} mean temperature of the northern hemisphere. Temperature is on the increase but the increase in the annual minimum temperature varies slightly.

The decadal climate trend reveals that both the mean, maximum and mean minimum temperatures of the decades shows an increasing pattern while the mean rainfall on the other hand shows a decreasing but fluctuating rainfall pattern.

The study also carryout chi-square test to find out an association between water level and fish catch volume in which the minimum expected count is 17.25 while the critical values under 0.05level of significance is 7.82 indicating association.

Also in the study the analysis of variance carried out reveals that there is little variation in the changes of volume of the fish species and fishing activities between and within fishing communities.

5.3 Recommendations

Amongst others, the researcher recommended that:

1. It is very important for the government and other stakeholders to provide more weather stations and relevant climate monitoring platforms across Bauchi state and Nigeria in general, for that is the only way the climate can be studied, known any implication it might have mitigated, and any benefit it may bring harnessed.

2. It is now a fact that climate elements influence water volume, fisheries and fishing activities in our rivers, so it is time river basin development authorities, fishermen and all stakeholders make use of researches like this one and work with it as part of measure to adopting changes in climate.

3. To mitigate the impact of climate change there should be commitment of workable strategies for sustainable tree planting program rather than cosmetic approach. Also fishers should diversify their livelihoods to farming, pastoralist and other occupations.

4. Public enlightenment and sensitization campaigns on climatic change and extreme weather events should be encourage through the print and electronic media and government must ensure attitudinal change of the citizens toward the environment through motivation and penalty.

5. In line with federal and state government's aggressive approach towards encouraging general fish production, hatcheries should be built in each state of Nigeria including Abuja. This is with the view to producing fish seeds for fish farmers for sustainable development.

5.4 Contribution to knowledge

Based on the research methods and findings the following contribution to knowledge were offered

1- The research presents for the first time in the study area, the top captured fish species in the valley which include the Tilapia spp the first most captured, the Clarias spp or cat fish, the second most captured, and the Brycinus spp as the third most captured. This in nut shell will call the attention of those who value these species thereby widening the fish market regarding the species and increasing the income of the fishermen and hence enhancing their livelihoods.
2- The research also presented 26 fish species available in the river valley from which the ornamental fishes will be identified and thereby providing base line information for ornamental fisheries management and Development.
3- The research provided as well the first hand information from the study area about the extinction of large fish species which constitute a loss of aquatic biodiversity. The extinct species in the study area may include the Nilotica spp, the marine spp and the prince Gymnacus to mention but a few.

5.5 Contemporary issues resolved

1-The research has provided an increasing awareness about the frequency and intensity of extreme climate events and the major likely impact on fisheries production in inland water systems.

2-The research has shown the danger of fishing and climate change as strongly interrelated pressures on fish stocks and water ecosystem in general.

3-The research has provided avenue and sensitization campaign and above all created a need for continued monitoring, provision of accurate and timely report on the rainfall phenomena.

4-It has also shown the importance of adaptation of extreme weather events by fishermen to ensure conservation of water ecosystems for sustainable Development.

5-Shows issues of climate change through rainfall variability to reduce or enhance fish productivity as water volume has influence on fish catch.

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APPENDIXES

Appendix 1: Length of Rainy Season 1986-2015 in Jama'are River Valley

YEAR	ONSET DATE	CESSATION DATE	LENGTH OF RAINY DAYS
1986	Mar-29	Oct-26	211
1987	May-18	Oct-05	140
1988	Feb-09	Oct-01	234
1989	Apr-16	Oct-15	182
1990	Apr-17	Oct-12	180
1991	Mar-14	Oct-22	222
1992	Mar-18	Oct-15	211
1993	Apr-17	Oct-19	185
1994	Apr-03	Oct-27	207
1995	Apr-15	Oct-06	174
1996	Apr-09	Oct-13	187
1997	Jun-30	Sep-27	90
1998	Apr-22	Oct-13	174
1999	Jun-01	Oct-15	136
2000	Apr-20	Oct-10	173
2001	Apr-01	Oct-04	186
2002	Apr-06	Oct-13	190
2003	Apr-04	Oct-14	187
2004	Mar-04	Oct-28	208
2005	Apr-28	Oct-18	173
2006	Mar-21	Oct-04	189
2007	Apr-06	Sep-21	168
2008	May-01	Oct-15	166
2009	Apr-21	28-Oct	190
2010	Apr-15	31-Oct	199
2011	Mar-22	Oct-07	198
2012	May-26	Oct-11	140
2013	Apr-22	Oct-18	178
2014	May-28	Oct-11	136
2015	Jun-23	Oct-15	114

Appendix 2: Mean Annual Rainfall: 5 years M A.

YEARS	MEAN ANNUAL RAINFALL	5 years MA
1986	946.1	
1987	744.6	880.08
1988	920.7	878.54
1989	909.4	975.24
1990	879.6	1019.48
1991	938.4	1072.46
1992	1228.1	1075.96
1993	1141.9	1118.14
1994	1174.3	999.04
1995	897.1	992.74
1996	1149.3	858.64
1997	632.6	841.38
1998	1110.4	873
1999	503.8	910.3
2000	810.8	886.06
2001	1307.4	958.48
2002	819.1	1017.22
2003	989.2	955
2004	865.9	1016.5
2005	1104.5	1045.32
2006	996.3	1162.4
2007	1126.6	1243.32
2008	1133.3	1211.96
2009	1451.3	1210.5
2010	1509.1	1138.48
2011	839.5	1046.62
2012	1119.3	916.18
2013	773.2	748.28
2014	992	524.42
2015	856.9	369.78

Appendix 3: Average Minimum Temperature 5 Years Moving Averages

YEARS	MEAN MIN. TEMP.		
1986	20		
1987	20	#N/A	#N/A
1988	20	#N/A	#N/A
1989	19	#N/A	#N/A
1990	19	#N/A	#N/A
1991	20	19.6	#N/A
1992	19	19.6	#N/A
1993	20	19.4	#N/A
1994	19	19.4	#N/A
1995	20	19.4	0.489898
1996	20	19.6	0.447214
1997	20	19.6	0.447214
1998	20	19.8	0.419524
1999	19	19.8	0.334664
2000	19	19.8	0.45607
2001	19	19.6	0.497996
2002	19	19.4	0.497996
2003	21	19.2	0.497996
2004	21	19.4	0.867179
2005	21	19.8	0.954987
2006	21	20.2	0.98387
2007	20	20.6	0.98387
2008	24	20.8	1.043072
2009	21	21.4	1.388524
2010	21	21.4	1.293058
2011	19	21.4	1.255388
2012	21	21	1.531013
2013	22	21.2	1.491308
2014	22	20.8	1.077033
2015	22	21	1.152389
		21.2	1.193315

APPENDIX 4: Questionnaire

Study on the Effects of Climate Change on Artisanal Fishery along a section of Jama’are River, Nigeria.

INSTRUCTION: tick or provide the required information where you feel appropriate please.

Section ‘A’: Demographic characteristics.

Gender a) Male ☐ b) Female ☐

Age a) 15 -20☐ b) 21-30 ☐ c) 31-40☐ d) 41-50 ☐ e) 51-60 ☐

f) 61 and above ☐

Level of Education.

a) Primary ☐ b) Secondary ☐ c) Higher ☐ d) Arabic ☐

Name of fishing community____

Years Spent in the Occupation____

Section “B”: (General comments by the fishermen on some key issues)

1-what is your total estimated annual catch over the past one-year period?

Comment____

2-what is the fish size ranges in your fishing area?

Comment____

3-Do you observe some overall reduction in fish sizes during the period 2010-2015, support your reason with a reason please.

Comment____

4-Do the fish size structure of dominant species show any major changes. Give reasons to your answer, please.

Comment____

5.Write the five most dominant fish species in your fishing area over a five-year period from 2010-2015.

1______________ 2_____________3__________________ 4______________ 5____________

6. List the fish species found in the fishing area from early 80s-to-early 90s.

1_________________ 2_________________3__________________ 4_____________________

5________________________6. ___________________7__________________

7. Itemized the 6 top captured species in your fishing area.

1____________ 2___________ 3___________ 4. _____________ 5. _____________ 6_________

8. Do you experience decline in fish catch volume from 2000-to the present time? Give reasons to your answer, please.

Comment with reason please____

9. Do you observe changes in the Temperature and Rainfall of your area? (tick the correct option)

i. Temperature

a. Increase b. Decrease c. Unchanged

ii. Rainfall

a. Increase b. Decrease c. Unchanged

10. How does that affect your occupation?

Comment____

11. How many kilometers do you travel/cover from your house to the fishing area?

Comment____

12. Climate change has affected water volume in your fishing area by either.

a) increasing the volume b) decreasing the volume c) fluctuating the volume.

Section 'C': (Views on the Effects of Climate Change on Artisanal Fishery in the Fishing Communities along Jama'are River)

Instruction: The questionnaire is developed using 5 point Likert scale ranging from 1= strongly agree, 2=agree, 3=Neither, 4= disagree,5= strongly disagree.

Please study all the items in this Questionnaire and tick a box that reflects your opinion in respect of scales 1, 2, 3, 4, or 5 in the format provided.

S/N	**ITEMS**	**5-POINT LIKERT SCALE**				
The statements below show some of the possible effects of climate change on artisanal fishery in the fishing communities along Jama'are river and responses of the fishermen.		1	2	3	4	5
A1	High water levels in the river as a result of increase rainfall, increases the volume of fish output					
A2	Low water levels in the river following low rainfall result to low volume of fish catch.					
A3	Change in river water flow resulted from rainfall variability increases fish availability.					
A4	There is a considerable decrease in the river water flow as compared to previous years.					
B1	Low water volume in the river valley may be responsible for the decrease of fish species.					
B2	Loss/decrease of fish species may also be connected to increase in temperature around Jama'are River Valley.					
B3	Presence of sand silt deposits affects the availability of fishes in the Jama'are river valley.					
B4	Climatic variability in recent times is causing reduction of fishing activities along Jama'are River Valley as compared to15-20 years back.					

B5	There have been decline in fish-catch and fishing activities as a result of climatic variability and trend over the years,					
B6	Over-exploitation is responsible for the collapse in fish production along Jama'are River.					
C1	Hanging up of fish catch nets at certain intervals is one of the strategies adopted during extreme weather events along the river.					
C2	Using all kinds of nets is rampant along Jama'are River Valley.					
C3	Using small size nets is frequented by fishermen along Jama'are River Valley.					
C4	Fishers along the River Valley are free to perform fishing activities with no regulations for conservation.					
C5	Rules and regulation are imposed by River Basin Development Authorities on fishing so as to conserve the fisheries.					

Thank you.

APPENDIX 5: Association between water level and fish catch volume along Jama'are River

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Effects of water level on fish catch volume * Responses about effects of water level on fish catch volume	876	100.0%	0	0.0%	876	100.0%

Responses about effects of water level on fish catch volume along Jama'are River.					
			Responses about effects of water level on fish catch volume		Total
			Agree	Disagree	
Effects of water level on fish catch volume	High water level increases fish output	Count	216	3	219
		Expected Count	201.8	17.3	219.0
	Low water level decreases fish output	Count	213	6	219
		Expected Count	201.8	17.3	219.0
	Change in	Count	190	29	219

	river flow affects fish availability	Expected Count	201.8	17.3	219.0
	River water flow considerably decreases	Count	188	31	219
		Expected Count	201.8	17.3	219.0
Total		Count	807	69	876
		Expected Count	807.0	69.0	876.0

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	41.328[a]	3	.000
Likelihood Ratio	46.562	3	.000
Linear-by-linear association	35.982	1	.000
N of Valid Cases	876		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 17.25.			

APPENDIX 6: Variation in demise of fish species and fishing activities along Jama'are River

A I) ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	6.423	1	6.423	3.215	.073
Within Groups	2183.577	1093	1.998		
Total	2190.000	1094			

A ii) Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Agreed	849	3.0412	1.41486	.04856	2.9459	3.1365	1.00	5.00
Disagreed	246	2.8577	1.40846	.08980	2.6808	3.0346	1.00	5.00
Total	1095	3.0000	1.41486	.04276	2.9161	3.0839	1.00	5.00

A iii) Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.877	1	1093	.349