HOUSEHOLDS' VULNERABILITY AND ADAPTATION TO WATER SCARCITY IN RURAL AREAS KATSINA STATE, NIGERIA

BY

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DECLARATION

This thesis is my original work and has never been presented for examination or degree award in any other University or presented as a seminar paper in any workshop or presented for publication in any journal or book.

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DEDICATION

To my late father, Alhaji Iro Rafindadi

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LIST OF ACRONYMS

ADF	-	African Development Fund
CDKN	-	Climate and development Knowledge Network
DFID	-	Department for international Development
DFRRI	-	Directorate of Food Roads and Rural Infrastructure
FAO	-	Food and Agricultural Organization
FGN	-	Federal Government of Nigeria
FMWR	-	Federal ministry of water resources
FRN	-	Federal Republic of Nigeria
IDRC	-	International Development for Research centre
IDWSSD	-	International Drinking Water Supply and Sanitation Decade
INEC	-	Independent National Electoral Commission
IPCC	-	Intergovernmental Panel on Climate Change
ITCZ		Inter Tropical Convergence Zone
ITD	-	Inter Tropical Discontinuity
IUCN	-	International Union for Conservation of Nature and Natural
IWMI	-	International Water Management Institute
LEEDS	-	Local Government Economic Empowerment and Development
LGAs	-	Local Government Areas
MDGs	-	Millennium Development Goals
NAPAs		National Adaptation Program of Action)
NASRDA	-	National Space Research and Development Agency
NEEDS	-	National Economic Empowerment and Development Strategy
NGO	-	Non-Governmental Organization
NPC	-	National Population Commission
NRC	-	National Research Council
NWRI	-	National Water Resources Institute
RBDA	-	River Basin Development Authorities
		Resources
RUWASSA	-	Rural Water Supply and Sanitation Agency
RVAC	-	Regional Vulnerability Assessment Committee
SIWI	-	Stockholm International Water Institute

SSA	-	Sub-Saharan Africa
UN	-	United Nations
UN/ISDR	-	International strategy for Disaster Reduction
UNDESA	-	United Nations Development of Economic and Social Affairs
UNDP	-	United Nations Development Programme
UNEP	-	United Nations Environment Programme
UNESCO	-	United Nations Scientific c and Cultural Organization
UNFCCC	-	United Nations Climate Change Conference
UNHCR	-	United Nations High Commissioner for Refugees
UNICEF	-	United Nations Children's Fund
WCED	-	World Commission on Environment and Development
WHO	-	World Health Organization
WRI	-	Water Research Institute
WWAP	-	World Water Assessment Programme

ABSTRACT

Water supply is one of the world's most pressing issues of the 21st century and its scarcity and consequent stress is now the single greatest threat to human health, the environment, global food supply as well as economic and social development (IDRC, 2002). In Sub-Saharan Africa, domestic water use accounts for only 9% of consumptive water demands (WRI, 1994), but limited water availability to satisfy this need is a major concern in rural areas of the semi-arid zones especially in northern Nigeria. The study addressed the role of limited and insufficient knowledge on socio-economic, political and biophysical factors in vulnerability to water scarcity in Katsina State. Solutions to stated problems were expected to assist in determining the extent of vulnerability to water scarcity, differences in vulnerability to water scarcity, factors affecting adaptation to vulnerability and finally constraints in adaptation and adoption. The general hypothesis that was used to guide in achieving the study objectives was that the status of vulnerability to water scarcity does not vary from one rainfall zone to another within the Katsina State.

To realise the objectives of the study, a comprehensive review of literature on current research trends and methods in the field of vulnerability and adaptation to household water scarcity was conducted topically guided by the literature review, a conceptual framework was developed on which the study method was anchored. The data used in the study were mostly primary data on household characteristics, household water demand and water availability which were collected through field survey. In some cases, secondary data sourced from existing databases were used especially in dealing with households' numbers, rainfall distribution and spatial information. Field data collection procedure involved multi-stage sampling procedure guided by the three differentiated rainfall Zones of Katsina State while secondary data was collected purposefully. A total of 400 households were sampled from each of the three rainfall zones of the state totaling 1200 households plus 12 focus group discussions and 12 key informants. The resulting sample data were used in the computation of the Water Scarcity Vulnerability Index (WSVI) as a ratio of Household water availability (HHWA) to Household water demand (HHWD) for each rainfall zone to get the spatial extent of household vulnerability to water scarcity. This resulted into five categories of vulnerability to water scarcity and these were acute, high, moderate, low and no scarcity. The results of vulnerability computation together with adaptation strategies were subjected to descriptive and inferential statistical analyses as well as spatial analyses to provide measures of distribution tendencies, dispersions, differences and associations. The statistical techniques used included frequency analyses (tabulation and graphing), crosstabulation analyses, one-way ANOVA, chi-squares test and Kruskal-Wallis H-test. All the statistical tests were at α 0.05 (i.e. 95% level of confidence).

The results of data analysis established that across the three rainfall zones of the rural areas of Katsina State water availability per capita was 26 litres per day as compared to the UNDP, (2006) recommendation for Nigeria of 38 litres per day indicating general water scarcity condition. Further, the WHO (2003) estimation of water access was found to under estimate the water access problem in rural Katsina State because it did not take into account other households water demands other than the human needs. There was significant difference in per capita water availability and this difference was due to rainfall variability thus reflecting the general geography of water availability in Africa with a tendency to have water scarcity increase with the distance away from the equator especially to the north. The indicators of vulnerability to water scarcity in the study area included low levels in formal education, inappropriate training in managing water scarcity, high poverty levels, over reliance on nature for water supply, sharing of water sources with livestock and wild life, long distances to water sources and minimal government involvement in water supply.

Adapting to water scarcity in rural Katsina State tended to vary with rainfall and households characteristics and the strategies involved were generally with any difference being a chance event. Formal knowledge was found to play insignificant role in water scarcity adaptation strategies as compared to the role of traditional knowledge in the study area. The government role in water scarcity adaptation strategy was peripheral. There was general lack of government policy on adaptation to water scarcity in Katsina State. Water pricing which need to be guided by government policy was generally opposed by communities in rural Katsina State and this conformed to global picture on opposition to water pricing on the basis of human right. The socio-economic factors affecting adaptation to water scarcity were identified as high cost of modern technology, weak local technology, weak community organizations, weak formal institutions, low income levels, lack of social cohesion and poor health conditions.

Generally rural Katsina State, on the basis of water scarcity vulnerability index, was found to be water scarce and vulnerability largely depended on rainfall conditions but moderated by socio-economic characteristics of households. The study established that there was general low adoption and assimilation of development plans relating to water scarcity. It was recommended that there should be diversification of livelihoods, improvement of income levels through suitable income generating activities and, increased government involvement in activities that would be alleviating vulnerability to water scarcity.

CHAPER ONE: INTRODUCTION

1.1 Background to the Study

At the global level, the overall water cover gives the impression of abundance with about three quarters of the earth covered with water. But this is not true since 97.5% of the earth's water is contained in oceans with only 2.5% being fresh water in rivers and lakes (0.3%), ground water (1.7%) and the rest,(0.5%), frozen in icecaps, glaciers and atmosphere (IUCN, 2007). Water supply is one of the world's most pressing issues of the 21st century and its stress and scarcity are now the single greatest threat to human health, the environment, global food supply, as well as economic and social development (IDRC, 2002). In terms of water supply, the issue is not whether or not people have access to water since everyone has access to water in some form or another as it is impossible to live without water. The fundamental question is whether or not the water is within reasonable proximity, reliable, safe for consumption and sufficient to meet human needs (UN-HABITAT, 2003).

According to the World Health Organization and the United Nations Children's Fund rural water coverage in Africa was 45 per cent in 2000, compared to 40 percent in 1990, still leaving 237 million people unserved (WHO, 2000). Meanwhile, urban water coverage in Africa was much higher at 83 per cent in 2000, with only 37 million urban dwellers unserved. People expected to be mostly affected by water scarcity are those living in the remote rural areas in Africa among the nearly 1 billion rural inhabitants worldwide still lacking access to water (Ravenga & Cassar, 2002). Hence likely to be highly vulnerable to water scarcity related problems. In Nigeria, more than 90% of rural areas and 60% of urban areas face water related problems (ADF, 2007). It is clear that rural areas of Africa and in Nigeria particularly are lagging significantly behind urban areas in water supply. This fact, coupled with high poverty levels in many rural areas and depressed levels of service sustainability, indicates a critical need for focused attention to the domestic water scarcity vulnerability in rural communities in Nigeria, specifically Katsina State. This study, therefore, addresses domestic water scarcity vulnerability in the rural areas of Katsina State.

A more recent rainfall mapping in Katsina State carried out by El-Tantawi (2012) using rainfall records of (1942-2008) years across northern Nigeria identified three broad rainfall zones in Katsina State, the northern margin lie areas receiving rainfall of less than 700mm and to the southern lie areas receiving total annual rainfall above 900mm while to the middle lie areas that receive total annual rainfall of between 701mm and 900mm. As rainfall is one critical element that determines vulnerability of a community to water scarcity, Communities in the rural Katsina State, therefore, experience variations in total annual rainfall received as one move from southern to northern margins.

In Sub-Saharan Africa, domestic water use accounts for only 9% of consumptive water demands (WRI, 1994) but limited water availability to satisfy this need is a major concern in rural areas of the semi-arid zone as is the case in northern Nigeria (Nyong and Kanaroglou, 1999). Consequently, efficient water management is important to maintain the health and wellbeing of the household particularly in the rural areas. To establish the extent to which household use and manage water resources, issues related to water demand and availability need to be critically examined and this study was focused on issues relating to vulnerability and adaptation to domestic water scarcity to enhance understanding of the complex issues involved in global water governance.

The term vulnerability is commonly used to denote an aggregate measure of underlying conditions and was used in this study to determine water scarcity; the latter being the gap between water availability and demand. The term adaptation is used to refer to the characteristics of households in terms of their capacity to anticipate, cope with, and adjust from impacts of water scarcity.

1.2 Statement of the Problem

Katsina state is located at the northernmost margin of Nigeria, within a region that has variously been described as Sudano-Sahelian, semi-arid, arid and the Sahel (Gadzama, 1990; Sawa et al., 2010; Abdulkadir, 2011). The Sudano-Sahelian region is one of the most delicately balanced ecosystems in the world and faces several social and ecological crises including drought, desertification, pest invasion, high poverty rate and high population pressure on the land that make water supply issues very challenging. In addition, low development of water supply infrastructure has made clean and safe water supply unavailable in the region.

Water is predominantly a limiting factor and is an issue that cannot be ignored as recurrences of droughts and climate variability continue to affect many communities in sub-humid Africa. Water scarcity occurs both in space and time.Although studies on community vulnerability and adaptation have been conducted globally and specifically in Africa (Ribot, 1996; Downing, 1992; Nyong, 2003; Babugura, 2005; Zakieldeen, 2009; Ford, 2011 etc) most of the work were conducted on climate change and climate variability. The result is that there is generally limited knowledge on the ways in which socio-economic, political and biophysical factors heighten or weaken households' ability to cope with and adapt to water scarcity. Local knowledge, institutional arrangements and adjustment to livelihood options demonstrate the extent to which local households have adapted to water scarcity. However, how the households have coped and adapted in the past and whether these strategies have strengthened or weakened over time have not been studied before. Moreover which coping and adaptation strategies have been successful and how they can be improved on or made more effective to reduce households' vulnerability to the problem remain unknown.

For achieving sustainable development of human societies, there is always the need to ensure that the perspectives of the local households are known and accommodated in all programmes aimed at achieving the goals of development. Water scarcity is a key determinant of livelihoods of virtually all inhabitants of the semi-arid region of Nigeria and there is, therefore, need to understand the complex issues of how the households adapt to water scarcity in order to concisely determine the constraints that need to be addressed in ensuring that the strategies of coping and adaptation are in tune with achieving the goals of sustainable development. This study shall advance an understanding of vulnerability to water scarcity and associated adaptation strategies across the three rainfall zones in rural areas of Katsina State of Nigeria. In particular, the study sought answers to the following key research questions:

i) What are the characteristics of the households that are vulnerable to water scarcity and the extent of differences across the three rainfall zones in rural Katsina State?

ii) What are the major policies, economic and social determinants of households' vulnerability to water scarcity across the three rainfall zones of rural Katsina State?

iii) What adaptation strategies are used by households to mitigate vulnerability to water scarcity across the three rainfall zones of rural Katsina State?

iv) What are the constraints to these adaptation strategies that need to be addressed to enhance households' ability to adapt to water scarcity in the study area?

1.3 Study Objectives

The broad objective of the study was to assess the households' vulnerability to water scarcity across the three rainfalls in rural areas of Katsina State and the configuration of forces that shape their ability to adapt to the problem. In specific terms, the objectives of the study were:

i) To determine vulnerability to water scarcity and its extent in the three rainfall zones of rural Katsina State

ii) To identify and determine the hierarchy of adaptation strategies employed in adapting to the water scarcity in the three rainfall zones of rural Katsina State

iii) To determine the main factors affecting households' adaptation to water scarcity across the three rainfall zones of rural Katsina State

iv) To varify the constraints that need to be addressed in order to enhance households' ability to adapt to water scarcity in the study area.

1.4 Research Hypotheses

i) $H_0^{(1)}$ -- There are no differences of vulnerability to water scarcity among the households in the three different rainfall zones of rural Katsina State

ii) $H_0^{(2)}$ -- There are no differences in the specific determinants of vulnerability to water scarcity across the three rainfall zones in rural Katsina State

iii) $H_0^{(3)}$- There are no differences in the kinds of adaptation strategies employed by households to cope with water scarcity in the three different rainfall zones of rural Katsina State

iv) $H_0^{(4)}$ – There are no differences in the determinants of strategies of adaptation to vulnerability to water scarcity across the three rainfall zones of rural Katsina State.

1.5 Justifications for the Study

Rural areas in developing countries are often neglected in the provision of water facilities and where such facilities exist, they are seldom fully utilized (WHO, 1992). Reviews of existing literature have revealed limited research on households' vulnerability to water scarcity. This study was, therefore, expected to contribute much to addressing households' vulnerability to water scarcity and equally generate additional intellectual debate about policy directions and implementation if the perceptions of the immediate communities toward vulnerability to water scarcity that were most affected were brought into equation. There would definitely be a great deal of insight to be gained from this where:

- First, the perception of the household toward water scarcity could expose the urgency with which the problem needs to be addressed.
- Secondly, the types of policies to be emplaced and the potentials for their effective implementation could be glimpsed from the perception of the household toward the subject of the policy.

It has been noted that public support or opposition to a policy is significantly influenced by the perception of the problem and how the policy affect the people (Leiserowitz 2006). In this study perception of the problem constituted core ideas and experience of local strategies and/or initiatives which could be adapted to solve water scarcity problems in rural communities in Nigeria and elsewhere in the African continent. This study took into account the views of the household, which for too long had been neglected, in dealing with important subject matters that affect them to ensure good governance in Katsina State. The results of this study were to provide better understanding of the challenges facing the household of the rural Katsina State with regard to vulnerability and adaptation to water scarcity. Further, the study was also to provide measures required in enhancing strategies that constrain vulnerability and adaptation to water scarcity thus, assisting, in policy making for water resources development in the State.

Synthesis of literature on climate change indicated that there were generally increased variations in precipitation characteristics every where, with wet areas becoming wetter, and dry and arid areas become more so (Dore, 2005). The reasons for increased variations in precipitation characteristics are many and one of which is changes in the major ocean currents especially the effect of El-nino and Southern Oscillation (ENSO) associated with evidence of an observed ‘‘dipole’’ pattern affecting Africa and Asia (Dore, 2005). Increasing global surface temperatures are very likely to lead to changes in precipitation and atmospheric moisture because of changes in atmospheric circulation, a more active hydrological cycle, and increases in the water-holding capacity throughout the atmosphere. These changing patterns call for renewed efforts for adaptation to climate change, as the changing precipitation pattern will also affect the regional availability of water and food supplies.

1.6 Operational Definitions of Terms

Vulnerability and adaptataion studies are replete with terms and definitions that overlap depending on the case study (Shreve, Costa, María Máñez and Kelman, 2014). The terms and concepts have been defined here as they apply to the present study.

Adaptation is the action or outcome in household that leads to better coping with, managing or adjusting to some changing condition related to water scarcity

Communities are electoral polling units each with an estimate of 200 households

Household Water Scarcity is the gap between household water demand and water availability, and expressed in percent.

Household Water Availability is the quantity of water that is available to household for meeting basic needs per day

Household Water Demand is thequantity of water required per household per day

Household is a social or economic unit consisting of one or more individuals, whether related or not, who live together and share both the pot and the roof

Perception is the act of apprehending by means of the senses or of the mind. It involves organization, identification and interpretation of sensoryinformation in order to represent and understand the environment. It depends on complex functions of the nervous system, but subjectively seems mostly effortless because this processing happens outside conscious awareness.

Rural is the remote area far away from the seat of government and having no infrastructural facilities, where the major economic activity was agricultural production.

Strategy is the method adopt for achieving a particular goal usually over a long period of time.

Vulnerability is the ability or inability of households to respond to, cope with, recover from or adapt to, any water scarcity stress.

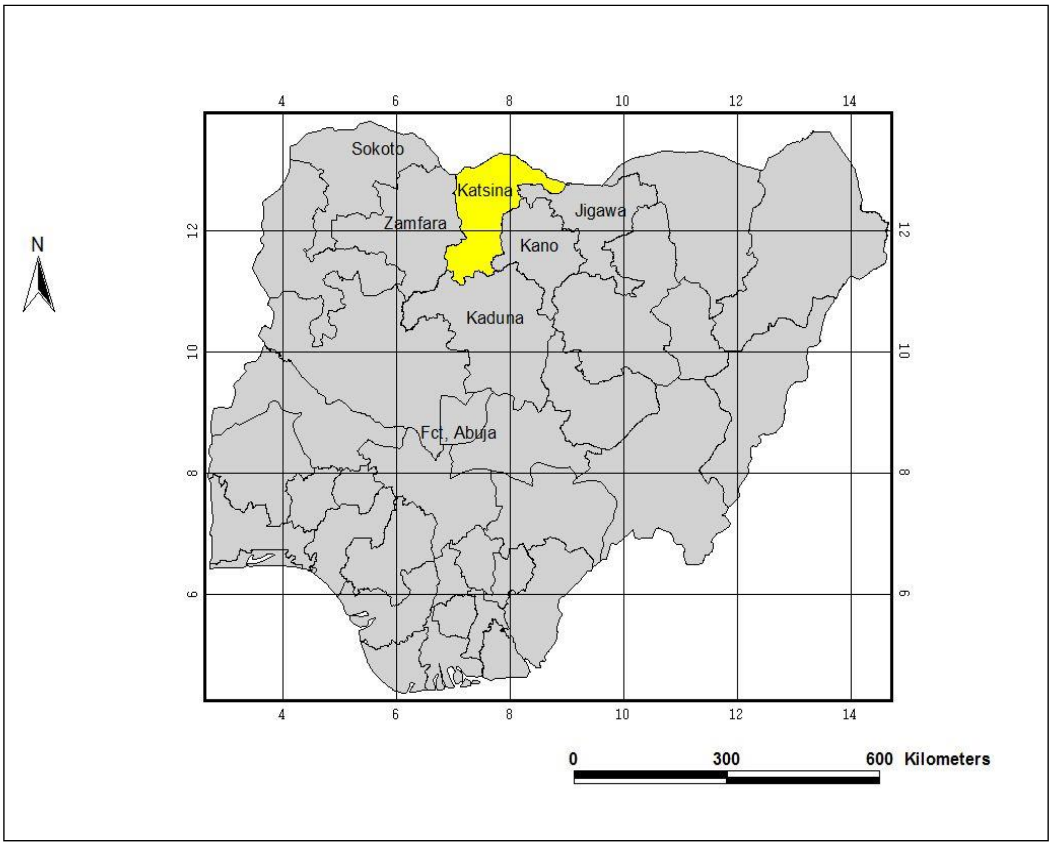
CHAPTER TWO: STUDY AREA

2.1 Physiography

2.1.1 Location and Size

Katsina State in Nigeria is located between latitudes 11°08'N and 13°22'N and longitudes 6°52'E and 9°20'E, covering an area of 23,938 sq km. The State is predominantly rural and shares border with Niger Republic to the north, Jigawa and Kano States to the east, Kaduna State to the South and Zamfara State to the West. Figure 2.1 gives the location of Katsina State within Nigerian Federation.

Figure 2.1: Location of Katsina State within Nigeria



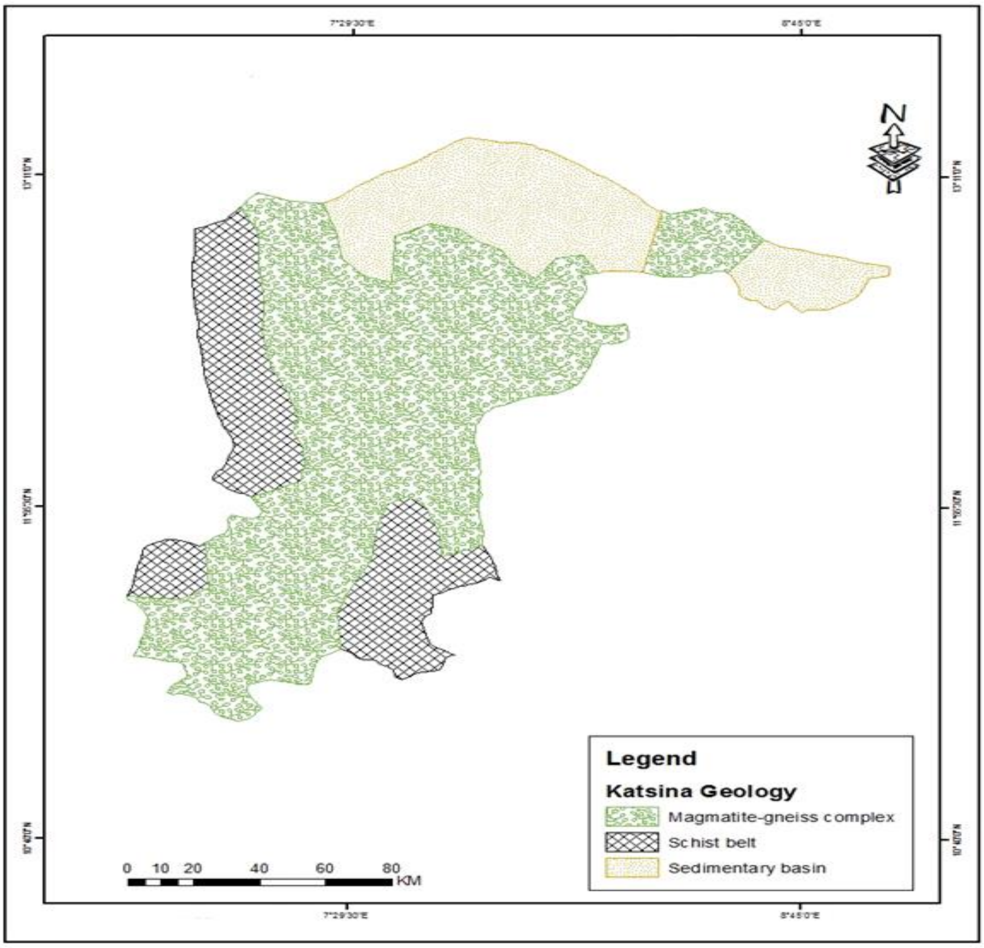
2.2 Geology

Figure 2.2 give the major geological formations of the study area. There are two broad geological formations in the study area namely Basement Complex and Sedimentary Formations. The Basement Complex is sub-divided into Migmatite Gneiss Complex and Schist Belt and accounts for over 80% of the total area of the state.Of the two sub-divisions, the Migmatite Gneiss Complex, dated Archean to Early Proterozoic

(2700-2000 Ma), is the most widespread in distribution across the state. The Migmatite Gneissic–quartzite complex according to Oyinloye (2011) evolved through 3 major geotectonic events:

i) Initiation of crust forming process during the Early Proterozoic (2000Ma)
ii) Emplacement of granites in Early Proterozoic (2000Ma) and
iii) The Pan African events (450Ma-750Ma).

Figure 2.2: Major Geological Formations of Katsina State



Source: (NASRDA, 2013)

The second, Pre-Cambrian rock types (schist belts) are mainly faulted and weakened medium to coarse grained foliated rock, with low capacity to hold water in ground layers. Thus, their aquifers are not economically viable to be subjected to high-water yielding exploitation. The Crystalline rocks of the Basement Complex which are typically associated with poor aquifers because the extent of weathering, fracturing and erosion is generally limited (Offodile, 2003) and hence produce low water yield. Solid rocks of the Basement Complex have porosities ranging from 1 to 3 per cent.

Permeability is also small because the pores are small and disconnected (Offodile, 2003). On the other hand, the distribution of the Sedimentary Basin formation is restricted to the northernmost tip portion of the study area.

Although folds, faults, joints and shear zones are common, they are too localized to be of significant importance as aquifers. Because of these, groundwater development through borehole construction has remained largely limited (Offodile, 2003). This result into low success ratio of previous borehole programmes in the Nigeria's Basement Complex. Water engineers in the country think the Basement Complex is not a suitable source of groundwater supplies. Consequently, several dams of different sizes have been constructed across the state (Figure 2.4). It could, however, be seen from Figure 2.4 that almost all the dams constructed across the state are within the Basement Complex geological formation. Basement Complex rocks are neither porous nor permeable except in areas where the rocks are cleaved, shattered, jointed, fissured or weathered. In places where aquifers exist across the state, groundwater is exploited artificially through wells, boreholes and many hand dug wells, an indication of considerable water available underground in the state. The areas of Sedimentary Basin are underlain by Sedimentary rocks of Cretaceous and lithologically consist largely of coarse and mottled feldspatic grits which favours formation of aquifers at deep ground layers with wells giving reasonably good yields.

The bulk of Katsina State is located within the Crystalline area and only at the northernmost tip of the state is Cretaceous Sediments. The Crystalline (Basement) hydrogeological zone has moderate to high gradient (implying higher potential for runoff), low permeability (implying lower rate of groundwater recharge). The above conditions favour high risk of water loss to runoff and low potential for groundwater accumulation. High potential water loss through runoff will imply that much of the rains received will be lost from upland to rivers and little will eventually permeate down the lower layers of the earth to add to groundwater reservoir. On the other hand, the Cretaceous Sediments area has moderate runoff, moderate gradient and moderate permeability implying that it has a comparatively better potential for groundwater accumulation than the other zone. This again confirms that the bulk of the study area is associated with hydrogeological conditions that do not promote high groundwater potential. Not surprisingly, the focus on medium and large-scale town-level water resources development has been on harnessing surface water potential by means of construction of dams of various sizes across the State.

2.3 Climate

Katsina state has a type of climate that can be identified as ‘AW’ using Koppen’s climatic classification. It is a tropical climate type with a clear wet and a dry season. The coolest month is normally experienced between December/January with temperature of less than 18^0C. The dominant climatic influence throughout the area is the Inter- Tropical Convergence Zone (ITCZ), also known as the Inter Tropical Discontinuity (ITD). It is a mobile zone where two opposing air masses meet and follows the apparent movement of the sun, North and South of the equator (Rowland, 1993). The Tropical Continental Air Mass (CT) and the Tropical Maritime air mass (TM) are the two dominant air masses that influence the climate in the study area. The CT air mass is a large body of dry and hot northeasterly air that originates from the Sahara desert (locally known as the *harmattan*), and is accompanied by marked diurnal temperature fluctuations. It blows between the months of November and January across the study area. To the south of ITD zone is the TM which originates from the Atlantic Ocean and produces winds that move mainly northwards, and are characteristically warm and moist. This air mass is responsible for the rainy season in the study area between the months of June and October while the dry season is caused by CT.

A year in the study area is divided into four seasons based on the prevalence of particular climatic elements at a particular time and the farming activities (Mohammed, 1994). These seasons are;

(a) “Bazara”

It is a period before the rain starts. It is the hottest period of the year and a transitional one between the *harmattan* and the wet seasons. The mid-day air temperature can be well over 40^0C.

(b) “Damuna”

This is the rainy season that lasts between 4 to 5 months with single rainfall maximum in the month of August. There are variations in terms of the rainfall duration and intensity between the villages. The average temperature is warm. It is the period of intensive rain-fed cultivation, the most important season in the life of a farmer.

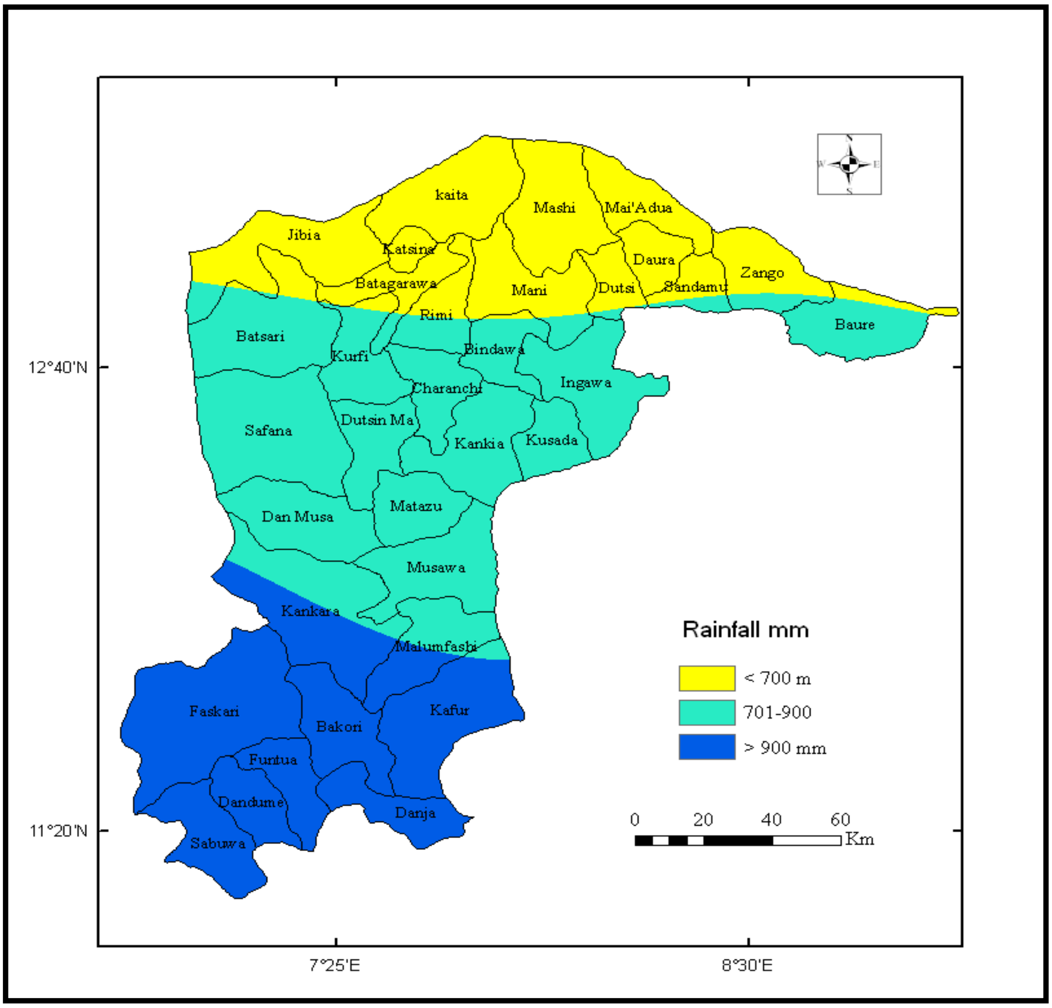
(c) "Kaka"

This is the period immediately after the rains. It is crop harvest season, a good period to farmers with a successful harvest. If the harvest is on millet, it is called 'kakargero' meaning the season of millet. If it is on sorghum, it is called 'kakardawa', the season arrival of new sorghum. This period coincides with the onset of cold, dusty and dry weather called the harmattan.

(d) "Rani"

This is the dry season. It is a period with very less or no farming activities.

Figure 2.3: Rainfall Zones and Local Government Areas of Katsina State



Source: (El-Tantawi, A; 2012)

2.3.1 Rainfall Variations

A very marked relationship between rainfall and latitude has been identified in the whole of West Africa, with annual rainfall total decreasing with increase in latitude. Kowal and Knabe (1972:70-93) used data from over 50 rainfall stations throughout the whole of Nigeria. Their analysis and computation showed that latitude correlates significantly with all major parameters of rainfall and in higher latitudes rainfall deficit becomes more pronounced. They computed a high negative correlation (r = 0.77) between rainfall and latitudinal position in northern Nigeria, signifying that the higher the latitude the less the rainfall. In semi-arid parts of northern Nigeria (where Katsina State is located), Mortimore (1991) noted that the ITD advances steadily northwards until about August when it halts and begins to retreat southwards, while the humid maritime air mass advances northwards and increases in depth causing rainfall to also increase. The onset of the rains in the northern Nigeria generally varies between March in the South to mid-July in the extreme North, while the effective rainy days vary from 60 to 200 days in length. On the other hand, rainfall cessation dates vary between September in the north and the end of October in the South (Mortimore, 1991). Rowland (1993) indicated that the dry season in this area is between nine to ten months long (from October to July).

In line with the latitudinal pattern of rainfall variation, there are three broad rainfall zones in Katsina State (El-Tantawi, 2012) as indicated in Figure 2.3. It could be seen from the Figure that while rainfall figures in the southern zone are above 900m, they vary between 700 and 900mm in the central zone and are less than 700mm in the northern zone. As rainfall significantly influences water budget of a catchment, this marked decreasing variation is to be associated with reduction in runoff and groundwater recharge as one move from southern to northern zones of the study area. Similarly, the seriousness of water scarcity crisis will increase as one move from south to northern margins of the study area. However the extent to which this is really so remains largely unknown due to inadequate research investigations on it.

2.3.2 Temperature Variations

Nigerian Meteorological Agency (NIMET 2010) has carried out a long-term (1958-2008) synthesis of temperature changes over Nigeria. The mean monthly dry season temperatures are above 30^0C while in the July to September temperatures are about 22^0 to 28^0C prevail. Mean maximum temperatures ranged between 31.1^0– 42.6°C during the hot season. They also observed that warmer than normal maximum temperatures prevailed with high positive values ranging between 1.9^0 and 2.9°C. Monthly minimum temperatures ranged from 11.1^0 - 19.2°C. Minimum temperatures during January are 0.5^0 – 1.5^oC warmer than normal over the period of record. Also, the minimum temperatures in December indicated colder than normal conditions. Likewise, the temperatures were 0.5^0 – 2.7^oC warmer than normal conditions. These clearly indicated that not only are temperatures high throughout the year in Katsina State, but the temperatures have also been increasing overtime suggesting increasing dryness overtime across the area.

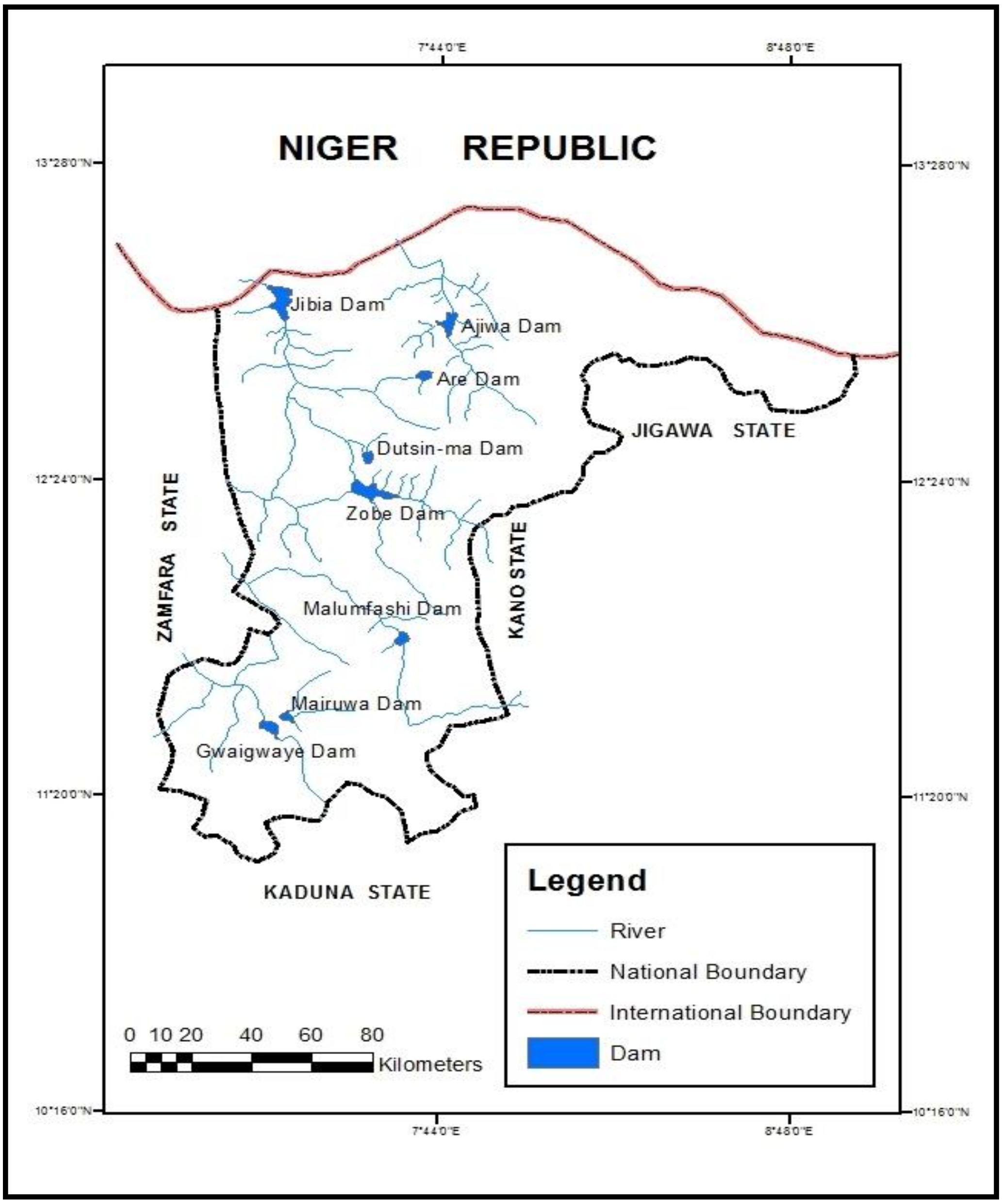
2.3.3 Evapotranspiration

Evapotranspiration across the study area is high throughout the year. Reflecting higher temperature pattern and long daily sunshine duration of 7-8 hours (Oguntoyinbo, 1983), This also causes surface water (rivers and ponds) to dry-up within short time after rainfall cessation and this situation aggravates water scarcity since water supply infrastructure (wells, boreholes and pipe-borne water supply) are not available for most rural dwellers which makes them to rely heavily on surface water sources in meeting their demands. Evapotranpiration also increases northwards compared to the southern part of the State.

2.4 Rivers and River Systems

Two major river systems, namely, the Niger, to the northwest of the region and Chad system to the northeastern part with headwaters River Sokoto-Rima to the northwest and River Kano-Hadejia to the northeast in Katsina State. The bulk of river flow is conveyed by relatively smaller streams that tend to dry up almost after rains stop. There are no major rivers within Katsina State except for the few mainly seasonal streams.

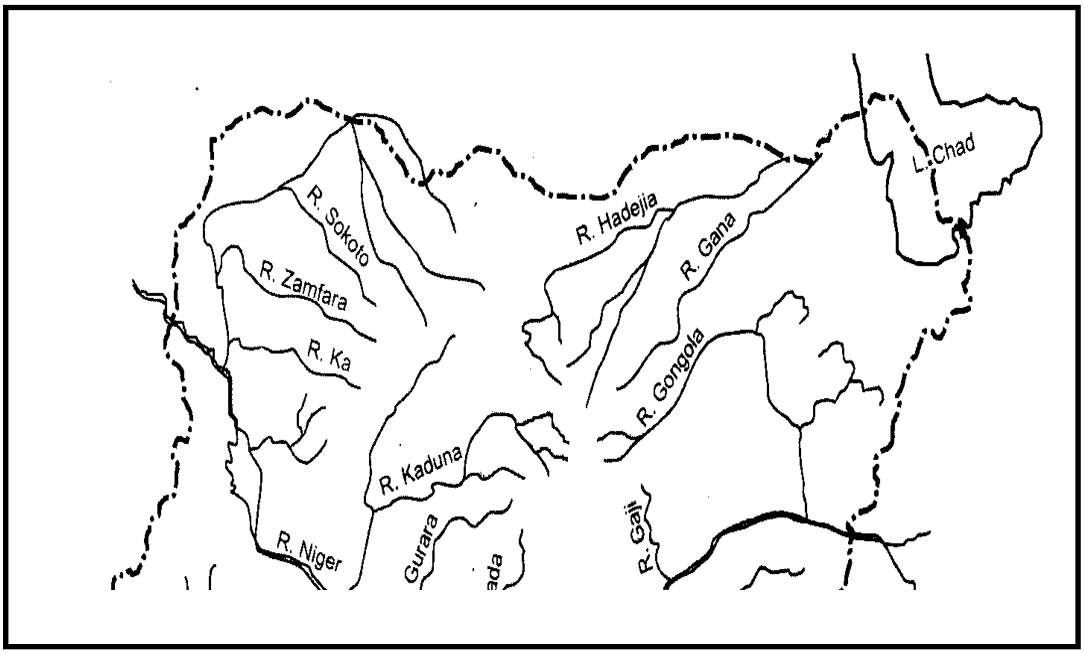
Figure 2.4: Major Drainage and Surface Water Resources of Katsina State



Source: (NASRDA, 2013)

Martins (1995) indicate that even the Sokoto-Rima River and Kano-Hadejia River Basin systems have low annual flow regimes. Estimated annual surface runoff of the two river systems has been put at 0.63 x $10^9 m^3$.

Figure 2.5: Major Rivers in Northern Nigeria with their Headwater in Katsina State



Source :(NASRDA, 2013)

The river discharges are low water flowing in months of June and October. The difference between minimum and maximum discharge could typically be very wide averaging 1:13 per year (Martins and Probst, 1991). The rivers depict bi-modal hydrograph and peak discharges which occur in July and September (Martins and Awokola, 1996). The generally low annual streamflow regimes of the rivers in the state are further compounded by high rate of siltation due to high erodibility of soils of the area and high rainfall erosivity (Mallo and Mgbanyi, 2013). Major rivers of Katsina state include the Koza, Sabke, in the north, Tagwai and Gada systems in the central of the state and in the south include the Karaduwa, Bunsuru, Gagare, Turami, Sokoto, Tubo, Chalawa and Galma rivers. All the river systems in the State, however, contain water in their channels only during the rainy season and have little or no water in the dry season, an indication of magnitude of water scarcity problem in the area. Rivers, Gada, Karaduwa, Tagwai, and Sabke have been dammed mainly for irrigation and domestic water supply (Figure 2.5).

2.5 Soil and Landuse

The soils of the state are classified as Typic Alfisols according to the USDA Soil Taxonomy and are described as generally loose and sandy (and hence highly erodible). They are well drained with low water retention (because Kaolinite is the dominant clay mineral), do not expand when in contact with water, it has low base therefore the saturation is low (largely due to the loss of exchangeable cations through leaching and are hence largely acidic in reaction). The soils are generally low in organic matter due to low vegetation cover and high oxidation of organic matter due to high temperatures (which also makes them to be, less cohesive and less resistant to erosion). The above properties of the soils make them to be highly erodable and this leads to generation of high rate of sediment transport during rainy season which leads to silting up of surface water bodies. This high rate of siltation results into loss of storage reduced ability to serve as water reservoirs.

Despite their low productive potentials, the soils of the state are put into productive agricultural use as farmers' subject them to heavy use of soil amendment (animal manure, organic fertiliser and urban waste). Also despite the low vegetation cover on the soils, they are put into intensive grazing though the practice is more pronounced in the central zone of state due to the process of a large forest reserve known as '*Dajin Rugu*' (*Rugu* meaning Forest). Due to high rate of livestock keeping among the residents of the state, pressure on little water supply sources was exerted by human beings and livestock, thus increasing vulnerability to water scarcity.

2.6 Socio-Economic Characteristics

2.6.1 Population and Demography

Nigeria's population is estimated to be 164 million in 2011 (based on annual growth rate of 3.2% from the 2006 Census of 140 million), spread over the landmass area of 923,768 km2 (NPC, 2006**).** The 2006 population census recorded population of Katsina State at 5,801,584 of which the main ethnic groups are the Hausa and Fulani. The latest national census in Nigeria was held in 2006. Of the 6 geopolitical zones that made up the country, the northwestern region (within which Katsina state is situated) accounts for 27.27% of the total population of the country (with 39,915,467 people) which is the highest, with the second highest region (southwest region) accounting for about 19% of the country's total population. These thus show that the northwestern region is the most populous in the country. Within the region, Katsina State had 3,753,133 people as at the 1991 census and 5,801,584 as at 2006 census. Using national growth rate of 2.76%, this figure was projected to 6,528,336 as at 2010 and 7,216,152 as at March 2014. Katsina State ranks as the 3rdmost populous State in the northwestern region of Nigeria (Census, 2006).

Further demographic analysis of the population of Katsina State also reveals that though the State wide population density figure was estimated by the NPC (2006) at 277.1 person per square kilometer (the second highest in the northwestern region of Nigeria), the density figure is highest in the southern zone (360 person per square kilometer) and least in the northern zone (207 person per square kilometer) while the central zone has 246 person per square kilometer. About 70% of the population lives in rural areas of which about 53% are females and 47% male. The urban population is concentrated mainly at the headquarters of the local government areas where incidentally the major social infrastructural facilities (schools, hospitals, electricity and water supplies) are concentrated.

According to the 2006 Population Census, across the countryone-third of the elderly population is still between ages 60-64, and two-thirds were aged 65 years and above. The oldest of the old were 10 percent of the total population 60+. With regards to sex composition of the elderly population, there were still more males than females in all age groups 60+, only 44 percent were females. The total sex ratio was 126, meaning that for every 100 elderly females, there were 126 elderly males. This ratio vary with age, the highest ratio was still at age 70-74, where, for every 100 elderly females, there were about 136 males.

Size of Households according to the National Demographic Household Survey NDHS, conducted by the National Bureau of Statistics in 2010, fertility remains high in Nigeria. At current fertility levels, Nigerian women will have an average of 6 children by the end of their reproductive years. The total fertility rate may actually be higher than 6.0, due to underestimation of births. In a 1981/82 survey, the total fertility rate was estimated to be 5.9 children per woman. A baseline survey of communities across the local government areas of the state conducted by the Katsina

State Community and Social Development Programme (a World Bank Assisted Project) indicate that household sizes vary between 3 and 36 persons, with most communities have average household sizes of above 5. Expectedly, local government areas in the southern zone have comparatively higher household sizes than those in the central and northern parts. Detailed age profile of the households revealed that about 5.2% were above 60 years of age, 32% were between 40 and 64 years, 23% between 20 and 39 years and about 38% are below 20 years of age. The small percentage of the elderly among the total population is not unexpected since Nigeria's population is demographically referred to as a "young" population (NDHS data and NPC, 2008).

2.6.2 Poverty Profiles of the State

The 2013 Katsina State CSDP survey report also revealed high incidence of poverty among the rural communities of the State. The report revealed that poverty level varied between about 54.4%-69%. Absolute Poverty, defined in terms of the minimal requirements necessary to afford minimal standards of food, clothing, healthcare and shelter was found to be above 60% in all the communities surveyed. For the-Dollar-per-day measure (referring to the proportion of those living on less than US$2 per day poverty line), the survey found out that about 50% of the people in the southern and up to about 70% in the northern parts of the state were living below US$2 per day.

2.6.3 Employment and Economic Activities

There many definitions of urban areas, but in most cases the word ***Urban*** is used to refer to all territory, population, and housing units located in places with a population of 2,500 or more. Accordingly therefore, **rural** is any territory that is not urban. In general, a rural area is a geographic area that is located outside cities and towns (Yen, 2011; Chigbu, 2012).

Different countries have varying definitions of "rural" for statistical and administrative purposes. In the literature however, the major features used to differentiate rural from urban areas are:

i. Low population density
ii. Large proportion of the population engaged in agriculture and/or primary production activities

iii. Lack or absence of industries and where they are found, are basically of cottage types
iv. Underdevelopment of various infrastructures.

In Katsina State, the Nigeria's Independent Electoral Commission undertook an enumeration of the settlements across the 34 Local Government areas of the State for the purpose of demarcating electoral areas and units. The results of the exercise (INEC, 2011) indicate that there are 5,363 settlements (communities) of which 34 are LGA Headquarters and the rest are settlements of various household sizes. The 2006 census of the country indicated that household sizes of the 34 LGA Headquarters vary between 1,426 and 6,982 (NPC, 2006). It was thus estimated that the population of LGA Headquarters in the State varied between 5,704 and 27,928 which characteristically qualified them as urban in nature. The household's sizes of all the remaining settlements were given as between 14 and 548. This means that when one excludes the 34 LGA headquarters whose estimated populations ranged between populations over 5,000 to about 28,000 which by the above definitions are classified as urban, then all the remaining settlements in the State are classified as rural.

The 2013 baseline survey of the Katsina State CSDP indicated that a majority of the elderly across the state were in agricultural labour force, working to produce livestock and crops for food and cash and thus contributing to national income. In relative terms, the elderly contributes more to agricultural production than other groups. This high rate of labour force participation is contrary to popular perceptions of the elderly as being largely retirees, and inconsistent with what simple demographic indices such as the dependency ratio implyTwo-thirds of all elderly persons were in the labour force, most elderly men, and some percentage of elderly women.

While the farming is undertaken by both Hausas and Fulanis, with Hausas being more into the farming activity, livestock grazing is done almost exclusively by the Fulanis who keep livestock for both themselves and on behalf of the Hausas. The Fulani are primarily settled or semi-settled cattle herders, with some limited crop production activities while the Hausa are largely crop cultivators, but often keep some animals. Livestock holding vary greatly but typically a Fulani keeps between 10 and up to 100 heads of cattle, sheep and goats. In most cases, difffierent individuals, both Hausas and Fulanis contribute livestock together to a singly Fulani to help keep and graze on their behalf. The major economic activities of the people are hence farming, livestock rearing and marketing of agricultural products. As water is a scarce commodity in the state, such activities were no doubt expected to be aggravating water scarcity problems in the State.

2.6.4 Urbanisation

Available data on urbanization in Nigeria is largely conflicting (Gould 1995; Adepoju 1995; Oucho 1998). Abiodun (1997) opines that such data constrains effective discuss. UN-Habitat and the World Bank are the most frequently cited sources of urban population statistics. However, their data are sometimes misleading and appear exaggerated as opined by Potts (2012). In Nigeria, virtually every census since 1952 has been highly contested (Potts, 2012).

The total number of 34 headquarters of local government areas of the State can be regarded as truly associated with urban characteristics. It is only in these areas one can find households' members that are employed in the formal sector, but even then most are engaged in small businesses on a subsistence basis. Home-based enterprises in this case play an important role in contributing to households' incomes, and providing some level of social protection. Incomes in the informal settlements of these 'cities' are thus low, intermittent and uncertain. This is compounded by very few opportunities for formal sector employment, the manufacturing sector, and private sector formal employment.

Thus, many residents of such 'cities' are involved in "multiple livelihood strategies", as they are compelled to employ diversified means of income generation through the acquisition of additional jobs. This practice is not only limited to those in the informal sector, but also by even those sections of the population dependent on fixed wages. As a result, the informal sector is no longer the preserve of the poor, but also includes professionals, administrators and other highly ranked formal sector employees.

In Katsina State, none of the 34 LGA Headquarters (which are classified as urban based on their population sizes) presently has an uninterrupted municipal water supply. In particular, it is only in Katsina town (which is the Headquarters of the

State), and some other LGAs that are connected with pipe borne water supply. Unfortunately, in none of these LGAs do households receive uninterrupted water supply. It is infact not uncommon for many households to go up to six months in a year without seeing a single drop of water coming through the municipal water supply pipes to which they are connected. Most households across the 34 main urban areas of the state therefore are left with no option than to rely on alternative water supply sources, especially wells and boreholes (both household-owned and community-owned). Infact, water vendoring (sales of water by vendors using push trucks) is a very common occupational activity and water selling points are common features across the 34 urban areas of the state. Thus, households in urban areas of the state cannot be said to be non-vulnerable to water scarcity but however the degree of their vulnerability may not be as much as those of rural households as water selling points and water vendoring, in addition to several wells and boreholes, can to some large extents be providing some relief to the households in addressing water scarcity problems in urban areas of the State.

CHAPTER THREE: LITERATURE REVIEW AND CONCEPTUAL FRAME WORK

3.1 Introduction

The literature review provides useful conceptual and practical links, which were used in constructing the methodology and interpretation of the results in this study. This chapter consists of the literature review and conceptual framework where literature review begins with theoretical literature and then empirical literature to underpin the problem of vulnerability to water scarcity as concerns the study. The organization of the literature review is such that there is logical topical sequence that eventually leads to conceptual framework of the study and study hypotheses.

3.2 Conceptual Definitions of Vulnerability

A formal definition of vulnerability draws upon concepts in epidemiology, comparative statics in economics and risk mapping of hazards. For long, several research workers have critically reviewed the contextual usage of the term vulnerability (Chambers 1989; Downing 1991; Drèze and Sen 1989; Mortimore 1991). The term then evolved into the disaster management thinking culminating in to the Disaster Risk Reduction Strategies (UNISDR, 2004).

The World Conference on Disaster Reduction (WCDR) was held from 18 to 22 January 2005 in Kobe, Hyogo, Japan, and adopted the ‘‘Hyogo Framework for Action 2005–2015’’ that underlined the need to promote strategic and systematic approaches to reducing vulnerabilities and risks to hazard (UN, 2005). The Framework stresses the need to develop indicators of vulnerability as a ‘‘key activity’’ at national and sub-national scales that will enable decision-makers to assess the impact of disasters on social, economic and environmental conditions and disseminate the results to decision makers, the public and populations at risk (UN, 2005). Although the international community does not formulate guidelines on how to develop indicators or indicator systems to assess vulnerability, the Hyogo Framework for Action underlines the fact that impacts of disasters on social, economic, and environmental conditions should be examined through such indicators.

There is no universal definition of vulnerability but various disciplines have developed their own definitions and pre-analytic visions of what vulnerability means. Schneiderbauer and Ehrlich (2004) and Thywissen (2006), provided a preview of the various definitions of vulnerability.Birkman (2006) argued that vulnerability is still a paradox when it comes to measurement since there is no precise definition. Vulnerability is a concept that evolved out of the social sciences and was introduced as a response to the purely hazard-oriented perception of disaster risk in the 1970s (Schneiderbauer and Ehrlich, 2004: 13). Since the 1980s, the dominance of hazard-oriented prediction strategies based on technical interventions has been increasingly challenged by the alternative paradigm of using vulnerability as the starting point for risk reduction. This approach combines the susceptibility of people and communities exposed with their social, economic and cultural abilities to cope with the damage that could occur. IPCC (2001) defined 'vulnerability' as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. ISDR (2004) defines vulnerability as:

> *the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards*.

In contrast, UNDP (2004:11) defines vulnerability as:

> *a human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard*.

While the definition of vulnerability used by the ISDR encompasses various conditions that have an impact on the susceptibility of a community, the UNDP definition considers vulnerability as a human condition or process. The human-centred definition used by UNDP affects the method used to calculate its Disaster Risk Index, especially with regard to the calculation of relative vulnerability (UNDP, 2004: 32). The Disaster Risk Index measures the relative vulnerability of a country to a given hazard by dividing the number of people killed by the number of people exposed. Using the number of the people killed divided by the number of the people exposed as the indicator to measure relative vulnerability corresponds with the understanding that vulnerability is primarily a human condition. Furthermore, the lack of appropriate data at the global level has restricted UNDP's opportunities to establish a broader index.

Although human society is the main focus of concepts of vulnerability, a fundamental question Turner et al., (2003) raises is on whether human vulnerability can be adequately characterised without considering simultaneously the vulnerability of the ''surrounding'' ecosphere? Cannon et al. (2003) on social vulnerability argue that social vulnerability is much more than the likelihood of buildings collapsing and infrastructure being damaged and that social vulnerability is a set of characteristics that includes a person's initial well-being; livelihood and resilience; self-protection; social protection and; social and political networks and institutions. This latter view (Cannon et al, 2003) reflects the fact that vulnerability is only partially determined by the type of hazard and is mainly driven by precarious livelihoods, the degree of self-protection or social protection, qualifications and institutional settings that define the overall context in which a person or a community experiences and responds to the negative impact of a hazardous event. It is important to note that the concept of social vulnerability also lacks a common definition (Adger, 2003, Weichselgartner 2001).

3.3 Adaptation

3.3.1 Meaning of Adaptation

Definitions of adaptation may be found frequently in the climate change and climate variability literature (IPCC, 2001; Smit *et al.*, 2000; Burton, 1997). Adaptation is an important approach for protecting ecological, social and economic systems, and may be seen to enhance the resilience of vulnerable systems and reduces the risk of damage to human from the impact of water scarcity. The term adaptation, as it is presently used in the global change field, has its origins in natural sciences, particularly evolutionary biology. Although the definition of adaptation in the natural sciences is disputed (IPCC, 2001) and it broadly refers to the development of genetic or behavioral characteristics which enable organisms or systems to cope with environmental changes in order to survive and reproduce (Futuyama, 1979; Winterhalder, 1980; Kitano, 2002). Individual adaptations (or adaptive features) are the features of organisms which have developed to ensure survival (Dobzhansky et al, 1977; O'Brien and Holland, 1992). Consideration of adaptation within natural sciences encompasses scales from the organism or individual to the population of a single species or an entire ecosystem (Krimbas, 2004).

The application of the term adaptation to human systems has been traced to the anthropologist and cultural ecologist Julian Steward, who used ‘‘cultural adaptation’’ to describe the adjustment of ‘‘culture cores’’ (i.e. regional societies) to the natural environment through subsistence activities (Butzer, 1980; O’Brien and Holland, 1992) define the process of adaptation as ‘‘one by which groups of people add new and improved methods of coping with the environment to their cultural repertoire’’. Denevan (1983, p. 401) considers (cultural) adaptation as a ‘‘process of change in response to a change in the physical environment or a change in internal stimuli, such as demography, economics and organization’’, there by broadening the range of stresses to which human systems adapt beyond biophysical stress.

Social science treatment of adaptation in human systems has been concerned with ‘‘success’’ or survival of a culture. Anthropologists and archeologists suggest that adaptationis a consequence of selection acting on variation through cultural practices (adaptations) which have historically allowed a culture to survive (O’Brien and Holland, 1992). Cultural practices are thus equated with genetic characteristics in the natural sciences; in this Darwinian view, a group which does not have adequate methods of coping with environmental stress will not be able to compete for scarce resources. In this treatment of the term, a cultural practice is an ‘‘adaptation’’ only if it developed to overcome stress, there by distinguishing adaptations from ‘‘adaptive features’’ that allow societies to function within their environments regardless of whether or not they evolved as a result of selection (O’Brien and Holland, 1992).

In more recent social science work, cultural practices that allow societies to survive (and, beyond that, flourish) are considered adaptive and can be distinguished based on behavior and (technological) innovation (Denevan, 1983). It is recognized that societies adapt to arange of stimuli including, but not limited to, environmental stress. Cultures (or societies) which are able to respond to or cope with change quickly and easily are considered to have high ‘‘adaptability’’ or ‘‘capacity to adapt’’ (Denevan, 1983).

3.3.2 Research Directions in Adaptation

The concept of adaptation has been used both explicitly and implicitly in the social sciences, including in natural hazards, political ecology, and the entitlements and food security scholarship. Some scholars of adaptation have employed the concepts and terminology of biophysical ecological change with a focus on flows of matter, energy and information (Odum, 1970) and related concepts of resilience, equilibrium and adaptive management (Holling, 1986). Others, particularly in the natural hazards perspective, have focused on perception, adjustment and management of environmental hazards (Burton et al, 1978). There are three bodies' research trends on adaptation discourse, namely, (a) adaptation and political economy and (b) adaptation options or measures to climate change stimuli, and (c) relative adaptive capacity of an object.

The first body of research assumes that adaptation is usually implicit in the political ecology field. The relationships between ecosystems and political economy are often treated as issues of adaptive management of risks related to political and social power relations, resource use, and global economies (Blaikie and Brookfield, 1987; Sen, 1981; Walker, 2005). First, work on entitlements and food security considers adaptation as astress response (stress response model) in light of access to resources and the abilities of people to cope (Downing, 1991; Adger and Kelly, 1999; Adger, 2000). A key feature of this field is its demonstration of how the adaptive capacity of individualsor households is shaped and constrained by social, political, and economic processes at higher scales. Similarly, research on global environmental risk and the social amplification of risk places adjustments and adaptations in the context of human driving forces, biophysical constraints and the social, economic and political attenuation of risks (Kasperson and Kasperson, 2001, 2005; Pidgeon et al, 2003).

The second model entails the conceptualizations of risks and their manifestation as disasters and includes the pressure and release (PAR) model (Blaikie et al, 1994; Wisner et al, 2004), identify the environmental stresses of hazards and the progression of social forces that contribute to vulnerability, including those that relate to adaptive capacity. This view of environment society coupled systems that specify the role of human adaptive responses is further developed in the vulnerability framework of Turner et al (2003) and the access model of Wisner et al (2004).

The third line of research is based on the analyses of adaptations in the climate change field that emerged concurrently with the growing awareness of climate change itself. An early example is Butzer (1980) who considered ‘‘cultural adaptation’’ (human ingenuity including technological innovation and long-range planning) in light of predicted climate change and its anticipated impacts on world food supply. Since then, analyses of adaptation to changing climatic conditions have been undertaken for a variety of purposes (Kelly and Adger, 2000; Smit et al, 2000).

One common purpose of adaptation analyses in the climate change field is to estimate the degree to which modeled impacts of climate change scenarios could be moderated or offset (or ‘‘mitigated’’) by ‘‘adaptation to the impacts’’ (Parry, 2002; Mendelsohn et al, 2000; Fankhauser, 1998). These analyses address Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), which commits countries to mitigate greenhouse emissions in order to avoid ‘‘dangerous’’ anthropogenic changes in climate. Adaptations are considered to assess the degree to which they can moderate or reduce negative impacts of climate change, or realize positive effects, to avoid the danger. These analyses are usually undertaken at broad scales, where equilibrium or statistical models are used to estimate impacts with and without adaptation, in order to address the question how serious or ‘‘dangerous’’ are specified scenarios of climate change (Dessai et al, 2003; Tubiello et al, 2000; Winters et al, 1998; Parry et al, 2001).

Smit and Wandell (2006) have argued that adaptations are conventionally assumed or hypothetical, and their effecton the system of interest is estimated relative to the estimated impacts (e.g. in terms of costs, savings, etc.). For this use, the focus is on the effect of the assumed adaptations. The purpose is to estimate impacts of climate change, and to estimate the difference adaptation could make. This work does not empirically investigate adaptations, examine the actual processes of adaptation or adaptive capacity, and explore the conditions or drivers that facilitate or constrain adaptations, or document the decision-making processes, authorities and mechanisms involved in adaptation. It takes certain assumed or hypothetical adaptations and then estimates the effects they would have on the calculated impacts of conditions captured in the specified climate change scenarios (Tol, 1996; Arnell, 1999). The term vulnerability has sometimes been used to describe the estimated net or residual impacts (initial impact costs minus net adaptation savings).

A second body of scholarship focuses on specific adaptation options or measures, for a particular system subject to climate change stimuli. These analyses address the articles of UNFCCC that commit countries to 'formulate and implement measures to facilitate adequate adaptation to climate change''. The purpose of these analyses is to assess the relative merit or utility of alternative adaptations, in order to identify the''best'' or better ones (Dolan et al, 2001; Klein et al,1999; Fankhauser et al, 1999; Niang-Diop and Bosch, 2004). The analysis involves selecting a suite of ''possible adaptations'', chosen by the researcher from hypotheses, observations, modeling, extrapolation, analysis, key informants or deductive reasoning. These possible adaptations are usually considered to be distinct and discrete, in order that they can be subjected to evaluation according to some common principles or criteria.

Among the tools used to rank or rate the relative merit of possible adaptations are benefit-cost, cost effectiveness and multiple-criteria procedures. Common variables employed are benefits costs, implementability, effectiveness, efficiency, and equity (Fankhauser et al, 1999; Feenstra et al, 1998; Smith et al, 1998; Adger et al, 2005a). Such analyses assume that there is, in practice, a process through which adaptations are selected and implemented, and that the relative evaluation analysis fits into this process. The focus of these studies is to rate or rank potential adaptations, but they rarely investigate the processes through which adaptation measures are undertaken, either in light of climatic change specifically (which is very rare) or as part of policy and decision-making processes to which adaptations to climate change might relate.

A third group of studies focuses on the relative adaptive capacity (or vulnerability) of countries, regions or communities, and involves comparative evaluation or rating based on criteria, indices and variables typically selected by the researcher (Van der Veen and Logtmeijer, 2005; O'Brien et al, 2004a; Adger et al, 2004; Brooks et al, 2005; Rayner and Malone, 2001). Essentially vulnerability is taken as the ''starting point'' rather than the residual or ''end point'' (O'Brien et al, 2004b), and it is assumed to be measurable based on attributes or determinants selected a priority. The expected application is that adaptation efforts should be directed to those areas with the greatest exposures or least adaptive capacity.

The main purpose of these third group of studies is to provide an evaluation of the relative vulnerability (and/or relative adaptive capacity) of the countries or regions, usually using some kind of indicator, scoring, rating or ranking procedure. Thus surrogate measures of exposure or sensitivity and elements of adaptive capacity for each system are estimated and then aggregated to generate an overall vulnerability ‘‘score’’ (or level or rating) for each system (Adger, 2006). The intent is to provide information for the targeting of adaptation initiatives, or the targeting of scarce resources. In this third type of research, the analyst selects the factors or determinants of vulnerability or adaptive capacity (sometimes with local inputs), obtains measures on these (usually aggregate surrogates from available secondary data), adopts an aggregation function over the measures (usually summation) and calculates an overall vulnerability value for each system. The purpose of the fourth type of analysis is to contribute to practical adaptation initiatives. Research that focuses on the implementation processes for adaptations is still not common; at least, it is not common under the label of ‘‘adaptation’’ research, and certainly not in the climate change field.

3.3.3 Application of Adaptation Studies

There is a vast body of scholarship in the fields of resource management, community development, risk management, planning, food security, livelihood security, and sustainable development that deals with the actual practices and processes of adaptation, although the word ‘‘adaptation’’ may not be explicitly used (Sanderson,2000; Gittell and Vidal, 1998; Alwang et al, 2001; Haimes, 2004). Since the term adaptive capacity is context-specific and varies from country to country, from community to community, amongst social groups and individuals, and over time, it varies not only in terms of its value but also according to its nature. The scales (households, community, or environment) of adaptive capacity are not independent or separate: the capacity of a household to cope with climate risks depends to some degree on the enabling environment of the community, and the adaptive capacity of the community is reflective of the resources and processes of the region (Smit and Pilifosova, 2003; Yohe and Tol, 2002).

Adaptive capacity has been analyzed in various ways, including via thresholds and ‘‘coping ranges’’, defined by the conditions that a system can deal with, accommodate, adapt to, and recover from (de Loe and Kreutzwiser, 2000; Jones, 2001; Smit et al, 2000; Smit and Pilifosova, 2001, 2003). Most communities and sectors can cope with (or adapt to) normal climatic conditions and moderate deviations from the norm, but exposures involving extreme events that may lie outside the coping range, or may exceed the adaptive capacity of the community. Some authors apply ‘‘coping ability’’ to shorter term capacity or the ability to just survive, and employ ‘‘adaptive capacity’’ for longer term or more sustainable adjustments (Vogel, 1998).

Watts and Bohle (1993) use ‘‘adaptability’’ for the shorterterm coping and ‘‘potentiality’’ for the longer term capacity. A system’s adaptive capacity and coping range (one feature of capacity) are not static. Coping ranges are flexible and respond to changes in economic, social, political and institutional conditions over time. For instance, population pressure or resource depletion may gradually reduce a system’s coping ability and narrow its coping range, while economic growth or improvements in technology or institutions may lead to an increase in adaptive capacity (deVries, 1985; Smit and Pilifosova, 2003; Folke et al, 2002).

Adaptations are manifestations of adaptive capacity. Or argued differently, changes in the system to better deal with problematic exposures and sensitivities reflect adaptive capacity. Clearly there are many forms and ‘‘levels’’ of adaptations, and these can be classified in many ways including by timing relative to stimulus (anticipatory, concurrent, reactive), intent (autonomous, planned), spatial scope (local, widespread) and form (technological, behavioral, financial, institutional, informational) (Smitet al, 2000; Wilbanks and Kates, 1999; Smit and Skinner, 2002; Huq et al, 2003). It is also possible to distinguish adaptations according to the degree of adjustment or change required from (or to) the original system (Risbeyet al, 1999). For an agricultural system facing water shortage exposures, a simple adaptation might be to use more drought resistant cultivars. A more substantial adaptation might be to shift away from crop farming to pastoralism. An even more substantial adaptation might be to abandon farming altogether (Zampaligre, Hippolyte, Schlecht, 2013).

The determinants of adaptive capacity are not independentof each other. For example, the presence of a strong kinship network may increase adaptive capacity by allowing greater access to economic resources, increasing managerial ability, supplying supplementary labor and buffering psychological stress. Similarly, economic resources may facilitate the implementation of a new technology and ensure access to training opportunities and may even lead to greater political influence. Individual determinants, thus, cannot be isolated adaptive capacity is generated by the interaction of determinants which vary inspace and time. The determinants of adaptive capacity exist and function differently in different contexts. For example, a strong kinship network may play an important role in a subsistence-based society and quite a different role in a developed world agribusiness context where financial and institutional structures will influence adaptability.

In general, as Smit and Wandell (2006) demonstrated, there is very little consensus for a robust, specific model of the elements and processes of local exposure, sensitivity, and adaptive capacity, beyond broad factors. These broad factors or determinants that influence sensitivities and constrainthe abilities of communities to deal with hazards or stressful conditions are too general guide in practical adaptation programs. Community-based analyses have shown that the conditions that interact to shape exposures, sensitivities, adaptive capacities, and hence create needs and opportunities for adaptation, are community specific. For example, the factor ‘‘technology’’ may be relevant in all cases, but the way in which technologies influence vulnerabilities and the types of technologies that may befeasible or available and how they interact with political, social and economic processes invariably differ from community to community.

3.4 Participatory Vulnerability Assessments

Some general principles are now apparent from community-based vulnerability assessments aiming to contribute to practical adaptation initiatives. One is that the researcher does not presume to know the exposure and sensitivities that are pertinent to the community, nor does the research specify a priori determinants of adaptive capacity in the community. Rather, in this approach these are identified from the community itself. The methods require the active involvement of stakeholders, considerable effort to ensure legitimacy, information collection on community relevant phenomena and processes, the integration of information from multiple sources, and the engagement of decision-makers.

Variants of participatory, ‘‘bottom-up’’, experience based assessment of community conditions have been employed in many fields including sociology, anthropology, geography, ethnography, risk assessment, rural development, international development and food security (Bollig and Schulte, 1999; Pelletier et al, 1999; Smith et al, 2000). In the climate change adaptation and disaster management fields, analytical frameworks very similar to these self assessments have been developed and some have been applied (Jones, 2001; Lim et al, 2004; Turner et al, 2003; Schroter et al, 2005).

Participatory vulnerability assessments allow for the recognition of multiple stimuli beyond those related to climate, to include political, cultural, economic, institutional and technological forces. Furthermore, the methodologies recognize the interaction of various exposures, sensitivities and adaptive capacities over time. What is vulnerable in one period is not necessarily vulnerable (or vulnerable in the same way) in the next, and some exposures and sensitivities (e.g. those recognized as‘‘creeping hazards’’ by Wisner et al, 2004) develop slowly over time. The approach recognizes that sources of exposures, sensitivities and adaptive capacities function across scales, from the individual to the national (Ford and Smit, 2004; Lim et al, 2004; and Va´ squez-Leo´ n et al, 2003).

The system of interest in this case is the community, but the analysis seeks to identify the broader conditions and structures within which the community functions. The exercise requires active involvement of community stakeholders. Researchers begin with an assessment of current exposures, sensitivities and current adaptive capacity, employing ethnographic incommunity methods (including such tools as semi-structured interviews, participant observation and focus groups), as well as insights from local and regional decision-makers, resource managers, scientists, published and unpublished literature, and other available sources of information. The aim of this analysis is to identify and document the conditions or risks (current and past exposures and sensitivities) that people have to deal with, and how they deal with these, including the factors and processes that constrain their choices (current and past adaptive capacity).

Once relevant conditions have been identified, and future livelihoods considered, information from other scientists, policy analysts, and decision-makers, are integrated into the analysis to identify potential future exposures and sensitivities (what conditions or risks the community may be facing) and future adaptive capacity (in what ways the community may potentially plan for or respond to these conditions) to determine future vulnerability. Opportunities to reduce future vulnerabilities are sought with community decision-makers, and representatives of other agencies with authority or influence. Experience to date has shown that the common adaptation practices involve modifying some existing resource management strategy, livelihood enhancement initiatives, disaster preparedness plan, or sustainable development program.

The goal here is not toproduce a score or rating of a particular community's current or future vulnerability. Rather, the aim is to attain information on the nature of vulnerability and its components and determinants, in order to identify ways in which the adaptive capacity can be increased and exposure sensitivities decreased. While adaptation options are evaluated in some way, the initiatives are rarely discrete stand-alone, exclusively climate change measures that areamenable to comparative scoring. Instead, adaptation initiatives tend to be incremental, modifying some existing water management strategy, disaster plan, and so on. This is commonly known as mainstreaming (Huq and Burton, 2003; Huq et al, 2003; Huq and Reid, 2004).

3.5 Vulnerability and Adaptation to Water Scarcity

3.5.1 Human Life and Water Requirement

Different sectors of society use water for different purposes. These include drinking, cooking food, removing or diluting wastes, producing manufactured goods, growing food, producing and using energy, and so on. White and Bradley (1972) have shown that the water required for each of these activities varies with climatic conditions, lifestyle, culture, tradition, diet, technology, and wealth. The type of access to water alone is an important determinant in total water use. In addition, the level of domestic water use varies with distance from the water source and with the climate (Gleick, 1996). The term “water use” encompasses many different ideas and is often misleading and confusing. Among other things it has been used to mean the withdrawal (intake) of water, gross water use (intake plus recirculation plus reuse), and the consumptive use of water.

Gleick (1996) used the term “withdrawal” to refer to the act of taking water from a source to convey it elsewhere for storage or use. Not all water withdrawn is necessarily consumed, however. Indeed, for many processes, water is often withdrawn and then returned directly to the original source after use, as in water used for cooling thermoelectric power plants. Gross water use is distinguished from waterwithdrawal by the inclusion of re-circulated water. Thus for many industrial processes, far more water is required than is actually withdrawn for use. The latter term, water consumption is the portion of water use that is not returned to the original water source. Water “consumption”or “consumptive use” is taken here to mean the use of water in a manner that prevents its re-use after being withdrawn, such as through evaporation, plant transpiration, contamination, or incorporation into a finished product and is no longer available for reuse. When the term water “use” is given, it refers to the amount of water required to meet a specific need or to accomplish a particular task. The new term "water footprint" is often used to refer to the amount of water used to produce goods and services to be consumed by an individual, community, business, or nation.

3.5.2 Water for Drinking

An absolute “minimum water requirement” for humans, independent of lifestyle and culture, can be defined only for maintaining human survival. To maintain the water balance in a living human, the amount of water lost through normal activities must be regularly restored. While the amount of water required maintaining survival depends on surrounding environmental conditions and personal physiological characteristics, the overall variability of needs is quite small. Routes for water loss include evaporation from the skin, excretion losses, and insensible loss from the respiratory tract. Humans may feel thirst after a fluid loss of only 1 per cent of bodily fluid and be in danger of death when fluid loss nears 10 per cent (ICRP, 1975).

Physiological studies prior to 1975 have generated "reference values" for a daily human water requirement. Minimum water requirements for fluid replacement have been estimated at about three litres per day under average temperate climate conditions. When climate and levels of activity are changed, these daily minimum water requirements can increase. In a hot climate; a 70 kilogram human will sweat between four and six liters per day without a. comparable change in food intake or activity (ICRP, 1975). The National Research Council of the National Academy of Sciences in the U.S.A. separately estimated minimum human water requirements by correlating them with energy intake in food. They recommend a minimum water intake of between one and one-and-a-half milliliters of water per calorie of food (1-1.5 ml/kcal). Note that a food calorie is equivalent to a kcal of energy.

According to Gleick (1996), the energy content of food will be represented by kcals. This does not include the water required to grow the food consumed, which is discussed later. With recommended daily diets ranging from 2,000 to 3,000 kcals, minimum water requirements are between 2,000 and 4,500 milliliters, or 2 to 4.5 liters per day (NRC, 1989). Using these data, Gleick (1996) set a minimum water requirement for human survival under typical temperate climates with normal activity at three litres per day. Given that substantial populations live in tropical and subtropical climates, it became necessary for Gleick (1996) to increase this minimum slightly, to about five l/p/d (litres/person/day), or just less than two cubic meters per person per year. A further fundamental requirementnot usually noted in the physiological literature is that this water should be of sufficient quality to prevent water-related diseases.

3.5.3 Water for Sanitation

There is a direct link between the provision of clean water, adequate sanitation services, and improved health. Extensive research has shown the clear health advantages of access to adequate sanitation facilities and protecting drinking water from pathogenic bacteria and viral and protozoa1 agents of disease. Effective disposal of human wastes controls the spread of infectious agents and interrupts the transmission of water-related diseases. According to some estimates, more than 1.7 billion people lacked access to adequate sanitation services in 1990, while over 1.2 billion people lack an adequate clean drinking water (Gleick, 1993). During the decade between 1990 and the year 2000, nearly 900 million more people will be born in water and sanitation-stressed regions (UN, 1990; Grover and Howarth, 1991). It has beenestimated that lack of clean drinking water and sanitation services leads to many hundreds of millions of cases of water-related diseases and between five and ten million deaths annually, primarily of small children (Esrey e al, 1991; Warner, 1995).

In some reviews of epidemiological studies related towater and sanitation, the provision of adequate sanitation services was the most direct determinant of child health after also providing a minimum amount of water for metabolic activity and hand washing (Cvjetanovic, 1986; Esrey and Habicht, 1986; Caincross, 1990; Esrey et. al, 1991). There are many technologies for improving access to adequate sanitation services, with widely varying water requirements. In regions where absolute water quantityis a major problem, alternatives that require no water are available. Where historical circumstances led to the use of wasteful, high-volume flush toilets, as much as 75 liters per capita per day, or more, have been used (Gleick, 1996). The choice of sanitation technology depend on the developmental goals of a country or region, the water available, the economic choice of the alternatives, and powerful regulatory, cultural, and social factors (White and Bradley, 1972; Kalbermatten et al, 1982). Because alternatives are available that require no water, it is technically feasible to set a minimum at zero. However, two factors argue against doing this, additional health benefits are identifiable when up to 20 liters per capita per day of clean water are provided (Esrey and Habicht, 1986) and where economic factors are not a constraint, cultural and social preferences strongly lean toward water-based systems.

Access to some water for sanitation, together with concurrent education about water use, decreases the incidence of diseases, increases the frequency of hygienic food preparation and washing, and reduces the consumption of contaminated food products. Accordingly, while effective disposal of human wastes can be accomplished with little or no water when necessary, a minimum of 20 liters per person per day was recommended by Gleick (1996) to account for the maximum benefits of combining waste disposal and related hygiene, and to permit for cultural and societal preferences. This level can be met with a wide range of technological choices.

3.5.4 Water for Bathing

A review of a range of studies in North America and Europe suggests average (not minimum) water use in industrialized nations for bathing to be about 70 litres per person per day, with a range from 45 to 100 l/p/d (Gleick, 1996). Data on water used for bathing in developing countries or in regions with no piped water are not widely available. Some studies suggest that minimum water needed for adequate bathing is on the order of 5 to 151/p/d and that required for showering is 15 to 25l/p/day (Kalbermatten et al, 1982). A basic level of service of 15 l/p/d for bathing was recommended by Gleick (1996).

3.5.5 Water for Food Preparation

The final component of a domestic basic water requirementis the water required for the preparation of food. While most detailed surveys of residential water use inindustrialized countries do not provide separate estimates of water used for cooking, (Brooks and Peters, 1988) estimate that water use for food preparation in wealthy regions ranges from 10 to 50 litres per person per day, with a mean of 30 liters per person per day. In a study done of the water provided for 1.2 million people in northern California, an average of 11.5 liters per person per day was used for cooking, with an additional 15 litres used for dish washing (EBMUD, 1991). Other studies in both developed and developing countries (White and Bradley, 1972; WHO, 1992; NRC, 1989; Black, 1990) suggest that an average of 10 to 20 liters per person per day appears to satisfy most regional standards and that 10 l/p/d will meet basic needs.

3.6 Water Scarcity

Water is life. Understanding water scarcity is important because it affects our basic needs. Not withstanding the views of users and policy makers, water scarcity requires effective policies to address the crisis. The crisis of water scarcity is most evident in Africa than any other continent. Sanitation and food production are twin issues that confront humankind on a daily basis. Report by TMP-GFSR (2013) has shown that up to 2.5% of GDP of African countries and $5.5 billion are lost annually due to inadequate sanitation. Only about 30% of sub-Saharan Africa uses improved sanitation facilities. It is unfortunate that the current global rush for farmland is actually a “great water grab,” with a number of African governments signing away water rights for decades with major implications for local communities. Yet 40% of people still without access to improved drinking water live in sub-Saharan Africa, and a study in Nigeria and Ethiopia found that only about 70% of the “improved” sources are safe to drink. Foreign aid covers up to 90% of some sub-Saharan African countries’ water and sanitation expenditures. Despite progress, the actual number of people without access in sub-Saharan Africa was greater in 2008 than in 1990. Without policy changes, this region will not meet the MDG target on water until 2040 and the one on sanitation until 2076. The number of Africans living in water-stressed areas is projected to be about 350–403 million by 2055 in the absence of climate change; with climate change, it could be 350–600 million people (TMP-GFSR, 2013).

The FAO (2007) defines water scarcity as the point at which the aggregate impact of all users impinges on the supply, or quality, of water under prevailing institutional arrangements to the extent that the demands from all sectors, including the environment, cannot be fully satisfied and that the problem is most prevalent in rural areas, where water stress affects the most vulnerable people. The UNDP (2006) report considers water scarcity from two points of view where: first as a crisis arising from a lack of services that provides safe water and, second as a crisis caused by scarce water resources. From these views it is concluded that the world’s water crisis is not related to the physical availability of water, but to unbalanced power relations, poverty and related inequalities.

Rijsberman (2006) notes that when an individual does not have access to safe and affordable water to satisfy her or his needs for drinking, washing or their livelihoods, then that person is water insecure and when a large number of people in an area are water insecure for a significant period of time, then that area is water scarce. Whether an area qualifies to be labeled “water scarce” depends on, for instance: How people’s needs are defined and whether the needs of the environment, the water for nature, are taken into account in that definition? What fraction of the resource is made available, or could be made available, to satisfy these needs and the temporal and spatial scales used to define scarcity.

The physical evidence of water scarcity can be found in increasing magnitude around the world, affecting rich and poor countries alike and the UN estimates that nearly three billion people live in water scarce conditions and this situation could worsen if current growth trends continue (UN-Water, 2007). The global water scarcity problem is manifested in millions of deaths every year due to malnourishment and water-related disease, political conflict over scarce water resources, extinction of freshwater species, and degradation of aquatic ecosystems with roughly half of all wetlands having been lost and dams seriously altering the flow of roughly 60 percent of the world's major river basins (Revenga et al, 2000).

Falkenmark et al (2007) gives four categories of water scarcity and these include demand-driven blue water scarcity, the population-driven blue water scarcity, the climate-driven blue water scarcity and, pollution-driven blue water scarcity. In the past population levels higher than 1000 people per flow unit of the resource indicated chronic water shortages (Falkenmark, 1989) as measured by the Falkenmark water Stress Index where humans require an estimated 100 litres/person/day for basic drinking, bathing and cooking while five to twenty times this amount is needed to meet the demands for agriculture, industry and energy. Chronic and widespread water scarcity occurs in countries with less than 1000 cubic meters per capita supply of renewable fresh water (Falkenmark, 1989). The Falkenmark Indicator is popular because it is easy to understand but it does not help to explain the true nature of water scarcity (Rijsberman, 2006).

Contrary to traditional belief that water scarcity relates water to food production, and not to water for domestic purposes that are minute at this scale (Rijsberman, 2006; Ohlsson and Burton (1999) contend that water scarcity does not only result from a physical lack of water but it is often also of difficulties in mobilizing more of the freshwater resources available. Falkenmark et al (2007) adds that lack of water in relation to water requirements is another issue that needs to be addressed. This has prompted the need to use the Basic Water Requirements of 50 litres per person per day as benchmark (Gleick, 1996) in which domestic water scarcity occurs when an individual has access to less than 50 litres per day to meet basic water requirements which should be of appropriate quality.

There is much talk of a water crisis, of which the most obvious manifestation is that 1.2 billion people lack access to safe and affordable water for their domestic use (WHO, 2000). Less well documented is that a large part of the 900 million people in rural areas that have an income below the two-dollar-per-day poverty line lack access to water for their livelihoods and this has major impacts on people's well-being. Lack of access to safe drinking water and sanitation, combined with poor personal hygiene, causes massive health impacts, particularly through diarhoeal diseases, estimated to cost the lives of 2.18 million people three-quarters of whom are children younger than 5 years old, annually, and an annual global burden of disease measured as 82 million Disability Adjusted Life Years (Prüss et al, 2002). The poorest of the poor are also most affected by lack of access to water for productive purposes, resulting in a vicious cycle of malnutrition, poverty and ill health. Fresh water is critical to an array of global challenges from health, to malnutrition, poverty, and sustainable natural resources management. It turns out to be difficult to assess whether water is truly scarce in the physical sense (a supply problem) or whether it is available but should be used better (a demand problem).

Water is a very complex resource. Contrary to a static resource such as land, water occurs in a very dynamic cycle of rain, runoff and evaporation, with enormous temporal and spatial variations as well as variations in quality that completely govern its value to people and ecosystems. That water can be a nuisance (in floods) as well as a life saving resource (in droughts) is obvious, but that both conditions can occur in one location within a single year is more surprising. Annual average water availability in such a situation has little meaning to measure water scarcity. Large parts of monsoon Asia suffer from severe water scarcity while the average annual resource availability appears to be plentiful. The question is there not enough or too much.

Spatial scales also impact the measures of water scarcity. Obviously, in very large countries such as China there can be water scarcity in the Yellow River basin at the same time as flooding in the Yangtze River basin. Many smaller countries experience the same phenomenon over much smaller spatial scales too. Water quality ought to be another major variable in an assessment of water scarcity. Fresh water may become polluted as it flows downstream and become de facto unusable. Do we measure the polluted water as part of the resource available to satisfy needs (after treatment)? Or leave it out and conclude that there is scarcity? These are important challenges we have to necessary contend with if we are to understand water scarcity in a given area.

3.6.1 Definitions of Scarcity

In the literature, specific terminologies are used to refer to various aspects of the subject. ‘Water use’ refers to ‘water that is being put to beneficial use by humans’. ‘Water withdrawal’ refers to the ‘gross amount of water extracted from any source in the natural environment for human purposes’. ‘Water demand’ represents the ‘volume of water needed for a given activity. If supply is unconstrained, water demand is equal to water withdrawal’ (UN Water, 2009). Water scarcity is defined ‘from the perspective of individual water users who lack secure access to safe and affordable water to consistently satisfy their need for food production, drinking, washing, or livelihoods’ (Molden et al. 2007).

Water scarcity is first and foremost a poverty issue. About 1.2 billion people live in areas of physical water scarcity and up to one in three people in the world face water shortages. In 2025, about 1.8 billion people will live in regions with absolute water scarcity and about two-thirds of the world’s population in areas of water stress (UN Water, 2007:4, 10). Importantly, ‘the appropriate scale for understanding water scarcity is at the local or regional level, notably within a river basin or a sub-basin, rather than at the national or global level’ (UN Water, 2007). The basic metabolism of the human body requires about 1,800–2,000 kcal every day, with every calorie of food consuming about one litre of water in food production. Thus, producing enough food to satisfy a person’s daily diet requires 2–3,000 litres of water. Only 2–3 litres of water are needed for drinking each day and between 20–300 litres for domestic needs (UN Water, 2007). The greatest water consumer is therefore agriculture and the food we eat.

The Falkenmark indicator is commonly used to measure water stress. ‘Water stress’ is defined as an annual water supply below 1,700 cubic metres per person. ‘Water scarcity’ exists when annual water supply is below 1,000 cubic metres per person and ‘absolute scarcity’ when it is below 500 cubic metres per person (Falkenmark, 1989). This indicator highlights the total run-off available for human use and distinguishes between climate and human-induced water scarcity. Subsequently, there have been other indices that have included different social variables, with the UNDP Human Development Index being widely accepted (Brown and Matlock, 2011).

Regarding water footprint, ‘a country’s water footprint is the volume of water used in the production of all the goods and services consumed by inhabitants of the country’. In 2009, the global water footprint was 1,240 cubic metres per capita per year and there were huge differences between countries. The average water footprint in the US was 2,480 cubic metres per capita, where as in China it was 700 cubic metres (UN Water, 2009:101). The relevance of the per capita water footprint may, however, be limited and misleading because it says nothing about the relationship between actual water use and water availability. Put differently, what is the relationship between possible water use and actual availability in time and space. Moreover, national averages conceal major differences between rich and poor.

3.6.2 The Multiple Dimensions of Water Scarcity

Water scarcity has to do with how societies spread over space, how their activities modify the environment and how this, in turn, impacts on them, and with how different segments of these societies are able (or unable) to mobilize financial resources and power in order to shape the patterns of access to water within the society. Since water is such a vital and omnipresent factor of life, it is no surprise to find that the deprivation of it, or its scarcity, may be associated with many circumstances and have many different impacts. The World Water Assessment Program (WWAP, 2001), for example, sees water stress or scarcity as “the condition of insufficient water of satisfactory quality and quantity to meet human and environmental needs”, but what characterizes “insufficient” as well as the category of “needs” is anything but a straight forward universal notion. Water scarcity has multiple dimensions (Molle and Mollinga, 2003).

A first distinction must be made between the different uses of water and the impact of its scarcity on people or the society. One may distinguish five categories of water use though these categories do not cover all water uses (for example, religious functions, in-stream uses such as transportation, recreation, etc.) but they offer a grading of possible scarcities that directly and most commonly impact on poverty, from basic needs to economic activities and health. Level 1: Drinking water, Level 2: Domestic water, Level 3: Food security needs, Level 4: Economic production, Level 5: Environmental needs. Molle and Mollinga (2003) argued that it may obviously not always be easy to segregate water scarcity strictly according to these five categories, because scarcity is highly dynamic and may affect these different “layers” at different points in space and time, and for varied durations. The cause of water scarcity is of central concern when we want to determine under which conditions or through which measures scarcity can be combated and redressed. In general, they argued that water scarcity can have five dimensions:

3.6.2.1 Dimension 1: Physical scarcity

This corresponds to an absolute type of scarcity, where the water sources available are limited by nature. This is the common situation in arid and desert areas, where water sources are limited to only a few wells, springs or qanats.

3.6.2.2 Dimension 2: Economic scarcity

This refers to the impossibility to cater to one of the above water needs or uses because of the incapacity to commit human resources (e.g. labor and time needed to procure water from very distant wells) or financial resources (e.g. payment for water) to access water.

3.6.2.3 Dimension 3: Managerial scarcity

This may occur because water systems are not properly maintained or managed. For example, reservoir carryover stocks may not be considered, aquifers mined, irrigation schemes chaotic, water distribution networks leaking, etc. Improper management induces this scarcity, since users who should normally receive water fail to be served properly.

3.6.2.4 Dimension 4: Institutional scarcity

This is a subtler dimension of induced scarcity, signifying a society’s failure to deal with rising supply/demand imbalances and to preserve the environment. Water shortages can be described to the inability to anticipate such imbalances and to supply adequate technological and institutional innovations. This may also include (although it is also linked to managerial capacity) third-party impacts, that is, water problems experienced by some users because upstream patterns of land and water use change and impact on downstream access to water (in quantity and/or quality).

3.6.2.5 Dimension 5: Political scarcity

This occurs in cases where people are barred from accessing an available source of water because they are in a situation of political subordination.The great variety of situations are illustrated by the above two classifications, which define a matrix of 25 quite different cases. For example, there may be a case where water for domestic use is available but where a person cannot afford it. There can also be a case of irrigators who suffer from a shortage of water because upstream reservoirs have been ill-managed. Africa provides vivid examples of an extreme case of politically constructed water scarcity category.

These various dimensions of scarcity may also vary in their temporal forms. Scarcity can be temporary or constant, characterized by a continuous gap between the water needed and the water available. Such a shortfall in water supply is more critical for the first two levels of uses, since this can be considered as the non fulfillment of a human right. Scarcity may have occurred as a reduction of the quantity of water used earlier and is then perceived as a stress that generally induces adjustments and reduces in the case of aquifer over-exploitation; the interaction is not necessarily upstream/downstream.

3.7 Spatial Dimension of Global Water Scarcity

The overall conclusion of all global water scarcity analyses is that a large share of the world population up to two-thirds will be affected by water scarcity over the next several decades (Shiklomanov, 1991; Raskin et al, 1997; Seckler et al, 1998; Alcamo et al, 1997, 2000; Vorosmarty et al, 2000; Wallace, 2000; Wallace and Gregory, 2002). Certainly it is clear and inescapable that, in terms of the Falkenmark index, as the population grows there will be proportionally less water available per capita as the resource base is more or less constant.

Table 3.1: Water resources indicators, applicable scales and data requirements

Indicator/ Index	Reference	Spatial Scale	Required Data
Access to drinking water and sanitation services	WHO, 2000	Country	percentage of population with access to drinking water percentage of population with access to sanitation services
Falkenmark Water Stress Indicator	Falkenmark, 1989	Country	total annual renewable water resources population
Dry season flow by river basin	WRI, 2000	River Basin	time-series of surface runoff (monthly data) population
Basic Human Needs Index	Gleick, 1996	Country	domestic water use per capita
Indicator of water scarcity	OECD, 2002	Country, Region	annual freshwater abstractions total renewable water resources
Indicator of water scarcity	Heap et al., 1998	Country, Region	annual freshwater abstractions desalinated water resources internal renewable water resources external renewable water resources ratio of the ERWR that can be used
Water availability index WAI	Meigh et al, 1999	Region	time-series of surface runoff (monthly) time-series of groundwater resources (monthly) water demands of domestic, agricultural and industrial sector
Vulnerability of Water Systems	Gleick, 1990	Watershed	storage volume (of dams) total renewable water resources consumptive use proportion of hydroelectricity to total electricity groundwater withdrawals groundwater resources time-series of surface runoff
Water Resources Vulnerability Index (WRVI)	Raskin, 1997	Country	annual water withdrawals total renewable water resources GDP per capita national reservoir storagevolume time-series of precipitation percentage of external water resources
Indicator of Relative Water Scarcity	Seckler et al, 1998	Country	water withdrawals in 1990 water withdrawals in 2025
Index of Watershed Indicators (IWI)	EPA, 2002	Watershed	15 condition and vulnerability indicators
Water Poverty Index (WPI)	Sullivan, 2002	Country, Region	internal renewable water resources external renewable water resources access to safe water, access to sanitation irrigated land, total arableland, total area GDP per capita under-5 mortality rateUNDP education index Gini coefficient domestic water use per capita GDP per sector Water quality variables, use of pesticides Environmental data (ESI)

Source: (Wallace and Gregory 2002).

Many studies have concluded that with population explosion and climate change, water will be scarce in areas with low rainfall and relatively high population density. Many countries in the arid areas of the world, particularly Central and West Asia and North Africa, are already close to, or below the 1,000 m^3/capita/year threshold. This is the part of the world that is most obviously and definitely water scarce in the physical sense, without much further debate. According to Wallace (2000), in 2000, people had less than a thousand cubic meters per year in the North-Africa belt (from Morocco to Egypt and including Sudan), and between one and two thousand in the Middle East and Southern Africa. For the most populous country of this region, Egypt, the Falkenmark indicator is likely to drop below500m^3/capita/year within the next 25 years.

Wallace (2000) estimates that in essence all of North, Eastern and Southern Africa, and the Middle East, will drop below 1000m^3/capita/year before 2050. West Africa and large parts of South and South-east Asia would be in the one to two thousand ranges at that time. It is often assumed that such water scarcity means that therefore people have insufficient water for their domestic use but that is not necessarily the case. At a minimum water requirement per capita of 50 litres per person per day, the domestic requirement is less than 20m^3/capita/year. Rijsberman (2004) has argued that the total amount of water required for domestic purposes is small, compared to the water required for other basic needs and is essentially unaffected by water scarcity. The people that lack access to water supply and sanitation are not affected by water scarcity in the physical sense, as expressed by the Falkenmark index, but lack access because the water service delivery is poor, or because they do not have access to sufficient financial resources to avail themselves of the services, i.e. they are poor.

The Falkenmark indicator thresholds do not indicate that water is becoming scarce for domestic purposes, but that water is becoming scarce for food production. Yang et al (2003), from an analysis of water availability, food imports and food security, concluded that there is a threshold of about 1500m^3/capita per year below which a country's cereal imports become strongly inversely correlated with its renewable water resources. The countries in Africa and Asia that will be below this threshold in 2030 are given in Table 3.2.

Water use is not just governed by population growth, however. In the 20th century the world population tripled but water use increased six fold (Cosgrove and Rijsberman, 2000a). Many water scarcity projections assume a rapidly increasing water use per capita, usually related to rising incomes (e.g. Shiklomanov, 1998; Raskin et al, 1997; Alcamo et al, 1997, 2000). Given that 1.2 billion people currently lack access to safe and affordable water and that the world is rapidly urbanising and industrialising, it is safe to assume that domestic and industrial demands will rise rapidly in developing countries, but it is much less evident how other demands for water will develop. How much water we will need per person in the coming decades to satisfy our daily needs is not fixed, as the Falkenmark indicator suggests, but depends on a myriad of policy and personal choices. This is in fact the heart of the matter for future water scarcity projections.

Table 3.2: List of countries in Africa and Asia having renewable water resources below the calculated threshold of 1500 m3/capita/year by the year 2030

Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
Afghanistan	Egypt	Kenya	Niger	Tanzania
Algeria	Eritrea	Korea Republic	Nigeria	Togo
Burkina Faso	Ethiopia	Lebanon	Pakistan	Tunisia
Burundi	India	Libya	Rwanda	Uganda
Cape Verde	Iran	Malawi	Saudi Arabia	Emirates
Comoros	Israel	Maldives	Somalia	Yemen
Cyprus	Jordan	Morocco	South Africa	Zimbabwe

Source: (Yang et al. 2003)

Alcamo et al (1997, 1999), using the Water Gap model and criticality ratio and their assumptions on how water use will grow with income, have estimated that 4 billion people, or more than half of the world's population, will be living in countries facing high water stress (criticality ratio greater than 40 percent) by 2025, Shiklomanov's analysis, based on his forecasts of rising demands, suggests that water withdrawals will rise by 25%, between 2000 and 2025 from 4,000 to 5,000 cubic kilometre (km^3) (Shiklomanov, 1998; Cosgrove and Rijsberman, 2000a). Gleick (2000), however, in an analysis of water demand projections over several decades has found that these forecasts were consistently too high. Forecasts of dramatic rises over the next several decades would not be realised, he found, but new forecasts would continue to project sharp increases in demand for the next period. The future demand for water is strongly correlated with our assumptions related to the values and lifestyles of future generations (Gallopin and Rijsberman, 2000).

The sharpest divergence in views is between those arising from the agricultural and environmental perspectives (cf. Hofwegen and Svendsen, 2000; IUCN, 2007; HRH The Prince of Orange and Rijsberman, 2000; ODI, 2002). These conflicting perspectives are laid out by Rijsberman and Molden (2001) in a background paper for the Bonn International Water Conference held in December 2001. From an agricultural perspective the argument is as follows. The Green Revolution based on modern, high yielding plant varieties, requiring high inputs of fertilizer and water has led to increases in world food production at a pace that outstripped population growth. Food prices have declined markedly, and increased water use in irrigated agriculture (Rijsberman, 2004).

In spite of increases in agricultural production and lower food prices, the task of providing food security to all is incomplete. Malnutrition persists, mostly in South Asia and Sub-Saharan Africa. Much malnutrition exists in regions dubbed “economically water scarce” by IWMI (2000), meaning that while there is water available in nature, sometimes abundantly, it has not been developed for human use. Small farmers and the poor are particularly disadvantaged and can face acute water scarcity. They do not have access to water to satisfy their needs for either food security or sustainable livelihoods. The agricultural community sees continued growth of irrigation as an imperative to achieve the goals adopted by the international community to reduce hunger and poverty. Under a base scenario that included optimistic assumptions on productivity growth and efficiency, IWMI estimated that 29% more irrigated land will be required by the year 2025, and because of gains in productivity and more efficient water use, the increase in diversions to agriculture would be 17%. FAO (2002, 2003a and 2003b) and Shiklomanov (1998) had comparable results. IWMI’s water scarcity map is based on a scenario dominated by food production sufficient to meet the needs of future generations as well as reduce malnutrition, at the most efficient levels of water use imaginable under essentially a business as usual scenario.

As discussed by Gleick (2002), global and national analyses of water scarcity serve many purposes, from raising awareness to pinpointing specific vulnerabilities and threats. They also have considerable drawbacks, however. Water is a dynamic and complex resource hard to describe in simple indicators, but data availability limits the application of more sophisticated indicators. Water problems are often local, mostly occurring at household level, while water data are usually large-scale or national. Thus, indices that specifically involve generation of household level data are most likely going to offer better evaluation of water scarcity especially at community level.

3.8 Limitations of Global Assessment of Water Scarcity

The global analysis of water scarcity is of very limited use in assessing whether individuals or communities are water secure. Many research workers have argued that the river basin (within which communities are located) are more and more adopted as the appropriate scale to understand the key processes with increasing water scarcity as human use goes up to the point where basins "close" (Keller et al, 1998; Molden 1997; Molden et al, 2001a, 2001b; Turton and Ohlsson, 1999; Molle, 2003).

Keller et al (1998), Molden (1997) and Molden et al (2001a), (2001b) a linear three-stage evolution of river basin development as water becomes progressively scarcer, starting with (a) a focus on augmenting supply through infrastructure; to (b) emphasis on water conservation and improved efficiency of use; to (c) a shift to re-allocation of water from one user to another, presumably shifting to a higher value use. On the other hand, Turton and Ohlsson (1999) and Molle (2003) attempt to develop this linear economic-engineering model further, through a deeper understanding of the socio-economic context in which water use takes place and the political economy of water resources development. These approaches serve both to assess and understand the complex physical flows of water in a basin as well as the many responses employed by, or open to, users and communities that face water scarcity. These analyses do not result in simple indicators. Others like Meigh et al (1998) have attempted to analyse water resources at a more refined spatial scale with essentially the same indicators as those employed at the global/national scale for example, Southern and Eastern Africa.

Rijsberman and Mohamed (2002) postulate that the impact of water scarcity on society is correlated to the rate of change in water scarcity in a basin. If the availability of water in an area decreases rapidly, say from 2,000m^3/capita/year to 1,500m^3/capita/year in the span of a decade, then people may experience scarcity more intensely then when water availability dropped at a lower rate but to an absolutely lower level. Where water scarcity is constant or changes slowly, systems of water use can adapt to those conditions.

Generally speaking, water institutions have developed in response to the local water scarcity context. This can be seen in the United States of America, for example, where the system of riparian rights has been adopted in the humid US East, while the system of prior appropriation, essentially tradable water rights and better suited to deal with water scarcity, was adopted in the dry US West (Molle, 2003). Rapidly increasing relative water scarcity requires water users and water institutions to adapt to new scarcity conditions. When institutions are in the adaptation process to the new levels of scarcity, the users are most affected by scarcity, or water scarcity is most "felt". The relative scarcity of a resource also determines its value to the user, increasing relative scarcity translates into increasing water values. As the scarcity and value of water goes up, so does the competition for water among users. With increasing competition, and lagging institutions, conflicts arise. Typical conflicts are those between rapidly growing urban areas that claim water from agriculture, for example, or conflicts between agriculture and the environment as agriculture seeks to expand or looks for new resources to replace those given up to urban areas. Conflicts among users over the allocation of water increase with increasing relative water scarcity.

Molle (2003) proposes a typology of the heterogeneous societal responses to scarcity. Institutional responses to increasing scarcity are often triggered by shock events, such as droughts, for example. Australia's evolving system of water governance, with its cap on development in the Murray-Darling basin, system of tradable rights and experimentation with returning water from use in agriculture back to the environment, is an interesting case in point.

3.9 Response toWater Scarcity

The traditional, engineering response to water scarcity has been to construct infrastructure, particularly dams, to increase human control over water resources and make a larger share of the total renewable resources available for human use. While that approach has, by and large, been successful in producing its primary output, cheap food, and has provided water supply and sanitation to large numbers of people, the flip side is also clear. Many people do not have access to safe and affordable water supply, despite enormous investments, close to half the world population lacks access to sanitation, many rural poor do not have access to water for productive purposes, groundwater levels in key aquifers are falling rapidly, many rivers are no longer reaching the sea, etc. etc. (e.g. Cosgrove and Rijsberman, 2000a).

Over the last several decades this has given rise to a backlash against water infrastructure investments and a well-established literature that calls for shifts from supply management to demand management. An expression of this shift in thinking is the “integrated water resources management” movement that has given birth to organisations such as the World Water Council and the Global Water Partnership. The most tangible proposals that have come out of this direction are: (a) to involve users more in the management of water, often through the establishment of forms of water user associations; (b) to price water and/or make it a tradeable commodity; and (c) to establish river basin authorities that integrate the usually fragmented government responsibilities for water into a single authority responsible for a hydrographically defined area, the river basin. All three of these approaches have been successfully employed in some areas and have been unsuccessful in others or, as most obviously in the case of pricing water have become highly controversial. None of these are usually presented as responses to increasing water scarcity even water pricing is usually more presented as a response to unsustainable recovery rates for operation and maintenance costs but all of these actions have a role to play in the institutional adaptation to increasing scarcity. Sandra Postel (1998, 1999, and 2001) and Peter Gleick (2000, 2002) have questioned the sustainability of the current system if it is not transformed in a significant way. Sandra Postel has proposed that a large-scale shift towards higher productivity, decentralized micro-irrigation would be the way forward to increase water productivity and make water use sustainable.

Narayanamoorthy (2004) examines the potential of drip irrigation to help solve the water scarcity crisis in India and concludes that there is an enormous potential. Others, such as Molle and Turral (2004), analyse the potential for demand management to make water use sustainable at the basin level, but conclude that the potential is over-estimated. This debate is not likely to be resolved any time soon. It is in fact, in this author's opinion a healthy debate that helps along the institutional adjustment to water scarcity discussed above.

Gleick (2000, 2002) discusses what he calls the "soft path for water" a term that hails from the energy sector and that in essence focuses on the improvement of the overall productivity of water rather than endlessly seeking new supplies as the appropriate response to water scarcity. There is an interesting parallel, not often drawn, between the water sector and the energy sector. The oil crisis of the seventies led to many studies projecting energy scarcity and to heated debates on whether there really was energy scarcity a debate that continues until today with every major blackout such as the US has experienced in the last few years. The most important impact of that debate on energy scarcity was probably that it led to very significant increases in energy efficiency. In other words, the link between economic growth and energy use considered fixed for a long time has been broken; economies have become considerably less energy intensive. A similar shift is needed for water and according to Gleick the trends can already be observed in the US economy. Gleick (2002) presents data that show that for the US economy the economic productivity of water was relatively constant from 1900 to 1970, at US$6.50 of gross domestic product per cubic meter of water withdrawn, and has subsequently risen dramatically to about US$15; total withdrawals at a national scale have stabilized and the use per capita has fallen.

Specifically for water and agriculture, IWMI has been calling for a similar focus on increased water productivity through an approach that is very similar to Gleick's "soft path", in various publications over the last 7-8 years (Rijsberman, 2004). This has culminated in a book that reviews the potential for improvement (Kijne et al, 2003) and a number of research initiatives that focus on increasing water productivity for food production and rural livelihoods, i.e. a CGIAR system-wide initiative called Comprehensive Assessment of Water Management in Agriculture and the CGIAR

Challenge Program on Water and Food. Together these represent a major effort by the international community to address water scarcity in agriculture. The most important question in the current debate on water scarcity is not so much whether it is true or not, whether we are going to run out of water or not, whether water scarcity is fact or fiction, but whether this debate will help increase water productivity.

3.10 Adaptation and Adaptive Capacity to Water Scarcity

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation to climate change as the set of: "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects" (IPCC, 2007). For the purposes of this guide, the focus is on 'planned' adaptation - i.e. adaptation that results from formal, conscious, and collective decision-making processes as opposed to 'autonomous' or 'spontaneous' adaptation.

The lexicon associated with climate change adaptation is large and inconsistently applied. Terms such as 'adaptive capacity', 'vulnerability', 'sensitivity' and 'resilience' are often used loosely and in some cases have different meanings depending on context (e.g ecosystems science vs. social science). Even the use of the term 'climate change' differs between the IPCC, for whom it refers to any change in climate over time (IPCC, 2007), and the United Nations Framework Convention on Climate Change (UNFCCC), where it refers to changes that are attributable to human activity over and above natural climate variability (UNFCCC, 1992).

Adaptive capacity, or the factors that enable social systems to respond proactively to environmental change, has emerged as a core domain of global change research (Burton, 1996; Smit and Wandel, 2006; Nelson et al, 2007). Much recent conceptual and empirical research focuses on identifying the demographic, economic, geographic, and some socio-political factors that diminish or enhance adaptive capacity (e.g, Yohe and Tol, 2002; Adger and Vincent, 2005). While these factors remain significant, they do not represent the complete picture. Relatively little attention has been paid to the role of motivation in the process of adaptation. Whatever external pressures they experience, individuals must perceive a need, an ability and motivation to act. Thus full comprehension of the adaptation process may require further disaggregation of related socio-cognitive factors including the complex relationships among the characteristics of individuals, how they perceive and acquire information about risk, and the role of social identity in their motivation to act.

It has been shown that adaptive capacity is influenced by not only economic and technological development, but also by social norms, values and rules (Klein and Smith, 2003; Robledo et al, 2004; Brooks and Adger, 2005; Næss et al, 2005; Tompkins, 2005; Ford et al, 2006; Adger et al, 2006; Coulthard, 2008), and that these adaptive responses vary between individuals and between and within communities, regions and countries (O'Brien et al, 2006). Adaptive capacity is, in other words, ''highly heterogeneous within a society or locality'' (Adger et al, 2006) and often influenced by factors such as class, gender, health, social status and ethnicity.

3.10.1 Passive Adaptation

It is the result of natural evolution of agricultural practices. It is more water intensive (if we speak about water use), but it is less time and emotion-consuming, does not require radical changes in the way of life of the villagers, and is more economically efficient with minor changes at early phases of drastic changes. In addition, it is efficient to a certain extent but constant changes. But in long-term perspective and under the changes passing at least one threshold, it leads to the quick depletion of water resources. As an eloquent example we can cite is currently occurring in the southeastern part of the country. The first aquifer (perched groundwater) in the villages is depleting due to diminishing recharge capacity; people are experiencing lack of water for watering vegetable gardens the activity traditionally practiced over the years. The solution was found in breaching the upper aquifer with a pipe and pumping water from the lower one. As a result depletion rate of the perched groundwater has increased, there is enough water for watering so far, and nothing has changed in agricultural practices and people's way of life. This type of adaptation can be recommended in the southern part of the country traditionally experiencing deficit and poor quality water resources, because their practices and way of life have evolved under the water scarce conditions.

3.10.2 Active Adaptation

It is more water-efficient; however, it is cost-intensive and needs important investments. It gives better results in the longer perspective, but it is much more efficient if implemented under the conditions that pass through a certain threshold. However, in its relation to societal effect of likely changes, it is separated in two subtypes.

3.10.3 Socially Passive Adaptation

When applied to rural activities and agriculture, is based on introducing drought resistant cultivars of the same crops traditionally cultivated in the area as well as on implementing improved irrigation techniques in existing or recently irrigated areas. This subtype is relatively more cost-intensive than passive adaptation category, but it is based on improving current agricultural practices and has neither important, nor immediate effect on people's way of life.

3.10.4 Socially Active Adaptation

It is the most radical among the presented types, because it requires change, sometimes very drastic, of the villagers' traditional occupations. For instance, introducing completely new crops or agricultural techniques, which villagers are not familiar with or introducing irrigation in previously non-irrigated areas. The vulnerability of the population increases not just due to global environmental change, but additional contribution is made by policy measures, especially when they are applied in anticipation of future conditions that are not yet obvious to the locals. In addition to increasing financial costs, it creates tension among villagers, it is emotion-consuming and, if translated in financial terms, its total costs can be the highest among all the presented types (and even higher than initially planned). But in long-term perspective, if properly implemented, it promises the best results.

Active adaptation is more risky and more difficult to implement, but it is more recommended in the regions of vulnerability. It is especially important, because this type of adaptation, in order to be efficient, must embrace all aspects of people's (mainly villagers') everyday life. The best (but not fast) way is to start from education and pass through all the water related aspects.

3.11 Household Water Scarcity and Water Governance in Nigeria

According to the Global Water Partnership, 'water governance' refers to the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society (Rogers and Hall, 2003). 'Governance' in its general sense refers to the processes and systems through which a society operates. It relates to the broad social system of governing, which includes, but is not restricted to, the narrower perspective of government as the main decision-making political entity. Governance refers to both formal and informal structures, procedures and processes.

Key elements of good water governance include equity, transparency, accountability, environmental and economic sustainability, stakeholder participation and empowerment, and responsiveness to socio-economic development needs. Cost-effectiveness analysis can guide governance by establishing water's proper value and identifying the most socially, economically and environmentally cost-effective policy options. By reorienting policy, reforming institutions, promoting education and awareness, increasing stakeholder participation, establishing international agreements and linking policy to research and development (R&D), governance can develop efficient water management practices. Effective governance must also remain flexible so that it can incorporate social and political changes of modernization and adapt to climate change.

In Nigeria, as in most other African countries, water supply to meet basic human needs is far from being adequate and the stress is more serious in rural communities. According to WHO (2010), only 32% of rural population in developing countries have access to safe drinking water and Dada (2009) notes that a large percentage of the rural population in developing countries continues to live without adequate access to safe and convenient water supply and sanitation and water supply is still unreliable. In Nigeria, more than 90% of rural areas and 60% of urban areas face water related problems (ADF, 2007).

For several years now, many previous Nigerian governments (both civilian and military) had emphasized on theneed for sustained rural water supply and sanitation. Up till today, the effects of all these are far from reality. Since independence in 1960, rural water supply and sanitation development in Nigeria has proceeded inconsistently (Nwankwoala, 2011). According to Ajayi et al (2003), Ezeigbo (2003), Hanidu (1990), Goni (2006), Offodile (2003, 2006), Oteze (2006), Oyebande (2006), Onugba and Yaya (2008), Nwankwoala and Mmom (2008), Nwankwoala (2009), Okeke and Uzoh (2009), rural water and sanitation in Nigeria suffered from the following governance problems:

- Poor co-ordination,
- Poor maintenance culture,
- Poor technical/institutional structure,
- Multiple programmes,
- Lack of data/information for planning,
- Over bearing bureaucratic control by various supervising ministries,
- Lack of professional inputs on projects, lack of community participation, inadequate funding,
- Irregular disbursements of subventions, inappropriate infrastructures
- Lack of adequate quality monitoring and evaluation, lack of clear policy direction, lack of focus in terms of goals and objectives (which resulted in the country's inability to achieve full coverage of the rural population with safe water and improved sanitation services).

Serious efforts at addressing rural water supply and sanitation issues began with the on-set of the International Drinking Water Supply and Sanitation Decade (IDWSSD, 1981 to 1990), which established target of universal coverage. This was followed immediately by the World Summit for Children (1990), which established goals of universal access to safe water and sanitation and complete eradication of Dracunculiasis (Guinea worm). Following this, the National Programme of Action (NPA) for the Survival, Protection and Development of the Nigerian Child envisaged achievements that emerged during this 30-years' period, some of which with the assistance of External Support Agencies (ESAs) undertook (and currently involved) in several massive water supply development projects through the following agencies:

1. National Borehole Programme (1981 to 1986);
2. UNICEF Assisted State Water and Sanitation Projects (1981 to 2010);
3. Directorate of Food, Roads and Rural Infrastructure (DFRRI) Rural Water and Sanitation Programme (RUWATSAN) (1986 to 1992);
4. World Bank Assisted Agricultural Development Projects (1983 to 1992);
5. UNDP's RUSAFIYA (An acronym in local language) Projects (1988 to 1993);
6. Japanese International Cooperation Agency's (JICA) Rural Water Supply Projects (1992 to1994);
7. Petroleum Trust Fund (PTF) Rural Water Supply and Sanitation Programme (1996 to 1999);
8. Improved Access to Water Supply and Sanitation Programme (2000 to 2001);
9. European Union (EU) Water and Sanitation Programme (2002 to 2009);
10. Department for International Development's (DFID) Water and Sanitation Pilot Project (2002 to 2008);
11. Water Aid's Rural Water Supply and Sanitation Programme (1996 to 2010);
12. National Rural Water Supply and Sanitation Programme (2001 to 2010);
13. Development of local manufacture of hand pumps (1988 to 2010).

Despite these bold and elegant initiatives, by most conservative estimates, the country is still recording less than 50% access to safe water and sanitary means of excreta disposal. Until recently (in year 2000), there has been no National Water Supply and Sanitation policy framework which defines policy objectives, guidelines and targets for the entire sector. Even then, the will power to ensure co-ordination, streamlining and lending of focus and thrust to all these initiatives are yet to be translated into action. The Rural Water Supply and Sanitation Sector and Action Plan, developed in 1992 after a major review by a cross-section of stakeholders, did not lead to the planning and implementation of a sound Rural Water Supply and Sanitation (RWSS) programme.

Water scarcity is a serious challenge to development efforts in rural communities (Nyong and Kanaroglu, 1999; Aguigwo, 1998; Olajide, 2011) and the creation of the

National Water Resources Institute (NWRI) and the River Basin Development Authorities (RBDA) in 1976 and Federal Ministry of Water Resources (FMWR) in 1977 were in direct response to the threat of famine brought about by the drought of the early 1970s (Hanidu, 1990). The most potent and relevant water regulation in Nigeria today is the Water Resources Decree of 1993 (FGN, 1993), put into effect by the then Military government of Nigeria and ties the right of ownership and power of administration of water resources to land ownership.

The provision of rural water supply services is the domain of the Federal, State and Local Governments but has not been successful in meeting more than a small portion of the demand for water (Hanidu, 1990). Drilling for water can lead to many environmental problems if no recourse to geophysical tests or obtaining of necessary permits from regulatory bodies is taken (FGN, 2007). There is growing evidence of a decline in water availability in northern Nigeria due to rainfall seasonality and variability (Woo and Tarhule, 1994; Hess et al, 1995; etc) while at the same time, the competition for water by human activities is exerting tremendous pressure on the limited water resources and the environment (Dabi and Anderson, 1998; Udoh and Etim, 2007)

From the literature review, there is evidence that many of the studies on vulnerability emphasised on climate change and climate variability related events but gave little attention to how household cope and adapt to water scarcity. Literature on Nigeria focused on water supply and estimation of the quantity of water used by rural households that obtain water from a source away from the household (eg Aguigwo, 1998; Gbadegesin, 2007; Abaje, 2009; Olajide, 2011) but this study was focussed on vulnerability and adaptation to water scarcity in rural Katsina State.

3.12 Conceptual Framework of Vulnerability

The different views on vulnerability are reflected in various analytical concepts and models of how to systematise it. There is the need to provide an insight into different conceptual frameworks, such as the double structure of vulnerability, selected approaches of the disaster risk community, such as the UN/ISDR Framework for Disaster Risk Reduction.

On the double structure of vulnerability, Bohle (2001) notes that vulnerability is considered as having an external and an internal side where the internal side relates to the capacity to anticipate, cope with, resist and recover from the impact of a hazard and the external side involves exposure to risks and shocks. In the 'sustainable livelihood framework approach to vulnerability assessment key elements are the five livelihood assets or capitals, the 'vulnerability context' viewed as shocks, trends and seasonality, and the influence of transforming structures for the livelihood strategies and their outcomes (DFID,1999) where the two major terms are sustainability and livelihoods. In the hazard and risk framework, vulnerability is defined as a component within the context of hazard and risk where vulnerability, coping capacity and exposure are considered as separate features (Davidson, 1997; Villagra´n de Leo´n, 2004; ISDR, 2004). The global environmental change community framework as developed by Turner et al. (2003), defines vulnerability in a broader sense in which definition and analytical framework of vulnerability encompasses exposure, sensitivity and resilience where vulnerability is viewed in the context of a joint or coupled human–environmental system.

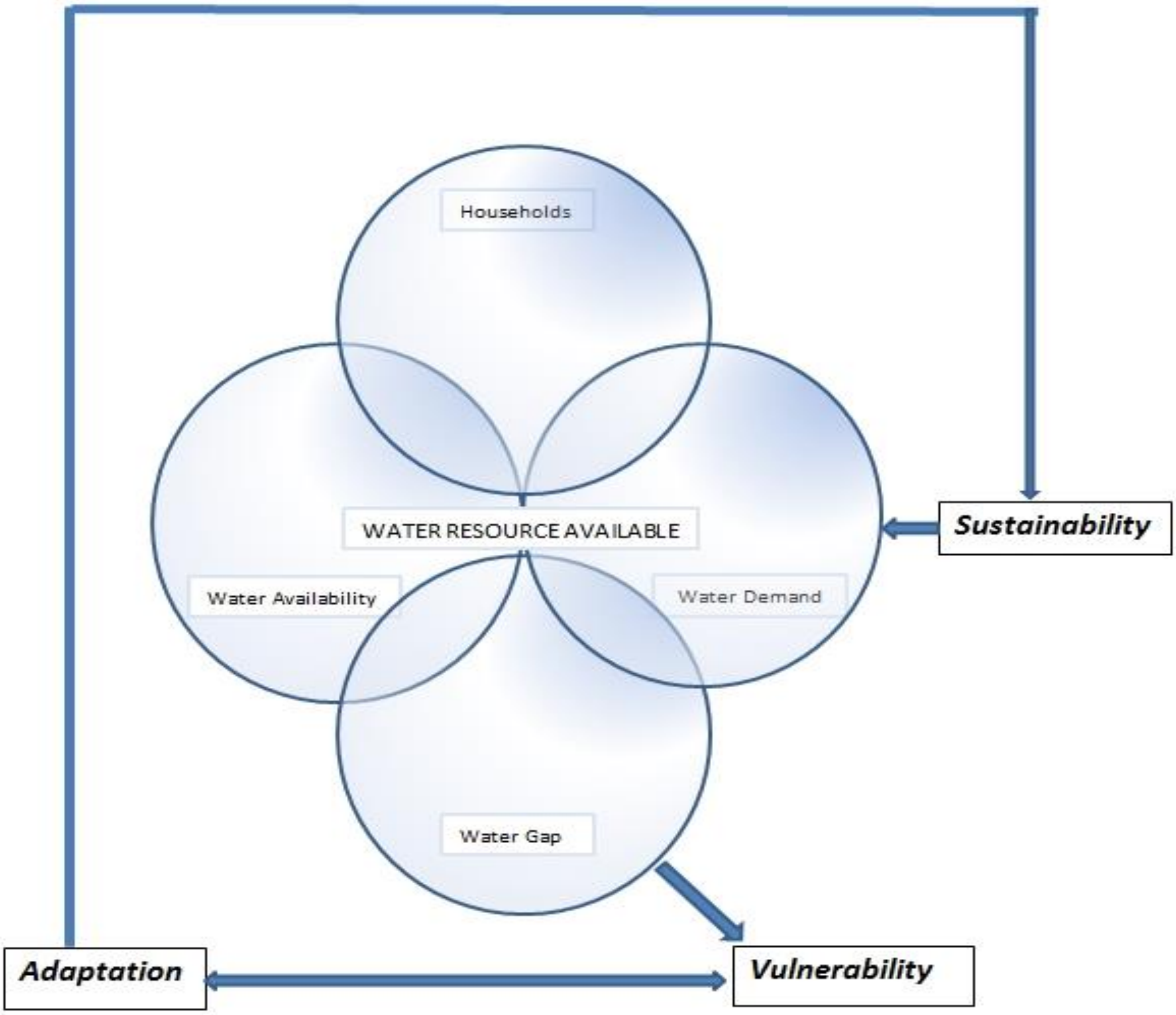
The framework that appears to best suit this study (Brooks, 2003) draws on the Regional Vulnerability Assessment Committee (RVAC) framework. The framework integrates both external and internal vulnerability. The external vulnerability refers to shocks and stresses that may threaten the wellbeing of communities. These include:

- Climate stressors, in this case drought,
- Socio-economic stressors (poverty, unemployment, poor health),
- Biophysical stressors (soil, vegetation, water, bio-diversity) and
- Political stressors (policy implication, laws, political freedom)

The internal dimension of vulnerability specifically focuses on coping and adaptation strategies taken to overcome shocks and stresses that result from external exposures. Coping and adaptation depends on various factors. These factors include:

- Socio-economic capital. These may be in the form of economic assets (e.g. finance, production equipment and markets), human capital (skills, knowledge, labour, health) and social capital (formal *and informal institutions, household and so*cial relations).

Figure 3.1: Conceptual Framework for Water Scarcity and Adaptation



Source: (Modified from Brooks, 2003)

- Ecological capital refers to natural assets; comprise water, land and biodiversity.
- Political capital (benefits from policy implementation, property rights, government institutions).

Given the above factors, household may cope, adapt and build resilience against external stressors or they could become stressed and vulnerable due to lack of these factors. From local history for example, most inhabitants in semi-arid areas including Katsina state know the frequency and likely consequences of drought. Using means at their disposal, most household in extreme climatic zones should be able to prepare for cope and adapt to drought. Why then, are some rural societies less able to prepare for or recover from expected climatic events such as drought? One could argue that, there are several factors such as those mentioned above that make societies more vulnerable to different types of climatic events (Brooks, 2003).

Figure 3.1 presents the conceptual framework that was adopted in this study in order to describe a logical sequence of steps for vulnerability assessment of water scarcity and households' adaptation to it. In the framework, the firststep of the assessment was to identify stakeholders and with the involvement of them it was required to define the water scarcity issues. Stakeholders were individuals or groups whose interests were affected by a system or a decision as well as those whose activities significantly affect the system. To reduce the risks of failing to identify key stakeholders, robust methods were therefore needed. With the involvement of these stakeholders, the water scarcity issues could be defined and the problem was explored in order to identify most important concerns and conflicts of the scarcity system.

Once the system's boundaries were defined, both spatial and temporal scales of the study need to be determined with the involvement of stakeholders. To capture the vulnerability of the water resources scarcity, different types of scales have to be considered: a scale representing the physical water resources subsystem; a scale representing the social subsystem; and if necessary, an additional scale that contains temporal and administrative aspect (Balica et al, 2009). Once the scale of the assessment was identified and the vulnerability assessment model of the water resources was selected, the next step was to select representative indicators. Adger *et al* (2004) identify two general approaches for indicator selection: (i) the deductive approach which is based on a theoretical understanding of relationships, and (ii) the inductive approach which is based on statistical relationships among a large number of variables. An inductive approach needs one or more proxy variable for vulnerability as the benchmark against which indicators are tested.

In this study, a deductive approach for indicator selection was selected. In a deductive approach, concepts need to be operationalized in order to test variables empirically: first, to create an understanding of the investigated phenomena and the processes involved; second, to identify the main processes included in the study; and, finally, we could move to select the best possible indicators for these factors and processes Adger *et al* (2004). Subsequently, different indicator approaches that cope with similar objectives reviewed in order to retrieve a list of prominent indicators that could be valid for the specific problem. Then, a pre-selection of potential indicators could take place. These indicators were tested carefully following respective selection criteria, data quality, and statistical correlations. In order to validate representative indicators, involvement of water managers, researchers, other resources managers, policy makers and key stakeholders was essential. Subsequently, the final indicator set could be defined, that comprehensively represents the system identified at the beginning of the procedure. This step was followed by data collection. Vulnerability assessment is an integrated assessment which requires social, economic and physical data. Therefore, sources of these data were diverse. So data collection process was all-encompassing as possible. As far as vulnerability to water scarcity was concerned, the key data collected here were on household, water demand, water availability characteristics. Others were issues related to adaptation to water scarcity and sustainability of water supply system.

Given the large data volume to be potentially generated, the operationalization of this framework certainly involve aggregation and weighting for the calculation of a concise index. In the literature, the analytical hierarchy process (AHP), proposed by Saaty (1980), is perhaps the most widely used method for aggregating indicators and evaluating and ranking alternatives within a decision making process, but many other methods exists, in particular within the broadest family of Multi-Criteria Decision Methods. A review on these criteria has recently been conducted by Gain et al, (2012).

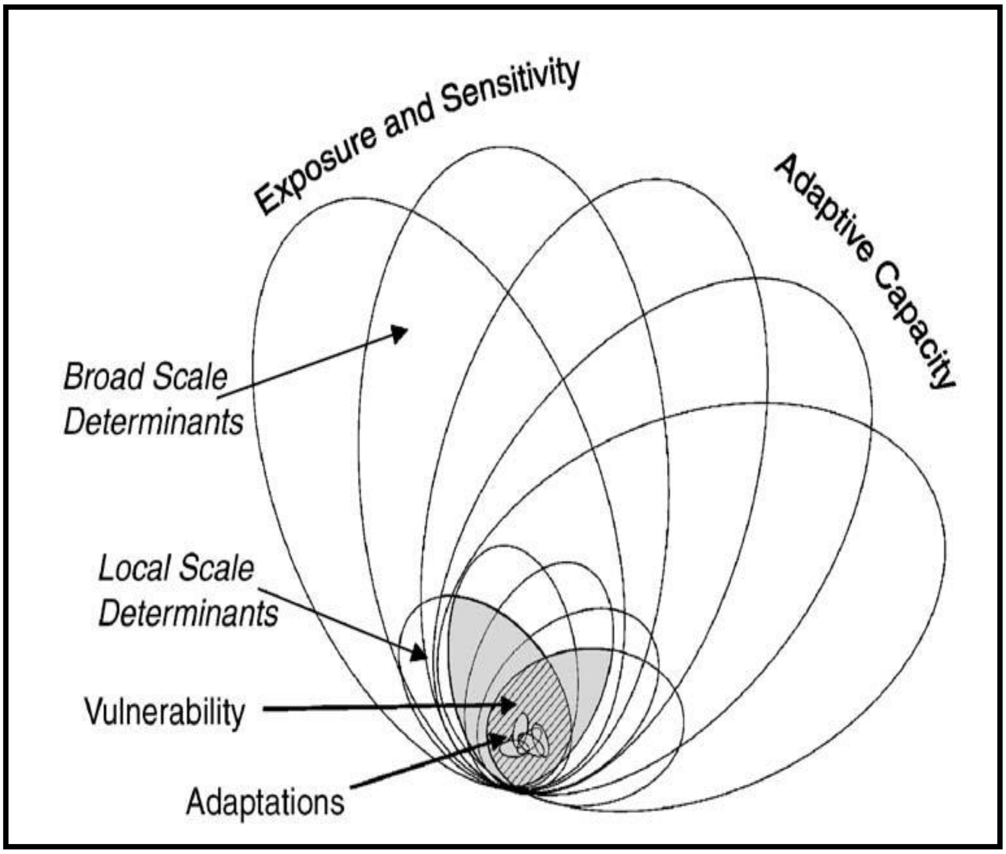
To aggregate indicators, it is necessary to normalize them. There exist a number of different normalization functions for a variety of different indicators. The most common application is to determine desirable and least acceptable (best and worst) values and to normalize the measured value between the two threshold values. The type of normalization function depends on the indicator under consideration and the preferences of the decision maker. Given the often not immediate relationship of indicator values with the objective of the assessment, the application of value function can play an important role. Value functions are mathematical representations of human judgments which offer the possibility of treating people's values and judgments explicitly, logically and systematically (Beinat, 1997). To construct composite indicator value and or index, the weighting of indicators are then to be carried out reflecting stakeholders' views.

In vulnerability assessment of water resources, both climatic as well as socio-economic scenarios and policy options are important. Climate scenarios are scenarios of climatic conditions, whereas socio-economic scenarios are scenarios of the state and size of the population and economy. For collecting the needed indicator values, outputs of simulation models are used. For example, the impact of climate change on water resources is usually estimated by defining scenarios of changes in climate conditions, simulated by general circulation models (GCMs), and linking them to a hydrological model to predict changes in river runoff, ground water recharge and extraction rates. Similarly, the hydrologic model can be parameterized with data coming from economic models (e.g, general or partial equilibrium models) and providing estimations of the most important variables of the social system, including for example land use. The outputs of the hydrologic model are then used as input of this indicator based approach. Likewise, for other socio-economic indicators, multiple scenarios have the additional advantage that a better understanding of the system under consideration is obtained. Once the vulnerability is assessed for both the present and for future scenario, the next step is to identify adaptation options that may reduce the vulnerability.

3.13 Limitations of the Present Model

Gain et al (2012) have advised that uncertainties of the results should be communicated among the stakeholders, policy makers, local stakeholders and interdisciplinary researchers are to be involved in identifying appropriate adaptation options.

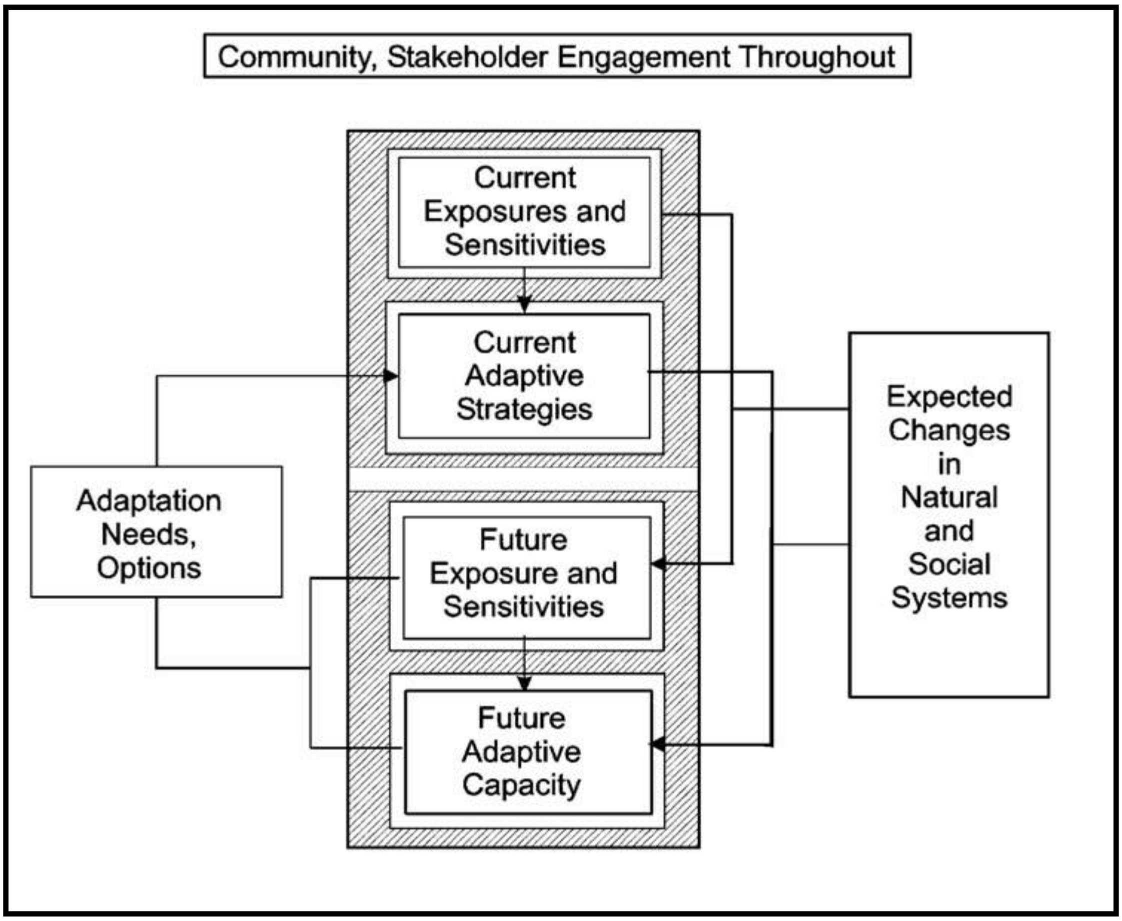
Figure 3.2: Nested Hierarchy Model of Vulnerability and Adaptation



Source: (Smit and Wandel, 2006)

Researchers from many disciplines have studied vulnerability in various contexts. Natural hazard researchers developed some of the initial conceptions, such as exposure based on the locational attributes (White 1945, 1964; Burton et al, 1993; Liu et al, 2008), but the bulk of the research has been conducted with regard to food security and other development issues (e.g, Watts, 1983; Chambers, 1989; Swift, 1989; Watts and Bohle, 1993; Blaikie et al, 1994; Bohle et al, 1994). More recent studies of vulnerability to global environmental changes have gained increasing prominence (Dow and Downing, 1995; Downing et al, 2001; Smit et al, 2000; Kasperson and Kasperson, 2001; Kates et al, 2001; Turner et al, 2003; Eakin and Luers, 2006; Adger et al, 2006).

Figure 3.3: Conceptual Framework for Vulnerability Assessment and Mainstreaming



Source: (Smit and Wandel, 2006)

Global change studies in the past have inventoried much of the empirical knowledge of impacts of climate change and factors predisposing populations to risks. Recently, the realization that human behaviors, institutional capacity, and culture are more important than biophysical impacts has encouraged greater interest in the issue of adapt- ability and resilience in global change studies (Burton, 1997; Smithers and Smit, 1997; Handmer et al, 1999; Kane and Yohe, 2000; Adger, 2000; UNEP, 2000; IPCC, 2001; Berkes et al, 1999a; Adger et al, 2006). Instead of focusing on predisposing factors, the emerging paradigm in vulnerability studies and sustainability science calls for a closer examination of resilience or adaptive capacity to withstand heightened vulnerability (e.g, Kasperson, 2001; Dow et al, 2006; Turner et al, 2003; Adger et al, 2006).

The dimensions of vulnerability vary from place to place, and constantly change over time, thus shaping and reshaping coping capabilities. Unfortunately, the analysis of the spatial and temporal components of vulnerability remains relatively weak. Some studies have been conducted on the spatial component of vulnerability, such as flood hazard mapping, earthquake risk zones and even composite all-hazard zones (Liverman 1990, 1999; Riebsame, 1989; Cutter et al, 2000). Recent efforts in the spatial mapping of vulnerability have attempted to capture the dynamics and spatial distribution of individual variables of concern and interactions between them (e.g, SEI, 2001; O'Brien et al, 2004; Polsky, 2004; Kasperson et al, 2005a; Luers, 2005). The temporal dimension, however, is still largely ignored (Cutter, 1996).

No matter how it is defined, vulnerability has been conventionally conceptualized as a snapshot, separated from complex interactions of coupled human–environmental systems over time. For example, the vulnerability-as-exposure view in hazards research tends to zoom in at a particular time of incident, without examining retrospectively at the constantly evolving circumstances that led to current level of exposure (Dow, 1992). Likewise, the politico-economic model of vulnerability in food security research also tends to use static socio-economic conditions (e.g, incomes) as a measure of coping capacity, and often fails to capture the rich diversity of resource pools available for formulating coping responses as well as changes in the larger economic and institutional context over time (Ribot, 1995; Ribot et al, 1996; Kates and Haarmann, 1992; Handmer et al, 1999; Berkes et al, 1999b; Downing and Bakker, 2000). However, there is an increasing recognition that vulnerability, building on these traditions, ''needs to account for dynamics (what is vulnerable in one period is not necessarily vulnerable in the next period) and account for the degree and severity of vulnerability'' (Adger, 2006, p. 275). Some fairly recent researches have started to focus on temporal dimensions of vulnerability (Ziervogel et al, 2005; Acosta-Michlik et al, 2006; Acosta-Michlik and Rounsevell, 2008).

CHAPTER FOUR: METHODOLOGY

4.1 Study Design

To fully track the vulnerability challenges faced by the people, it is important to include in the analysis methods that vulnerability is also:

- ***i)*** ***Qualitative***: emotions and the value of intangibles (e.g. photographs and artefacts for example) are important.
- ***ii)*** ***Subjective***: characteristics termed “vulnerable” depend on the point of view adopted. For instance, upland rain-fed farmer may see flooding one side as vulnerability while on the other side lowland irrigation farmer may see it as being helpful. The label depends on to whom the damage was being done and the point of view adopted.
- ***iii)*** ***Proportional***: percentages of people or infrastructure affected in addition to absolute numbers. For example, communities often have small populations relative to megacities, so even if 100% of a community’s population is affected by an event, it is unlikely to match the numbers which could be affected during a similar event in a megacity. Yet 100% of a population affected can be much worse than 1% of a population affected. Absolute and proportional metrics provide different characteristics of vulnerability. As well, here they are presented as being quantitative. Is there meaning in comparing “qualitative absolute” with “qualitative proportional”?
- ***iv)*** ***Contextual***: vulnerability depends on each specific situation. Some languages do not have a word for “vulnerability” and the concept is difficult to explain within that cultural context.

From the above therefore, studying vulnerability of society to a particular problem requires identification of the main indicators that would not only provide the basis for understanding the extent of the vulnerability but also the factors that influence it. Studies have shown that the vulnerability of individuals and human population to risks is dependent on several factors including the geographical location, exposure of population and infrastructure, socio-economic and cultural conditions, political and institutional structures as well as coping and adaptive capacity that differentiate the impacts on people and human system (Wisner et al, 2004; Barroca et al, 2006).

Tables 4.1 to 4.3 are the main indicators of vulnerability and factors influencing adaptation to water scarcity that have been identified from the literature using a deductive approach and were adopted for use in this study. To operationalise the use of this approach, some fundamental concepts were first defined and adopted. Following this, different indicator approaches were reviewed in order to retrieve a list of prominent indicators that might be valid for the kind of analysis intended in this study. Thereafter, a pre-selection of potential indicators was made after which the indicators were tested accordingly. To validate the selected indicators, involvement of water managers, researchers, resources managers, policy makers and other key stakeholders was necessary after which the final indicator sets that comprehensively represent vulnerability and adaptation to water scarcity were identified. Following the identification of the indicators, data collection scheme was designed. In this study, assessment of vulnerability and adaptation to water scarcity was considered as an integrated approach which requires social, economic and physical data, and for this reason, different sources of data had to be utilized as described in table 4.1-4.3 below.

4.2 Types and Sources of Data

In this study, data were collected on indicators of water vulnerability and adaptation to water scarcity through both field data collection and secondary data analyses methods using appropriate methods of data collection. The indicator variables included in the sample data were vulnerability to water scarcity (Table 4.1), adaptation strategies (Table 4.2) and factors influencing adaptation (Table 4.3). These indicators were sourced from field through surveys, primary data, and from existing data stores and publications. The field surveys were carried out in rural Katsina State of Nigeria. The secondary data on the indicators came from NPC, 2006 (population data), INEC, 2011 (sampling boundary units based on polling units), spatial data on rainfall (El-tantawi, 2012) spatial data on the administrative boundaries, rivers and dams (NASRDA, 2013).

Table 4.1: Indicators of Vulnerability to Water Scarcity

S/N	Indicator	Variable to measure on the field
1	Economy	• Per capita Income level • Occupation type being engaged in • Expenditure profile
2	Education	• Level attained • Training type received • Proportion of family members that received educational training in a household • Literacy rate of the entire community
3	Health	• Occurrence of Water borne disease • Incidence of Water-related mortality • Public expenditure on disease control • Public expenditure on water treatment • Access to secure and clean water • State support for community water treatment
4	Nutrition	• Food type being cooked • Water-related food diseases being encountered
5	Infrastructure	• Water supply facilities available • Water source being used • Sanitation facilities being used • Healthcare facilities being used • Access road used to reach water source • Distance to water supply source • Presence of quality monitoring programmes • Per capita water availability
6	Governance	• Presence of water supply programme • Presence of officials for water related management issues
7	Geography/Environment/ Demography	• Topographic condition • Groundwater recharge potential/rate • Amount of rainfall received • Total rainfall duration • Population profile • Presence of water-bearing rivers and streams
8	Technology	• Level of knowledge on water exploration • Level of knowledge on water extraction • Level of knowledge on water quality maintenance • Level of knowledge on water harvesting • Level of knowledge on water conservation • Water distribution technology available • Per capita skills on water resources exploitation • Per capita skills on water resources treatment

Source*: Various (Marchi et. al, 2000; O'Brien et. al, 2004; Tschakert et. al, 2007; Liu et. al, 2008; Daresa et. al, 2009; Nielsen and Reenberg, 2010; Ahmed et. al., 2011; Frank, 2011; Gain et.al, 2012)*

Table 4.2: Indicators of Adaptation to Water Scarcity

S/N	Indicator	Variable to measure on the field
1	Local knowledge	• Extent of local knowledge available • Per capita knowledge of adjustment options • Per capita use of the knowledge systems available
2	Adjustment of household practices	• Cooking practices • Washing practices • Domestic Animal watering
3	Adjustment in water supply source	• Alternation in supply source • Rainwater harvesting • Development of surface water conservation options
4	Population Mobility	• Seasonal migration • Permanent migration • Livestock relocation
5	Adjustment in livelihood options	• Alternation of livelihood sources • Permanent change in livelihood options • Movement to change livelihood source • Change in the character of livelihood type
6	Institutional options	• Institutional arrangements available • Extent of per capita use of the options • Incentives and motivations to use the options

Source***: Various (Marchi et. al, 2000; O'Brien et. al, 2004; Tschakert et. al, 2007; Liu et. al, 2008; Daresa et. al, 2009; Nielsen and Reenberg, 2010; Ahmed, et. al, 2011; Frank, 2011; Gain et.al, 2012)***

The general aim of quantitative approach is to classify features, count them, and construct statistical models in an attempt to explain what is observed. Quantitative data is more efficient and provides ability to test hypotheses. In addition, using a quantitative approach a researcher tends to remain objectively separated from the subject matter.

Quantitative approach in geography has been defined by Fotheringham *et al,* (2000) as consisting of "… one or more of the following activities:

- ✓ Analysis of numerical spatial data;
- ✓ Development of spatial theory; and
- ✓ Construction and testing of mathematical models of spatial processes."

Murray (2009) also listed the following as categories of methods used in quantitative geography:

- ✓ Geographic information systems;
- ✓ Airborne sensing (global positioning system, photogrammetry and remote sensing);
- ✓ Statistics and exploratory spatial data analysis;
- ✓ Mathematics and optimization;
- ✓ Regional analysis; and,
- ✓ Computer science and simulation.

Thus, Murray (2009) argued that quantitative geography is the collection of methods that are applied, or could/can be applied, by Geographers and others to study spatial phenomena, issues and problems. Whatever the case and whichever method is used, Geographers have for long been relying heavily on classic quantitative methods, and have developed rather important extensions in the study of spatial problems and issues. Of the many quantitative techniques Geographers do apply, statistics is the commonest. Infact, surveying and sampling have been widely relied on in geographic research and among the techniques used in this regard include qualitatively oriented semi-structured surveys targeting geographic areas and geographic issues to large scale opinion studies. As with many disciplines, classic descriptive statistical measures (mean, variance, higher ordered moments, correlation, etc.) have been an important part of quantitative geography, as have classic statistical models (regression, analysis of variance, principle components, factor analysis, multidimensional scaling, etc.) and non-parametric approaches (Wrigley and Bennet,t 1981).

These various techniques enumerated above have for long been assisting Geographers in effectively analysing spatial pattern, phenomena issues and processes, which makes quantitative approach highly relevant in Geographic research. This hence informed the decision of this study to utilise the approach to investigate issues related to vulnerability to water scarcity in rural areas of Katsina State.

Table 4.3: Factors Influencing Adaptations to Water Scarcity

S/N	Indicator	Variable to measure on the field
1	**Political capital**	• Kinds of policies already existing • Extent of implementation of the policies • benefits from policy implementation • property rights, • government institutions
2	**Ecological capital**	• Natural resources comprise water, • land • biodiversity
3	**Socio-economic capital**	• Economic assets • Production equipment • Markets • Human labour • Human health • Formal institutions • informal institutions • Household • Social relations
4	**Technological capital**	• Indigenous Technology • Introduced technology

Source*: Various (Marchi et. al, 2000; O'Brien et. al, 2004; Tschakert et. al, 2007; Liu et. al, 2008; Daresa et. al, 2009; Nielsen and Reenberg, 2010; Ahmed et. al, 2011; Frank, 2011; Gain et.al, 2012)*

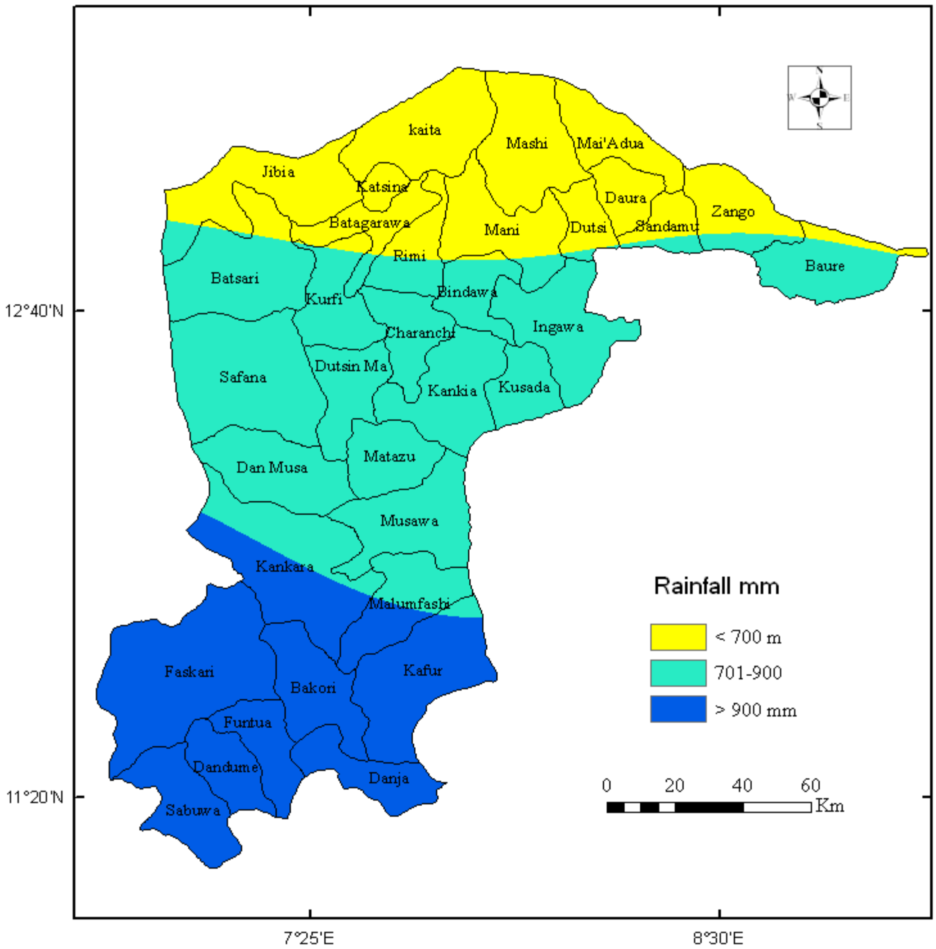
The use of secondary data in this study was considered significant in ensuring quality and authenticity of overall research. The data particularly helped to provide a variety of background information for the research that enabled the construction of a historical profile and baseline context for the study. It also contributed to the development of evaluation tools for particular theoretical and methodological approaches as applied by other social scientists. The primary data (i.e. collected from the field) were collected on household demographic characteristics, quantity of water available and demand through survey of household water budgeting, which was undertaken by examining for every household the daily water need and water use relative to the household sizes. In addition, data were collected on indicators of vulnerability and adaptation to water scarcity, as well as on the factors determining them. Sample of the questionnaire used to collect information on all these items was presented as Appendix I.

4.3 Data Collection

4.3.1. Reconnaissance Survey

At the beginning of this study (February 2012), a reconnaissance survey was conducted across the Local Government Areas (LGAs) belonging to the three main rainfall regions of Katsina State (Figure 4.1). The essence of the survey was to familiarize the researcher with the study area (especially in terms of size and number of households) and identify background information relevant to the study. Between 21/11/2012 and 2/12/12, another reconnaissance survey was carried out across the LGAs selected for the study in order to identify the suitable communities (sampling frame) that were used in the main primary data collection exercises. It was also used to test the capability of the instrument to provide the required data, and to identify communities that would be included in the study. The reconnainance sample data were used in the computation of appropriate sample size given the sampling frame. From the reconnaisance data it was established that there were 34 LGAs with total communities of 5,363 and the household number of 1,130,733. It was the households' number that represented the sampling frame in the study and on which the appropriate sample size calculation, given variations by rainfall zone and number of communities, was based.

Figure 4.1: Main Rainfall Zones in Katsina State



Source: (El-Tantawi, A 2012)

4.3.2 Sampling Frame and Sample Size

From the reconnainance survey results, it was established that at the time of the study, there were (1,130,733) households in Katsina State which were distributed across the three rainfall zones as 403,551 in the north; 405340 in the central and 321842 in the south. From the households, only those using water for domestic purposes within a rural local government area were included in the sampling frame from which the sample data was drawn in this study. From this sampling frame, a sample size of 1200 households, 400 households from each rainfall zone, was drawn using the following procedure:

i) List all households by local government area per rainfall zone

ii) Get the number of households per rainfall zone

iii) Compute the appropriate number of households per zone using the formular (Yamane 1967)

$$n = \frac{N}{1 + N(e^2)} \quad \text{………………Eq(1)}$$

Where:

n = sample size
N = population (number of households per rainfall zone)
e = error margin
1 = constant

For the FGDs, membership was drawn from the same households in Katsina State but only those who did not participate in the general survey were included with each FGD made up of 10 indviiduals from the households. The FGD formation took into consideration the communities across rural Katsina State which were 12 in number thus 12 FGDs. The study further sought information from the key informants in the water sector and the selection was based on local government water supply management structure where the head of water and sanitation was considered to be the key informant. A total of 12 key informants from Daura, Maiadua, Mashi, Kaita, Matazu, Kusada, Charanchi, Safana, Danja, Faskari, Funtua and Sabuwa were included in the sample data.

4.3.3 Sample Size Determination

The issue of determination of sample size remains an unsettled as many formulae exist in the literature. A review of such literature shows that sample size determination methods all assume a normal distribution in which the critical statistics are the mean, standard deviation, and the variance.

Of the many formula available, three (Cochran,1963; Yamane, 1967; Scheaffer *et al*, 1996) appear to be the most widely used among research workers (Israel, 1992; Evans et al, 2000; Dell et al, 2002; Sincich et al, 2002; Särndal *et al*, 2003; Mora and Kloest, 2010).

Cochran (1963) who proposed the following formula for sample size determination for large population:

$$n_0 = \frac{Z^2pq}{e^2} \quad \text{………………..Eq(2)}$$

Where n_0 is sample size; Z^2 is the abscissa of the normal curve at $1- \alpha = 0.95$; e is the desired precision; p is the estimated proportion requiring known N; and q is 1- p. The problem with Cochran's equation is the use of an "estimated proportion." This estimation has its limitation when used for large population and also where *N* is unknown or small. In this study the number of households in each region is known.

Tare Yamane proposed a simplified population proportion method to correct the weaknesses found in Cochran and the finite population correction methods. (Yamane, 1967: 886) proposed the following formula, meant to estimate the upper limit of the sample size, viz:

$$n = \frac{N}{1 + N(e^2)} \quad \text{……………….Eq(3)}$$

Where n is the sample size; *N* is population size and *e* is the error precision level. Yamane creates a table where the minimum sample can be read from a table with two known information: population size and the level of precision. N is large and therefore there is no need for further correction. Except in cases where the population size changes over time, the formula can fit into virtually all sampling settings. In situations where the total population size changes (for instance that of tourists arriving at a tourism site which will vary with season), Yamane's formula cannot be used.

Scheaffer et al (1996) have provided an improved version of the population proportion method employed by Yamane in arriving at his formula. Assuming a small population, the improved method Scheaffer et al (1996). Thus, unlike Yamane (1967) who insists that *N* is given, Scheaffer *et al* (1996) recognizes the uncertainty of *N* and provided the method to estimate the population total that can be used for minimum sample calculation. Scheaffer et al. (1996) thus proposed the estimated population total as:

$$N = \frac{t}{p} \quad \text{.......................Eq(4)}$$

Where *N* is the actual total population, tis tagged and released individuals and *p* is the proportion of tagged individuals to the population.

In this study, the population is all households in rural Katsina state whose population is given from the population census, 2006. Thus, the value of N unstable. Hence, the formula of Tare Yamane appeared to be quite applicable in this study.

4.3.4 Data Collection Instrument

This study used a number of instruments in data collection process and these included the questionnaire, global positioning system receiver, camera, and observation data sheet. These instruments were required in the collection of primary data during field survey. Data sheet was also useful in the extraction of secondary data from the data bases or publications.

The questionnaire used in the study was structured in such away to capture information required to address the research questions, meet the objectives and test the hypotheses (Appendix I). The questionnaire variables were both closed and open-ended where the closed questions were meant to extract information from the respondents fitting to some expected framework. On the other hand, open-ended questions were expected not only to provide the required information but also to solicit for additional insight on the variables of concern. For response control the research assistants had to undergo training on how to handle open ended questions in the execution of questionnaires in the field. The questionnaire comprised four sections (A-D). Section 'A' addressed the background information on the respondents and comprised 9 items and Section 'B' comprised 46 items and addressed indicators of vulnerability to water scarcity. Section 'C' addressed issues related to adaptation to water scarcity and comprised 13 items and Section 'D' comprised 11 items and addressed issues related to factors influencing adaptation to water scarcity.

The questionnaire for focus group discussions was designed on the basis of responses from the field survey so as to capture the information already collected but from a different informed perspective from the communities. The perspective sought from the focus groups related to water resources experiences, water sources conditions, supply, and strategies for gaining access to water.

The observation sheet was used to capture data on number of water sources from each community, presence of streams, rivers, dams, water related activities, water storage facilities, water equipments available, presence of water officials, time for collecting water and the methods of conveyance, distance to reach the water sources. The data sheet was also used to collect information on population in terms of total number, density and spatial distribution from the records of the National Population commission of Nigeria.

Handheld GPS receiver was used to capture the geographical coordinates (longitude and latitude) of each of the 12 communities where the coordinates were to represent the geographic center of every community. The receiver was also used to record locations of all water supply sources in the various communities (Table4.5)

Camera was used to capture some important geographical features relevant to the objectives of the study as at the time of the field survey, such as sources of water supply, indicators of difficulties or challenges' in obtaining water and indicators of adapting strategies in water scarcity hazard.

4.3.5 Sampling Procedure

To get the 1200 households as specified in the sample size computation and which were distributed proportionally according to the three rainfall zones, 400 households per rainfall zone, a multi stage sampling technique was used as the activity involved different procedures at different time. For the proportional distribution of the households, the land surface of Katsina State was first stratified in to three rainfall zones using rainfall condition as the basis of stratification (Figure 4.1). To sample the households, the first activity after stratification of Katsina Land surface was to identify the local government areas in Katsina State which where found to be 34 in number across the rainfall zones (Strata). The next step was to identify 12 communities (Electoral Polling Units) within the 12 LGAs with potential high demand for water. The potential high demand for water was measured by the communities with the highest number of households in LGAs, thus introducing purposeful sampling at this stage.

The LGAs with communities having high potential demands for water were then sampled randomly by first proportionally assigning number of 4 (12 LGAs distributed proportionally) LGAs per rainfall zones and then drawing the 4 LGAs per zone using random method. The random method was carried out by assigning each of 34 LGAs a random number which was then placed in a container whose contents were thoroughly mixed for fair chance of being drawn. The LGAs were then drawn by picking the first 4 with replacement to keep the chance of an LGA being included the same for each rainfall zone resulting in 12 LGAs. The resulting LGA data constituted sampling clusters which were resampled using simple random technique for the households to be included in the 1200 households sample data resulting in 100 households per community being included. To do this, a list of all the households in the selected 12 communities per 12 LGAs was drawn and then distributed according to the rainfall zones allocations. The 4 commuinties per 4 LGAs per rainfall zone were randomly sampled by assigning all the households random numbers which were then placed in a drawing drum. The first 100 numbers were then included in the sample with replacement but ensuring no duplication of the drawn numbers. This resulted in 400 households in the whole sample distributed proportionally across the three rainfall zones.

From the 400 households, only those designated as head of the household were included in the survey sample data. This was because the study assumed that the head of the household was the decision maker in resourse allocation and use. Water as a resource within the communities would have required decision making in allocation and use where the head of the household was expected to be a major player.

Table 4.4: Distribution of Total and Selected Communities across the Three Rainfall Zones in the Study Area

Isohyet Zone	Number of LGAS Per Zone	Local Govt. Area	Number of Commu-nities[a]	Total House-holds[b]	Estimate Number of Households per Community for the zone	No. of Households to Study in the Zone (Selected using Yaro Yamani Formula)[c]
Northern	12	Jibia	164	30,778	**221**	**400**
		Katsina	281	52,835		
		Batagarawa	153	34,678		
		Mani	166	32,920		
		Dutsi	89	22,915		
		Sandamu	127	26,105		
		Maiadua	169	36,953		
		Mashi	154	32,046		
		Kaita	119	34,581		
		Rimi	151	29,180		
		Zango	108	29,359		
		Daura	144	41,201		
		Sub-Total	***1825***	***403,551***		
Central	14	Batsari	184	38,342	**207**	**400**
		Kurfi	111	20,970		
		Safana	136	34,391		
		Danmusa	141	20,779		
		Matazu	106	21,418		
		Musawa	118	31,639		
		Kankia	135	29,407		
		Ingawa	129	32,498		
		Kusada	81	17,634		
		Bindawa	154	29,020		
		Dutsinma	143	30,939		
		Malumfashi	227	34,022		
		Baure	184	38,765		
		Charanchi	108	25,516		
		Sub-Total	***1957***	***405,340***		
Southern	8	Faskari	157	35,423	**204**	**400**
		Funtua	202	39,600		
		Danja	133	23,112		
		Bakori	172	26,949		
		Kafur	176	37,468		
		Dandume	115	25,951		
		Sabuwa	73	25,170		
		Kankara	*205*	*43,752*		
		Sub-Total	***1581***	***321,842***		

Sources: (a) INEC (Independent National Electoral Commission) Katsina State (2011) Directory of Polling Units in Katsina State. Published by Katsina State, INEC.

(b) NPC (National Population Commission) 2006 National Population and Housing Census. NPC, Abuja.

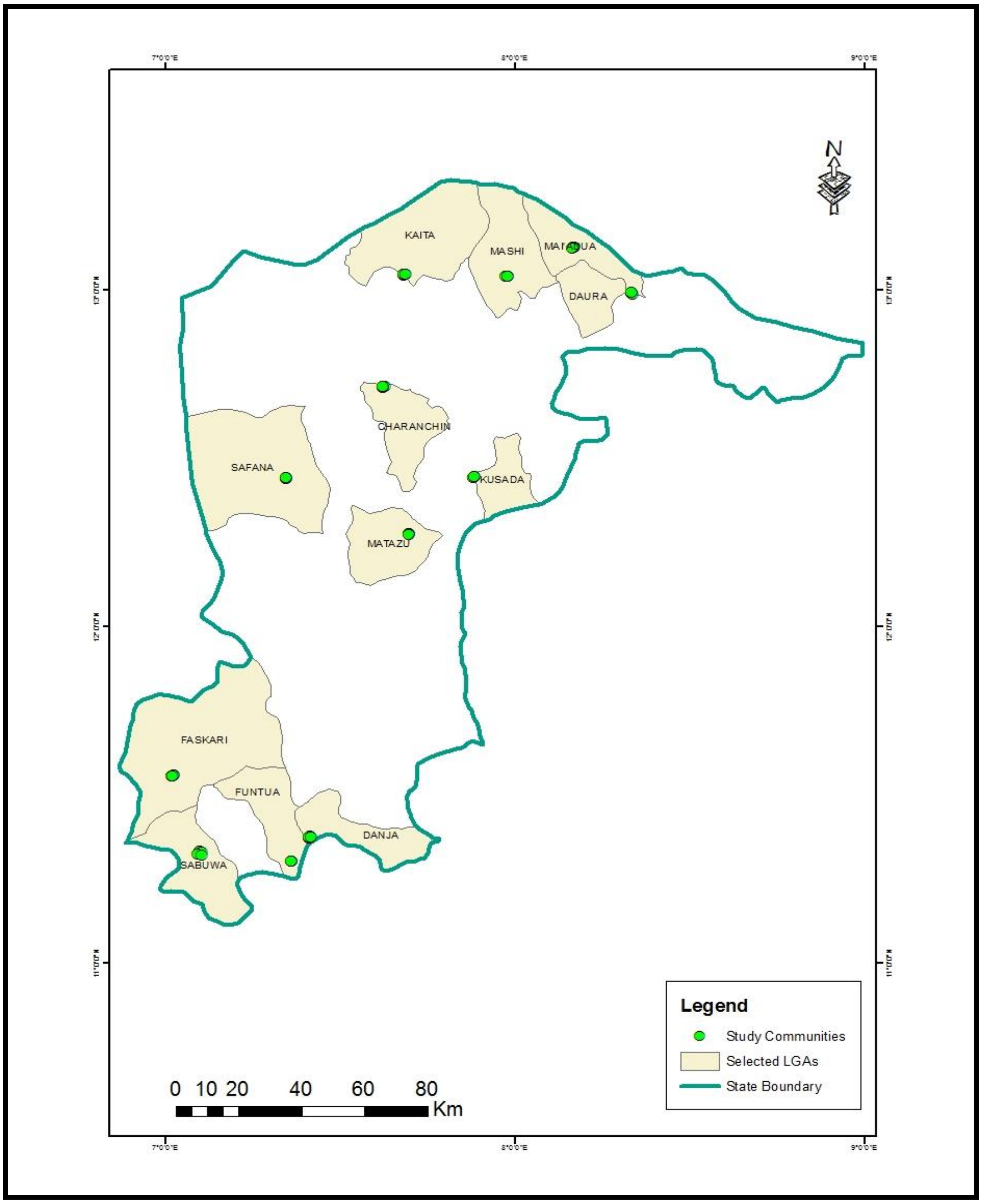
(c) The Taro Yamane (1967) formula for calculating sample size

Table 4.5: Details on the Communities and Households Studied

Rainfall Zone	LGA	Community Studied	Longitude	Latitude	Household Size of the Community	No. of Respondents Studied
North	Kaita	Walawa	7.685870	13.048282	264	100
			7.682705	13.045449		
			7.682587	13.049484		
			7.687715	13.047362		
	Mashi	Gyarta	7.973768	13.041326	326	100
			7.978987	13.041477		
			7.980494	13.042418		
			7.979186	13.043521		
	Maiadua	GwajoGwajo	8.170588	13.127755	421	100
			8.167777	13.127065		
			8.166769	13.128591		
			8.166060	13.125393		
	Daura	Gurjiya	8.335984	12.990811	247	100
			8.333881	12.990027		
			8.336917	12.988574		
			8.335994	12.993884		
Central	Safana	Yarsanta	7.345787	12.442276	348	100
			7.346275	12.441427		
			7.346495	12.442611		
			7.345240	12.443187		
	Kusada	Kofa	7.882476	12.444591	256	100
			7.882460	12.443229		
			7.885255	12.445691		
			7.883785	12.447221		
	Matazu	Malamawa	7.696964	12.277245	354	100
			7.697597	12.276500		
			7.696239	12.276149		
			7.696846	12.275080		
	Charanchi	Kuraya	7.630112	12.714572	285	100
			7.624598	12.713002		
			7.623374	12.710574		
			7.621733	12.714101		
South	Funtua	Ashraha	7.360979	11.302589	265	100
			7.359831	11.30372		
			7.361097	11.303252		
			7.362401	11.303231		
	Danja	Tudun-jae	7.328353	11.292053	324	100
			7.328997	11.290927		
			7.326733	11.290169		
			7.327849	11.290874		
	Faskari	Maigora	7.025833	11.558611	428	100
			7.023461	11.560993		
			7.019491	11.558103		
			7.022656	11.556947		
	Sabuwa	Damari	7.242286	12.790971	322	100
			7.240371	12.790856		
			7.241841	12.789752		
			7.241256	12.792399		

Source: (Researcher, 2013)

Figure 4.2: Spatial Distributions of the 12 Studied Communities Across the 12 LGAs Selected Across the Three Rainfall Zones of Rural Katsina State



Source: (Researcher, 2013)

A copy of the questionnaire was made for administration to each of the 1,200 households across the three rainfall zones. Table 4.5 gives details on the distribution of the questionnaire. The reconnaince survey had found the literacy level in the study area was very low and this made it very difficult for most of the respondents to understand and complete the information needed on the questionnaire. Consequently, the researcher and the assistances had to administer the questionnaires through in-depth interviews to get the appropriate responses to the questions which were both open ended and closed.

The Household surveys were undertaken over a period of 6 months (December 2012 and June 2013). Over the 6 months period, several visits were made to the selected communities. With the help of twenty four research assistants (two per each of the 12 communities), the households selected for the interviews were first informed of the period of visit in order to prevent a conflict between personal schedules of the respondents and the interview period. Households that did not mind to be interviewed at any time were interviewed immediately they were seen during the visits. This proved very convenient and saved considerable time for the researcher. During the interview sessions for every household, the researcher and field assistants read out the questions and explained them in local Hausa language and the responses were filled in the relevant section immediately. In that way, the contents of all the 1,200 questionnaires (for the 1,200 households) were filled.

Plate 4.1: Key Informants Interview Session at Gwajo Gwajo Community, Maiadua LGA

Plate 4.2: Making Personal Observation at a Site of an Abandoned Borehole at Yar Santa Community, Funtua LGA

During the field survey, it was important to record events or features within the survey area that were of interest to the study. This was done through systematic observation which resulted in generation of information that was used qualitatively in discussing the results of the survey data analyses. The use of observation data was recognized as one of the primary sources of data collection normally used in qualitative research, because observation results tend to reflect the natural occurrence (Bogden and Biklen, 1982).

Plate 4.3: Key Informants' Interview with Officials of Katsina State Rural Water Supply and Sanitation Agency

Plate 4.4: A Focus Group Discussion Session with Select Members of Kofa Community, Kusada LGA

Observations were made on key items of interest to this study and these included water supply source, water supply infrastructure, nature of water abstraction, techniques of conserving the water, water conveyance and, distance to water source. At each observation point, a photograph of the environment was taken followed by detailed record on field note book of feature characteristics to be used in descriptive analyses.

For the FGDs, the researcher administered the questionnaire in a purposeful way where a single questionnaire was used to seek group response to particular issues which had earliar been identified in the general survey as contentious, lacking in clarity or not mentioned and yet observed by the researcher as a potential issue in water scarcity in rural Katsina State. The participation was open to all focus group members but the recorded response for each issue discussed must have been a concensus. Where no concensus was reached, the elder was mandated to provide a response.

FGD membership was based on age which must have been 40 years and willingness to participate. Focus Group Discussion (FGD) was considered as a rapid appraisal technique that involved a semi-structured discussion planned to address the study objectives (McNamara, 1999; Babbie, 1995). The use of FGD in data collection was based on the view that it offered socially oriented data collection platform which was flexible and also providing a chance for face to face data validation thus, speedy results. The discussions were expected to bring out aspects of the topic that would not have been anticipated by the researcher and would not have emerged from interviews with individuals. Through FGDs, the affected individuals and communities were able to speak for themselves, which resulted in the provision of knowledge that enhanced the capacity to understand the viewpoint of local people.

Before undertaking the FGD sessions, the various communities were informed through community leaders and motives and intentions were made clear to eliminate mistrust and suspicion. An FGD was held at every community at a date mutually agreed upon between the researcher and community members. The FGDs were undertaken to collect historical data about the water resources experiences, adaptation strategies, also to gather information and personal narratives about the conditions for water sources, supply, what strategies are employed for attaining access to water, and what people thought and knew in relation to these issues. The FGD sessions across the twelve studied communities were carried out over a period of 1 month (June and July 2013).

For some specific information, key informants were contacted to provide data required especially on water resources, supply, challenges and adaptation strategies. The key informants in this study were the RUWASSA officials, LGA water and sanitation staff. Information obtained from these individuals was used to compliment data collected from focus groups, households' survey and secondary sources especially at the interpretation and discussion stage. For any official to be considered a key informant he must have been accepted by either other staff members as head of the section from which the information was sought which in all cases meant the custodian of the required information. The questionnaire for the key informants was administred purposefully since RUWASSA and the head of LGA water department were considered to be the custodian of water information and for this reason, the centre and all the 12 heads of water departments in the 12 LGAs were interviewed using a specifically designed questionnaire for specific information from the official perspective.

During the general survey, FGDs and interviews in the field, attempt was made to locate the position of water facilities using GPS receiver. The facilities whose positions were recorded included the boreholes, wells and, surface water bodies (rivers and ponds). For each position marked using GPS, a photographic record was made in order to assist in creating an attribute data base which could be compared with the information received from the other field surveys. The camera and field observation sheet were used not only capturing the location attributes but also other information on vulnerability to water scarcity in rural Katsina State which were apparent.

4.4. Data Processing and Analysis

4.4.1. Data Processing

Field data from questionnaire was first assembled in to a single sample data in the form of a data code sheet. For the open ended questions, all the responses per question were first compiled, and then assigned meaning in the context of vulnerability to water scarcity before including in the coding sheet. The coding sheet and associated data was then used to design a data entry interface in excel and SPSS. Data entry was approached from the basis of quality assurance protocol where each case was entered twice by different data entry assistants and at the end of data entry exercise a comparative analysis of the two database files was done to limit data entry errors.

A frequency distribution analysis on all variables was used as a tool for identifying outliers and missing responses which were confirmed with the results in the questionnaires. The clean data fileswere used to create the study database file from which all the variables required to address the stated questions were available.

FGD information data from the communities included in the study were compiled into one data file and this was then subjected to a cleaning process to ensure clarity and comformity to the information sought as well as to reduce data entry errors. Clarity and comformity were particularly informant in the FGD data because in some cases participants were saying the samething but in different ways. The resulting information was summarized and re-written so as to fit the key issues discussed with each community. The data summary was organised community by community to ensure that the important questions and associated responses were captured. Attendance of each FGD session by the reascher was used as quality control and assurance measure. The FGD data file was used to generate information that was used in supporting or in validating the results of the household survey. Key informants interview information discussed were recorded in common data sheet which was then captured as a data file using excel and SPSS. The data file was then subjected to a cleaning process to ensure clarity and comformity as well as minimum sampling errors.

Observation sheet information was recorded in such away that every item observed was under the sub heading assigned according to its relevance in the water vulnerability study. The results were a table of observed features that related to specific variables in the households and FGD data files. The GPS observations were used to relate the household data, FGD data and observation data to specific location on rural Katsina State.

Data processing was used as a quality assurance measure to ensure integrity in the resulting data files.The data files were used in creating information required for answering the research questions and meeting the study objectives through data analyses procedure as explained below.

4.4.2 Data Analyses

To extract background information and, characteristics of households' vulnerability, adaptation to water scarcity from the sample data, this study applied basic descriptive analysis techniques of cross tabulation and frequency tabulations to provide both spatial and distribution tendencies required in the descciption of the vulnerability to water scarcity in rural Katsina State. The results of the descriptive data analyses were, in this study, the basis for higher statiscal technique. For each of the data analyses discussed below, the results were checked against the FGD data and the key informant data which were scripted to aligned with the relevant objective. In scripting the FGD data and key informant data, the intention in all cases was always to capture key responses with regard to the objectives of the study. Scripting is a very useful tool in analyzing nominal measurements (qualitative information) as it assists in clarifying results of the quantitative analyses and also providing platform for theory development or theory validation on the subject matter.

4.4.2.1 Determining Water Vulnerability Index

The UN estimated water availability per capita as 20 litres per day (WHO, 1996) but this estimate does not take into account the differences in water availability by specific members of a household. Water availability in a household may be affected by age where an adult may require up to 20 liters while child may not require far lessthan the UN estimate. The study, therefore, did not use the UN esmate as a measure of water availability to avoid over estimation.

Consequently, vulnerability to water scarcity in this study was determined through interviewing individual households on actual water availability and water demand from which water scarcity vulnerability index in the study area was generated as.

$$WSVI = 1 - \left(\frac{HHWA}{HHWD}\right) \times 100 \quad \text{…………………Eq(5)}$$

Where:

- WSVI is Water scarcity vulnerability index
- HHWA is Household water availability
- HHWD is Household water demand
- 1 was the value of water sufficiency a household should have if all its water demands are met

The ratio between water demand and availability of a household was used to define the water sufficiency of the household. This was expressed using a simple index:

$$\text{Water Sufficiency} = \left(\frac{\text{HHWA}}{\text{HHWD}}\right) \times 100 \quad \text{……………..Eq(6)}$$

Depending upon the ratio between what was demanded and what was made available to it, the water scarcity vulnerability index values were obtained using the above formula and this could be as low as 0% and as high as 100%. This means that practically, the lower the values the lower the vulnerability index of a household and the higher the value the greater the vulnerability.

Further analyses of the above scenario and in comparison with the classifications developed by other research workers (e.g Birkman, 2006; Heapet al,1998) enabled the study to develop a vulnerability classification system that was used in the interpretation of the results obtained from the conduct of household survey (Table 4.6).

Table 4.6: Interpretation Table for Classifying Vulnerability to Water Scarcity

Vulnerability Class	**Range of Values of Household Water Scarcity Vulnerability Index**	**Class Definition**
I	0%	No scarcity
II	>0 - 5%	Low Scarcity
III	6 – 15%	Moderate Scarcity
IV	16 – 35%	High scarcity
V	Above 35%	Acute Scarcity

The vulnerability index calculation involved a number of data mining procedures that required small computation programs to be written both in excel and SPSS to generate new variables in the sample database. This then was followed by running frequency analysis and crosstabulation analysis procedures in the descriptive statistics menu of SPSS.

4.4.2.2 Testing for Difference in Vulnerability to Water Scarsity

It was important in this study to consider differences in vulnerability to water scarcity by household and by rainfall zones. Differences in vulnerability by households were tested using the vulnerability indices as a single sample in t-test. The single sample t-test was computed using the formula:

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} .... Eq(7)$$

Where

$\bar{x}$ = Sample mean

μ_0 = Population maean

s = Sample standard deviation

n = Sample size

The single sample t-test did not provide a measure of difference by rainfall zone and this required more than two groups of vulnerability measurements. The households' vulnerability indices organized by rainfall zones were subjected to ANOVA and the procedure was as followss:

1. Estimate the within variance and between variance by first computing the total variation about the mean for all samples using the formula:

$$\sum_{i=1}^{N} \left(X_i - \bar{X} \right)^2 ....Eq(8)$$

2. Partition the total variation

	Rainfall Zones of Katsina			**Total**
	North	**Central**	**South**	
Scores	X_{11} X_{21} X_{31} . . X_{N11}	X_{12} X_{22} X_{32} . . X_{N22}	X_{1k} X_{2k} X_{3k} . . X_{Nkk}	
Sums	$\sum_{i=1}^{N_1} X_{i1}$	$\sum_{i=1}^{N_2} X_{i2}$	$\sum_{i=1}^{N_k} X_{ik}$	$\sum_i \sum_j X_{ij}$
Means	$\bar{X}_{.1}$	$\bar{X}_{.2}$	$\bar{X}_{..k}$	$\bar{X}_{..}$
Number of cases	400	400	400	1200

Where

- the individual scores are represented by X_{11}, X_{21},…X_{ij}, the sample means by $\bar{X}_{.1}$, $\bar{X}_{.2}$,… $\bar{X}_{..k}$, and **grand** mean by $\bar{X}_{..}$.
- the dots are used in the subscripts in order to distinguish column means from row means which are used when adding a second nominal scale.
- X_{ij} represents the score of the i^{th} individual in the j^{th} column.
- The sum $\sum_{i=1}^{N_1} X_{i1}$ indicates the N_1 scores in the first column are summed and the same is true of the remaining columns.

The total variation is, therefore, the difference between individual scores within a rainfall zone and its mean score and the difference between the category mean and the grand mean.

3. Square both sides of the equation $X_{ij} - \bar{X}_{..} = (Xij - \bar{X}_{.j}) + (\bar{X}_{.j} - \bar{X}_{..})$ to get:

$(X_{ij} - \bar{X}_{..})^2 = (Xij - \bar{X}_{.j})^2 + 2(Xij - \bar{X}_{.j})(\bar{X}_{.j} - \bar{X}_{..}) + (\bar{X}_{.j} - \bar{X}_{..})^2$ which is the sum of square deviations for all individuals

4. To achieve, first sum down each column and then add the resulting figures for each category making the middle term zero since summing down any particular column of a constant results in a zero. The equation in step 3 then becomes

$$\sum_i \sum_j \left(X_{ij} - \bar{X}_{..}\right)^2 = \sum_i \sum_j \left(X_{ij} - \bar{X}_{.j}\right)^2 + \sum_i \sum_j \left(X_{.j} - \bar{X}_{..}\right)^2 \quad \text{……Eq(9)}$$

Total Sum of Squares (TSS) = Within Sum of Squares (WSS) + Between Sum of Squares (BSS).

5. The total variation can be partitioned into two parts:

- The ***Within Sum of Squares*** which is used to obtain the first estimate of the common variance σ^2. The Within Sum of Squares is written as

$$\sum_{i=1}^{N_1} \left(X_{i1} - \bar{X}_{.1}\right)^2 + \sum_{i=1}^{N_2} \left(X_{i2} - \bar{X}_{.2}\right)^2 + \ldots + \sum_{i=1}^{N_k} \left(X_{ik} - \bar{X}_{.k}\right)^2 \quad \text{……Eq(10)}$$

- The **between Sum of Squares** is obtained by involving the deviations of category means from the grand mean. It is a measure of the variability between samples. The second estimate of the variance is based on the between sum of squares.

The between Sums of Squares is the explained variation while the within Sums of Squares is the unexplained variation. The within variations is referred to as unexplained variation because it is a variation which is not accounted for by the categorised variables. It is the amount of variability within the categories as compared with differences between them, which determines how closely the two variances are associated.

6. Estimate the two variances from the two separate sums of squares through division by the approximate degrees of freedom, N-1, since $\hat{\sigma}^2$ is unbiased estimate of σ^2, 1 degree of freedom having been lost through the computation of the grand mean $\bar{X}_{..}$. For the between sum of squares, which represents the sum of squared deviations of the k sample means from the grand mean, the degrees of freedom is k-1 where k is the number of categories (3), one having been lost because of the fact that the weighted average of the $\bar{X}_{.j}$ must be $\bar{X}_{..}$. In the case of the within class estimate, 1 degree of freedom is lost in each column through the computation of the $\bar{X}_{.j}$. For the within sum of squares the degree of freedom is N-k where N is the number of observations (1200). The Total degrees of freedom is N-1 = (N-k) + (k-1)

The two estimates of the common variance therefore become:

- Within estimate = $\dfrac{\sum_i \sum_j \left(X_{ij} - \bar{X}_{.j} \right)^2}{N-k}$ ……..Eq(11)

- Between estimate = $\dfrac{\sum_j \left(\bar{X}_{.j} - \bar{X}_{..}\right)^2}{k-1}$ ……..Eq(12)

The expected value of the within estimate is σ^2, regardless of whether or not H_0 is true.

7. The expected value of the between estimate, however, is

$$\sigma^2 + \frac{\sum_{j=1}^{k} N_j(\mu_j - \mu)^2}{k-1} \quad \text{……Eq(13)}$$

Compute F statistic by dividing the between estimate by the within estimate, as summarised below:

	Sums of Squares (SS)	Degrees of freedom (df)	Estimate of variance	F
Total	$\sum_i \sum_j \left(X_{ij} - \bar{X}_{..}\right)^2$	N-1		
Between	$\sum_j \frac{\left(\sum_i X_{ij}\right)^2}{N_j} - \frac{\left(\sum_i \sum_j X_{ij}\right)^2}{N}$	K-1	$\dfrac{\sum \frac{\left(\sum_i X_{ij}\right)^2}{N_j} - \frac{\left(\sum_i \sum_j X_{ij}\right)^2}{N}}{k-1}$	
Within	TSS – Within SS	N-k	$\dfrac{TSS - betweenSS}{N-k}$	

8. Decide to reject or not to reject the null hypothesis by comparing the computed F with the critical F at the stated confidence level ($\alpha = 0.05$), where if the computed F is greater than critical F, the null hypothesis that there was no significance in vulnerability to water scarcity between the three rainfall zones in Katsina State and any difference was a chance event was rejected. On the other hand if the computed F was less than or equal to the critical F, the

null hypothesis was not rejected and the conclusion was that there was not enough evidence from the collected data to reject the null hypothesis and therefore rainfall zones alone could not be relied on to provide satisfactory explanation for the observed differences in vulnerability to water scarcity in Katsina State.

Since the ANOVA procedure is long the explained process was facilitated by SPSS using the one way ANOVA procedure in the test of mean analyses.

4.4.2.3 Determinig Differences in Strategies and, Determinants in Adaptation to Water Scarcity

The strategies and determinants in adaptation to water were considered crucial elements to vulnerability to water scarcity and for this reason it was important to determine if the observed differences in strategies and determinants were chance events or significant characteristics of rural Katsina State. To do this, the study recognized the possibility of households and/or communities having more than one strategy in dealing with water scarcity and that there could be more than one strategy in adaptation to water scarcity across the three rainfall zones. To deal with more than one response, a variable was created whose inputs were responses from other variables dealing with different responses to the same issue and the resulting variable was a multiple response. The multiple response variables was used to create a frequency table which when ordered provided rank response in terms of strategies and this provided a hierarchy of strategies. The hierarchy of response strategy for each rainfall zone was generated by subjecting the multiple response variable to a cross tabulation analyses where the zone was the classification control variable. The results of multiple response cross tabulation by rainfall zone which were in the form of frequency scores of strategies by zone were entered in a chi-square test procedure to test the hypothesis that the differences in strategies by rainfall zone were chance event and, therefore, not representative of the water scarcity adaptation situation in rural Katsina State. The tests in all cases were at α 0.05 with varying degress of freedom.

The chi-squares test was also used where data were frequency scores even in cases where there are no multiple responses but the data on the indicators were frequency scores and ANOVA could not be used. The formula used in computing the chi-squres statistic was:

$$\chi^2 = \frac{(O - E)^2}{E} \quad \text{……..Eq(14)}$$

Where

O = the observed frequency

E= expected frequency

The expected frequency was computed using the formula:

$$E = \frac{\text{Row Total} \times \text{Column Total}}{\text{Ground Total}}$$

Where data measurements were at the scale level in determinants of vulnerability to water scarcity in the three zones as was the case of expenditure the ANOVA (see test of difference in vulnerability to water scarcity). Accordingly, the chi-squares statistic and ANOVA were used where appropriate to test the following four working hypotheses of the study:

i. There are no differences in the vulnerability to water scarcity among households in the three different rainfall zones in rural Katsina State.
ii. There are no differences in the specific determinants of vulnerability to water scarcity across the three rainfall zones in rural Katsina State
iii. There are no differences in the kinds of adaptation strategies employed by households to cope with water scarcity in the three different rainfall zones of rural Katsina State
iv. There are no differences in the determinants of strategies of adaptation to vulnerability to water scarcity across the three rainfall zones of rural Katsina State.

The procedure above was carried out on SPSS platform.

4.5 Scope and Limitations

The study was focused on vulnerability to water scarcity and adaptation among the rural communities of Katsina State. A rural community was used here to refer to all communities outside the headquarters of the 34 Local Government Areas of the State. Local Government headquarters usually have some elements of urban characteristics (presence of amenities, high population density, type of employment etc) across the State and for this reason they were therefore not considered in the to water scarcity assessment. The urban areas tend to have priority in service and resource allocation and were therefore expected to distort vulnerability indices in rural Katsina State.

In the identification of the most vulnerable households to water scarcity, consideration was given to the water demand and availability in terms of the households' size but individual vulnerability in the households was not taken in to consideration. This study was generally focused on the identification of the most vulnerable households, adaptation strategies and factors affecting adaptation, all from the perspective of either the households or the communities in the domestic water scarcity problem of rural Katsina State. The approach in dealing with vulnerability to water scarcity was not hydrological neither was it meteorological but more of household or community defined approach. This study did not, therefore, seek to work out the water balance as a vulnerability index component neither did it consider quality of water from the various sources.

CHAPTER FIVE: RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents and discusses the results of data analyses based on collected data in this study. The presentation and discussions were guided by the objectives of the study as well as the responses from the field. Table 5.1 to 5.33 and Figures 5.1 to 5.60 present the responses received on the major issues considered to assess water scarcity vulnerability and adaptation conditions of the various communities studied across the three rainfall zones in rural areas of Katsina State.

5.2 Profiles of the Households Studied

The study findings figure 5.1 indicated that across the three rainfall zones, (94% in the north, 91% in the central and 98% in the south) of the respondents were male and this reflects the cultural household hierarchy in Katsina State since the study sampled only the head of households. Katsina State is located in the extreme north-west Nigeria which is predominantly a conservative Hausa-Muslim society in which female heading of households is very uncommon. Decision making in the households especially on resource is the responsibility of the head of household especially in the Hausa society. It was the view of the study that water scarcity was a resource use problem that required the custodian of decision making involvement.

Figure 5.2 showed that majority of the respondents (92% in the north, 93% in the central and 97% in the south) were married across the three zones while the figures for widowed and divorced were generally very low across the study area. This is not unexpected as in Islamic tradition; it is very much encouraged that someone gets married as soon as he/she reaches the marriageable age, as being married is more or less considered as being synonymous to being responsible. In the event of death, no much time is taken before replacement is made of the deceased wife/husband. In terms of water scarcity, marital status affects the house structure in decision making which inturns affects strategies and adaptations and thus vulnerability.

Figure 5.1 Gender Profile in the Communities Studied across the Three Rainfall Zones of Rural Katsina State

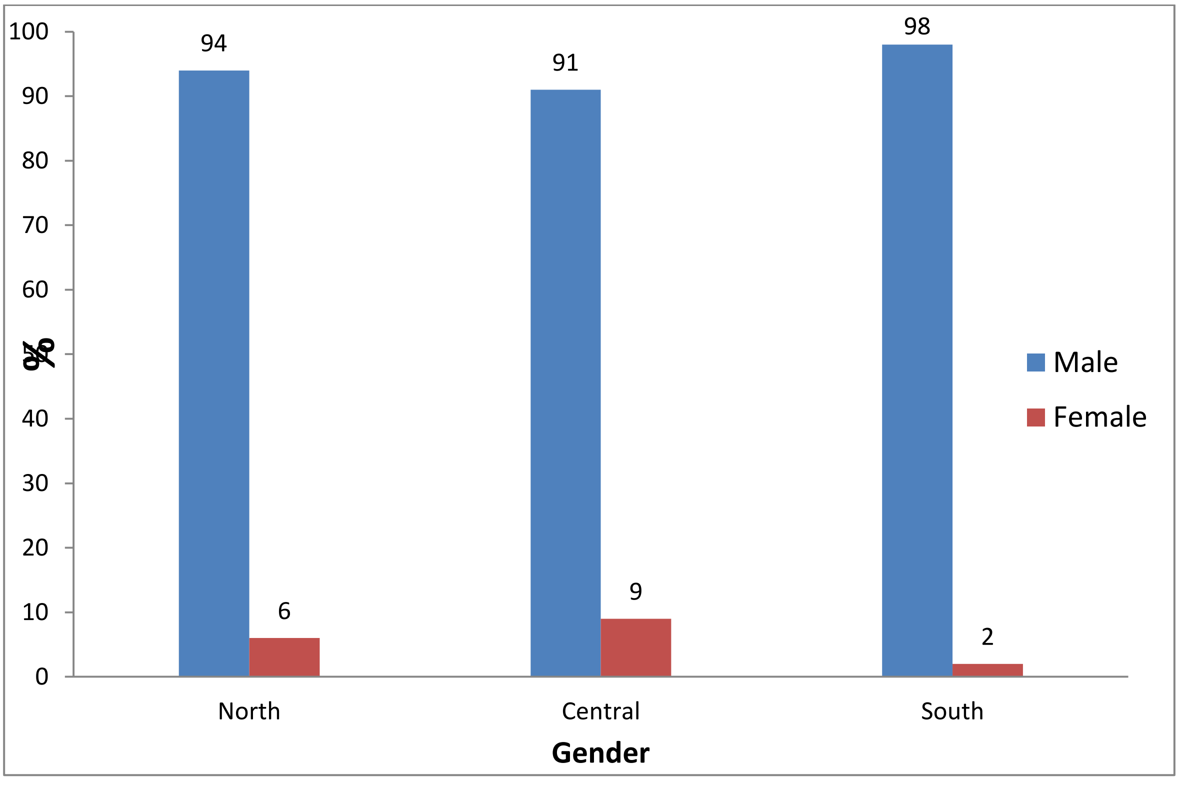


Figure 5.2 Marital Status in the Communities Studied across the Three Rainfall Zones of Rural Katsina State

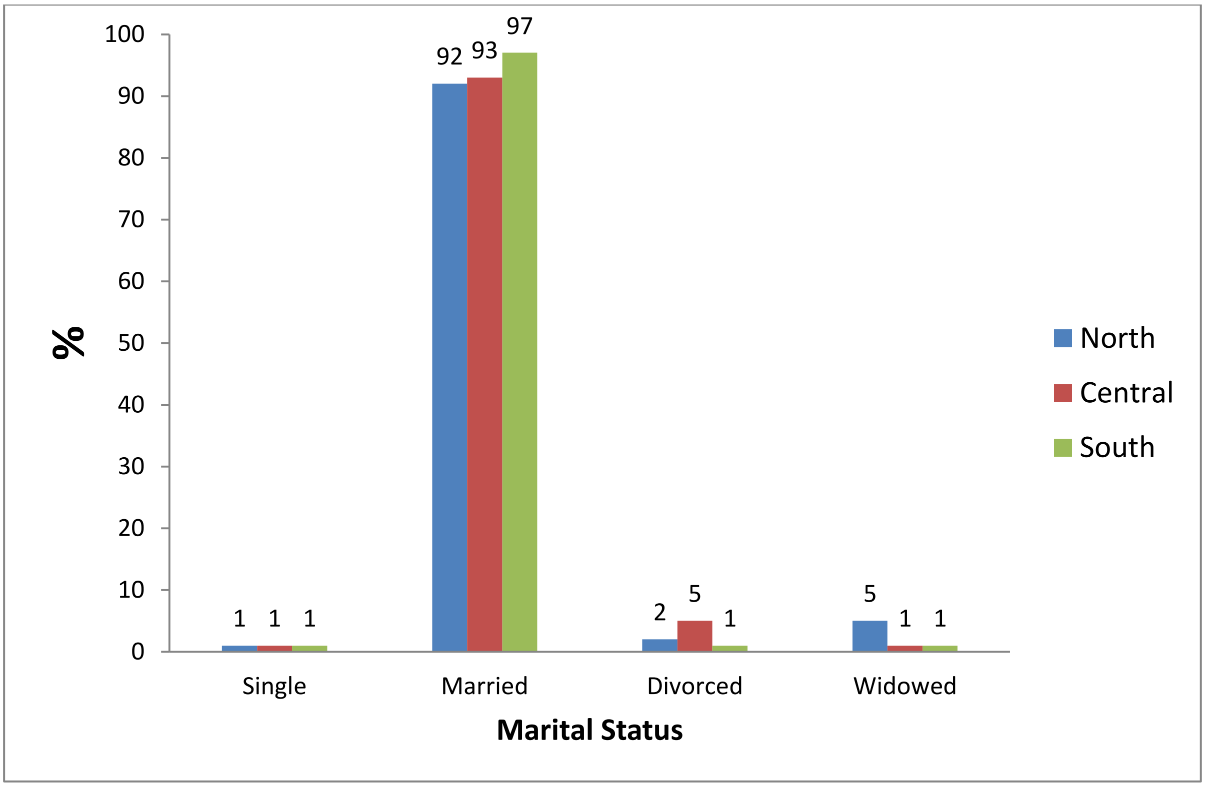


Table 5.1 Household Size across the Three Rainfall Zones of Rural Katsina State

Household Size	Rainfall zone		
	North	Central	South
1-5 Members	168(42%)	176(44%)	56(14%)
6-10 Members	156(39%)	120(30%)	152(38%)
11-15 Members	44(11.0%)	52(13%)	72 (18%)
16-20 Members	24(6%)	32(8%)	64(16%)
21 and Above Members	8 (2%)	20(5%)	56(14%)

Table 5.1 and Figure 5.3 gives data on household sizes of the respondents and it indicated that the pattern of household sizes varies clearly between the three rainfall zones. The average households size in the study area was 9 but when evaluated by rainfall zone there was indication of decrease of households size from south to north, the south zone had an average of 13, central 8 and north 7 the results which when subjected to a one way ANOVA at α=0.05 was found to be significant (F computed 77.2 and F critical 3.0). This difference in households' sizes by rainfall zone could mean differences in water demand and therefore differences in vulnerability to water scarcity. This argument is based on the assumption that the greater the number of household size, the greater the demand for water and if it this, in a water scarcity area, then expectedly the vulnerability to water scarcity. From the preceding discussion it is clear that the south should be vulnerable to water scarcity in terms of households' size but this is not true since the south has more rainfall than the two other zones. It could be, therefore, household size in rural Katsina State was affected by water availability and this could explain the decrease from south to north as far as the rainfall condition.

Figure 5.3 Household Size in the Communities Studied across the Three Rainfall Zones of Rural Katsina State

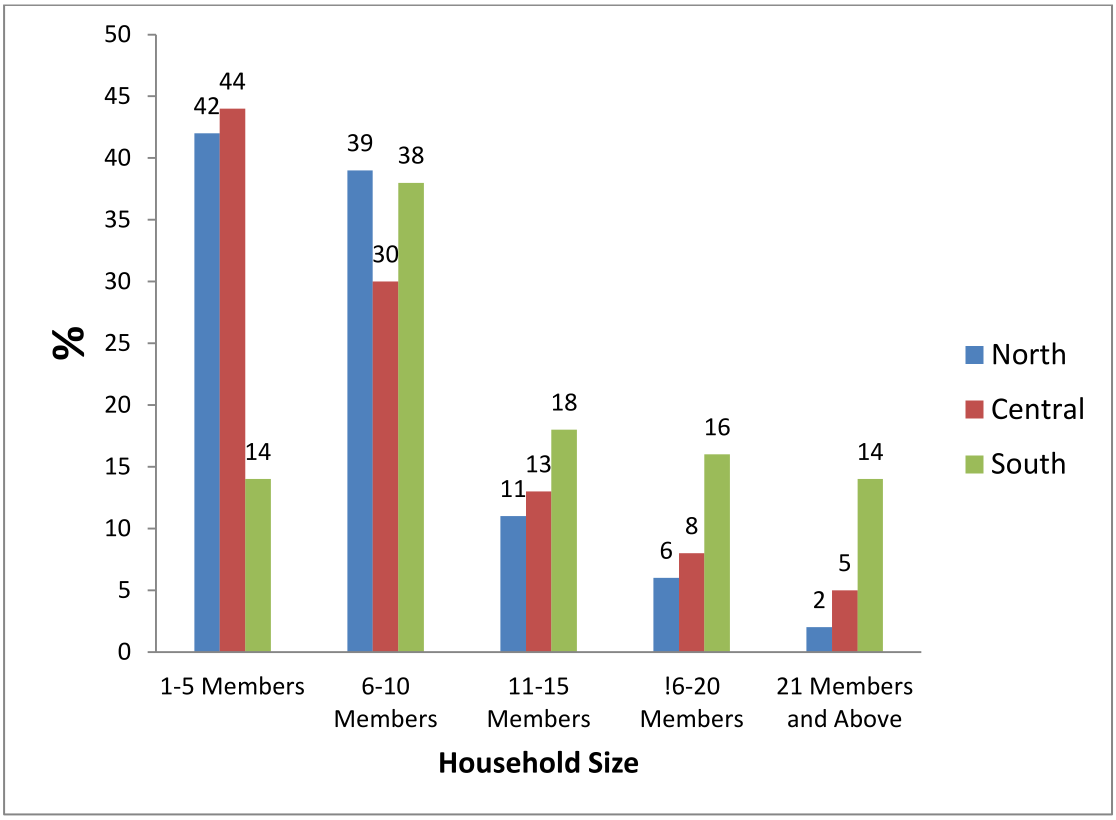


Figure 5.4 Age Profile in the Communities Studied across the Three Rainfall Zones of Rural Katsina State

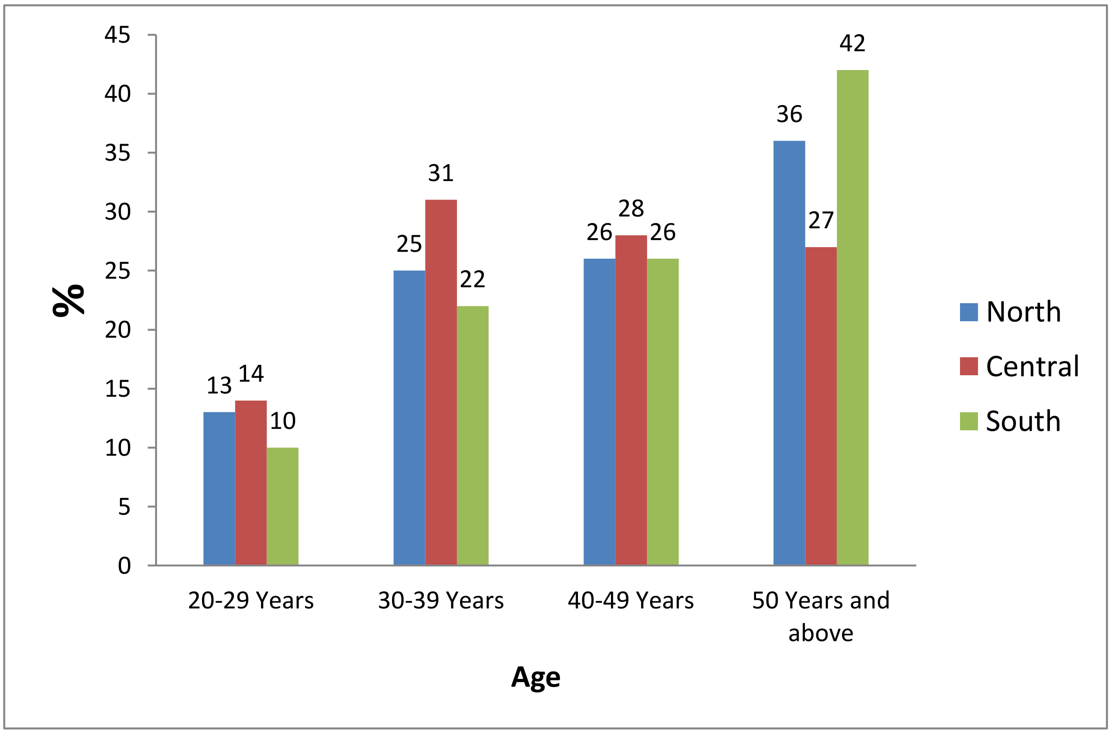


Figure 5.4 gives the age profile of the respondents across the three zones. It could be seen from the figure that (13% in the north, 14% in the central and 10% in the south) of the respondents across the three zones are less than 30 years of age and (25% in the north, 31% in the central and 22% in the south) are less than 40 years of age. These indicate that about 60% of the respondents were in general above 40 years of age. The middle to old age nature of the heads of households in the area is partly expected given that the family system being practiced in Hausaland of northern Nigeria is such that the most elderly in a household is usually the head. In situations where there is more than one family (i.e. husband, wife and siblings) within the same household (such as where a father and his sons together with their wives are dwelling within one household), the father being the most elderly is automatically the head. In the event of his demise, the most elderly male child becomes the head. This kind of an extended family kinship as practiced in the study area has a practical implication on water demand. It specifically suggests that one household may end up having much higher water demand than what a typical household may require on a world scale.

Various household and demographic surveys conducted in Nigeria (McDonald et al, 2000; Adegbija, 2003; NPC, 2006; NBS, 2012; UNDP, 2013), indicated that literacy level and school enrolment in Hausaland of northern Nigeria are low. The results obtained in this study on highest educational level of the respondents (Figure 5.5) indicated that less than 40% ever went through any form of formal, western education and less than 23% ever went beyond secondary education level. This could mean over reliance on traditional knowledge of water scarcity strategies and adaptation, thus low uptake of modern or scientific means of limiting vulnerability to water scarcity.

Figure 5.5 Highest Educational Level in the Communities Studied across the three Rainfall Zones of Rural Katsina State

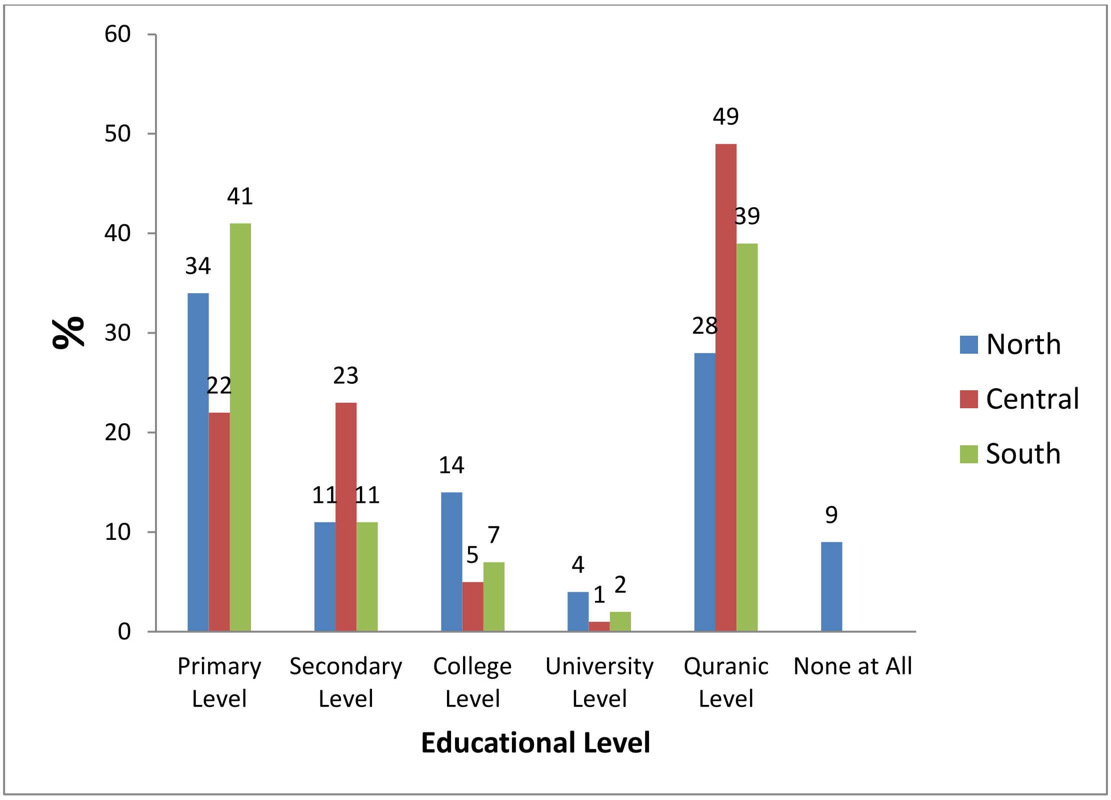


Figure 5.6 Ethnic Composition of the Communities Studied across the three Rainfall Zones of Rural Katsina State

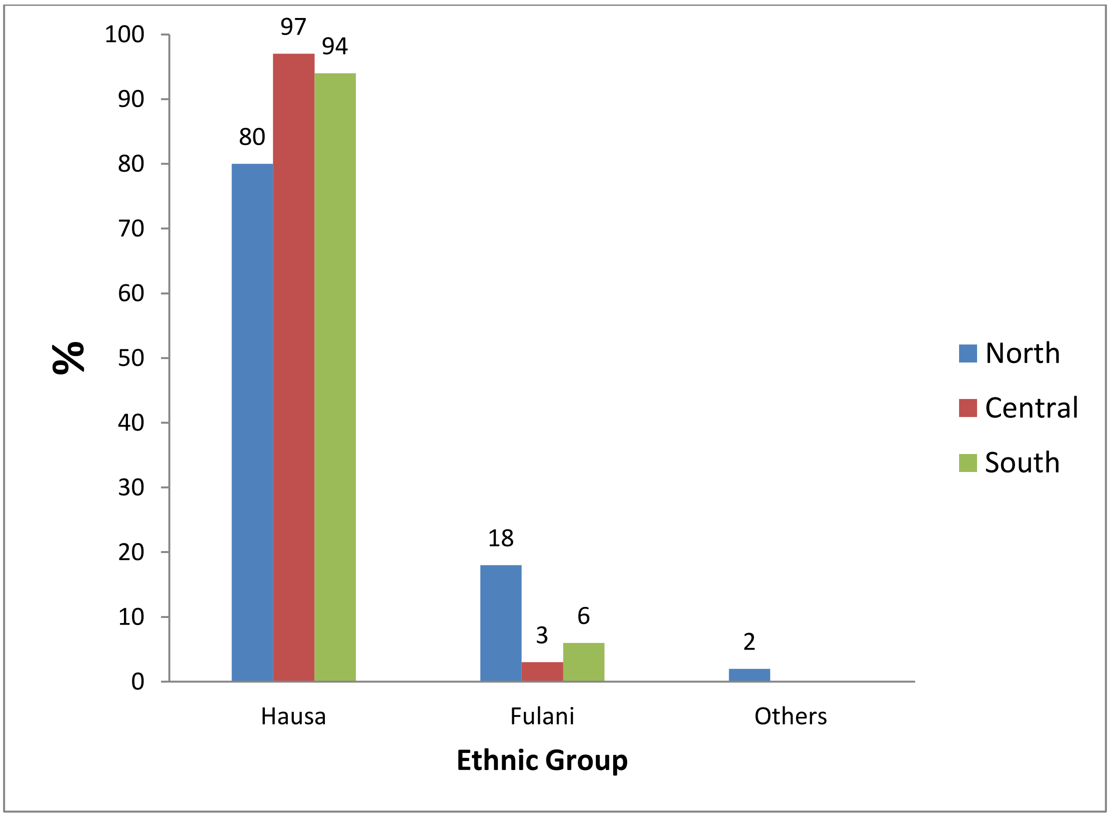
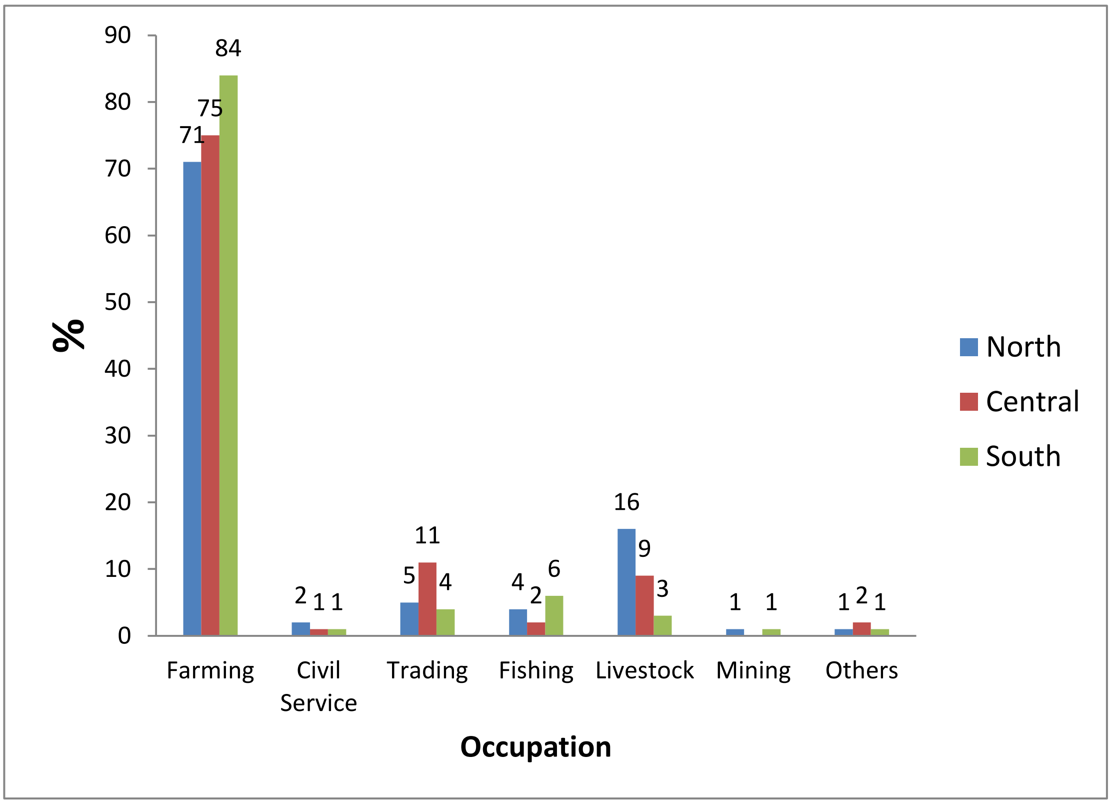
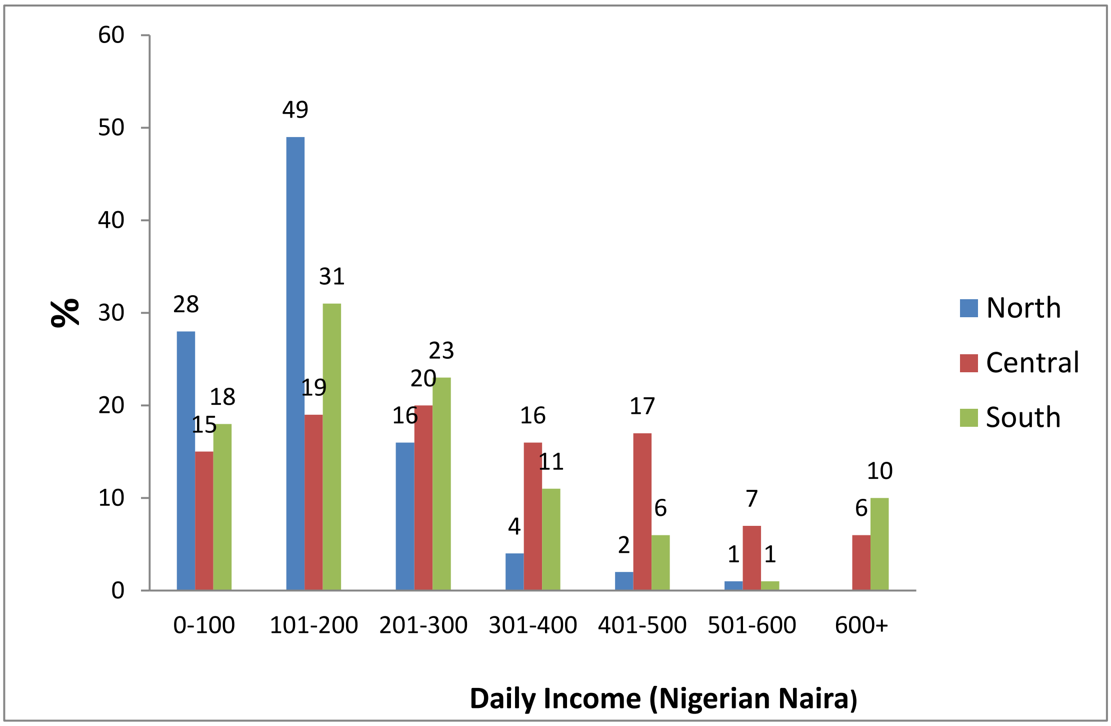


Figure 5.7 Major Occupational Activities in the Communities Studied across the Three Rainfall Zones of Rural Katsina State



On livelihoods, results indicated that (71% in the north, 75% in the central and 84% in the south) of the respondents (Figure 5.7) were involved in farming activities and this tends to conform to the livelihoods picture in rural sub-Saharan Africa (The World bank, 1993). Over dependence on farming in rural Katsina which in most cases is rainfall based is an indication of livelihood vulnerability to water scarcity. People of Hausaland of northern Nigeria are known to be actively involved in farming and cereal crops and livestock produced in the region accounts for over 75% of national food supplies (Watts, 2010).

Figure 5.8 Daily Incomes (Nigerian Naira) of Household Heads of the Communities Studied across the Three Rainfall Zones of Rural Katsina State



The daily income profile of the respondents was given in Figure 5.8. A close look at the figure reveals that less than 17% of the respondents earn above 400 Nigerian Naira (about USD 2.5) per day. Between 14% and 49% on the other hand earn between 100 Naira (about 0.6 USD) per day. As UN benchmark poverty level is defined using daily income of US$ 2 (equivalent to 330 Naira) per day, it could be seen from the figure that only between 1% and 17% of the respondents have income levels above this limit. This implies that over 80% of the respondents are actually below the so-called poverty line and this means high exposure to environmental problems such as water scarcity.

National poverty incidence surveys conducted between 1996 and 2004 indicated that 65.6% of Nigerians were below the poverty line in 1996 but this declined to 54.4% in 2004 (Omonona, 2010). Nigeria's National Bureau of Statistics estimated that about 61% of the population falls below the national poverty line (of less than 2US$/day), with the northwest region of the country (where Katsina State is located) recording a figure of up to about 78% (NBS, 2012). 2013 estimates of the World Bank gave the percentage of Nigeria's population under multi-dimensional poverty as 83.5%, while those under severe poverty at 33.9% and the population below income poverty line at 68% (World Bank-HDR, 2013). Despite some disagreements in statistics on poverty, there is a distinct disparity between regions of the country interms of poverty levels and, therefore, vulnerability levels. In the northeast region of the country, it was 72.2%, in the North West; it was 71.1% and North Central 67.0%. On the contrary, South East (26.6%) has the lowest level of poverty in Nigeria followed by South/South (35.1%) and South West (43.0%). Omonona (2010), however, has shown that compared to actual poverty prevalence, most Nigerians, irrespective of their regions, were of the opinion that they were much poorer. In fact, more residents of the South East (77.6%) and South/South (74.8%) considered themselves poor compared to residents of the North/West (71.9%). Theoretically the poor are more vulnerable to water scarcity and since the results have shown that most respondents were below the poverty line in the study area, then expectedly vulnerability to water scarcity should be high in rural Katsina State

The observed high income inequality between regions of the country is very much consistent with observations made by several research workers (Aigbokhan, 2010; Omonona, 2010; NBS, 2012). In fact the country has been observed to have more unequal distribution of income than Ethiopia, Madagascar, India, and Niger.

5.3 Vulnerability to Water Scarcity

Vulnerability is commonly defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of a phenomenon (such as climate change, water scarcity, drought e.t.c). Vulnerability is a function of the character, magnitude, and rate of a phenomena to which a system is exposed, its sensitivity, and its adaptive capacity. In this study, a number of issues were examined within rural Katsina State to assess the vulnerability of the households to water scarcity.

5.3.1 Water Demand and Availability

Water demand and water availability were considered fundamental elements in the computation of water scarcity in rural Katsina State and Table 5.2 and 5.3 provided the background data of the results used in the computation of household water demamd and availability across the three rainfall zones of rural areas of Katsina State while Table 5.4 provides a descriptive statistical summary of household daily water demand and availability in each of the 4 communities studied across the three rainfall zones of the State. Table 5.5 and 5.6 presents the background data of the results of per capita water demand and availability across the three rainfall zones of rural Katsina State and table 5.7 shows distribution central tendencies measures as well as dispersion measures of per capita daily water demand and availability of the households in each of the 4 communities studied across the three rainfall zones of the rural Katsina State. Both table 5.4 and 5.7 indicate general water scarcity conditions in all the three rainfall zones. Graphical representation of water scarcity situation in rural Katsina State (Figures 5.9 and 5.10) also indicate general water scarcity situation. From table 5.4 and figure 5.9, it was observed that mean values of household water demand varied between 257 litres in the north to 548 in the central and 363 litres in the southern zone thus indicating difference in water scarcity by rainfall zone.

The picture in table 5.4 and figure 5.9 indicate wide disparities between what the households demand and what was available in each of the three rainfall zones where, given the demand was clearly highest in the central zone, followed by the south and then the northern zone. On the other hand, the availability was highest in the south, then the central and then the northern zone. The trend of the water availability over the three rainfall zones clearly follow the expected trend (decreasing with decreasing rainfall amount, from south to the northern part of the study area), with mean values of 276 litres, 170 litres and 150 litres, respectively. That of the demand clearly did not follow the rainfall pattern. Rather it was highest in the central, and least in the northern zone.

A one way ANOVA was computed for water demand and availability and the results for water demand was that the computed F was 214.0 and critical F was 3.00 at $\alpha=0.05$ while for water availability the computed F was 204.7 and critical F was 3.00 at $\alpha=0.05$. This meant that the observed differences in water demand and availability between the three rainfalls zones were not chance events, the differences could be due to significant geographical differences.

Table 5.2 Daily Household Water Demand across theThree Rainfall Zones of Rural Katsina State

Daily Water Demand (Litres)	**Rainfall zone**		
	North	Central	South
0-199	143(35.8%)	44 (11%)	80(20%)
200-399	187(46.8%)	69(17.3%)	173(43.3%)
400-599	59 (14.8%)	114 (28.5%)	80(20%)
600-799	9 (2.3%)	80 (20%)	46 (11.5%)
800+	2 (.5%)	93 (23.3%)	21 (5.3%)

Table 5.3 Daily Household Water Availability across theThree Rainfall Zones of Rural Katsina State

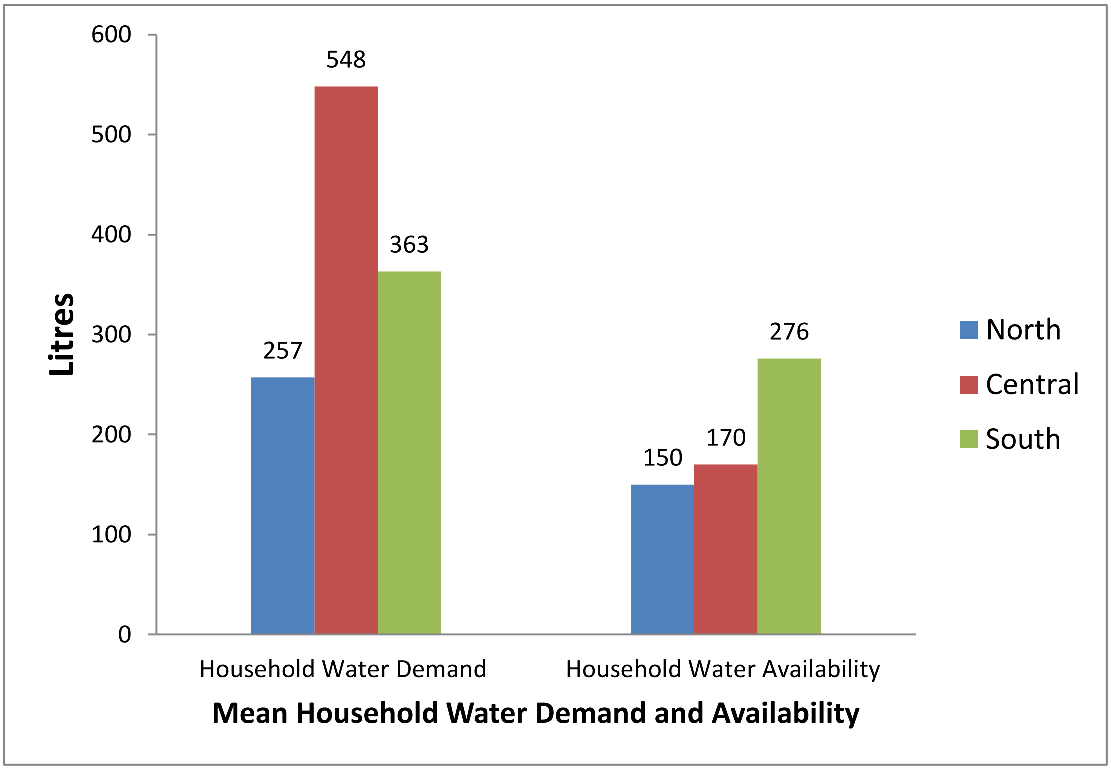
Daily Water Availability (Litres)	Rainfall zone		
	North	Central	South
0-199	283(70.8%)	275 (68.8%)	153(38.3%)
200-399	106(26.5%)	85(21.3%)	160(40%)
400-599	10 (2.5%)	27(6.8%)	47(11.8%)
600-799	1 (.3%)	13 (3.3%)	22 (5.5%)
800+	0(0%)	0 (0%)	18 (4.5%)

Table 5.4 Mean Daily Water Demand and Availability of Households across Different Communities in the Study Area

Zone	Community Studied	Daily Household Water Demand (litres)			Daily Household Water Availability (litres)		
		Mean	Standard Deviation	Coefficient of Variation %	Mean	Standard Deviation	Coefficient of Variation %
North	Walawa	206	106	51.5	145.5	89.9	61.8
	Gyarta	216.8	106	48.9	127	70.4	55.4
	Gurjiya	287	152	52.9	132.6	81.5	61.5
	Gwajo-Gwajo	317.6	182.6	57.5	194.9	130.2	66.8
Mean for the Zone		***257***	***147.6***	**57.5**	**150**	***99.0***	***66.0***
	Malamawa	558	175.1	31.4	111.7	69.7	62.4
	Kofa	559	173.0	30.9	128	88.9	69.5
	Kuraye	412.7	360.7	87.4	343	166.2	48.5
Central	**Yarsanta**	659.6	322.2	48.8	99.5	53.5	53.8
Mean for the Zone		***547.5***	***284.4***	**51.9**	**170**	***144.0***	***84.9***
	Ashraha	276	97.7	49.6	197	116.0	42.0
	Maigora	395	148.8	70.5	211	156.7	52.8
	Tudun-Jae	297	230.1	43.8	525.6	271.0	91.2
South	**Damari**	481	116.7	61.9	188	251.2	52.2
Mean for the Zone		***362.5***	***212.8***	**77.1**	***276***	***223.6***	***61.7***

Source: (Researcher, 2013)

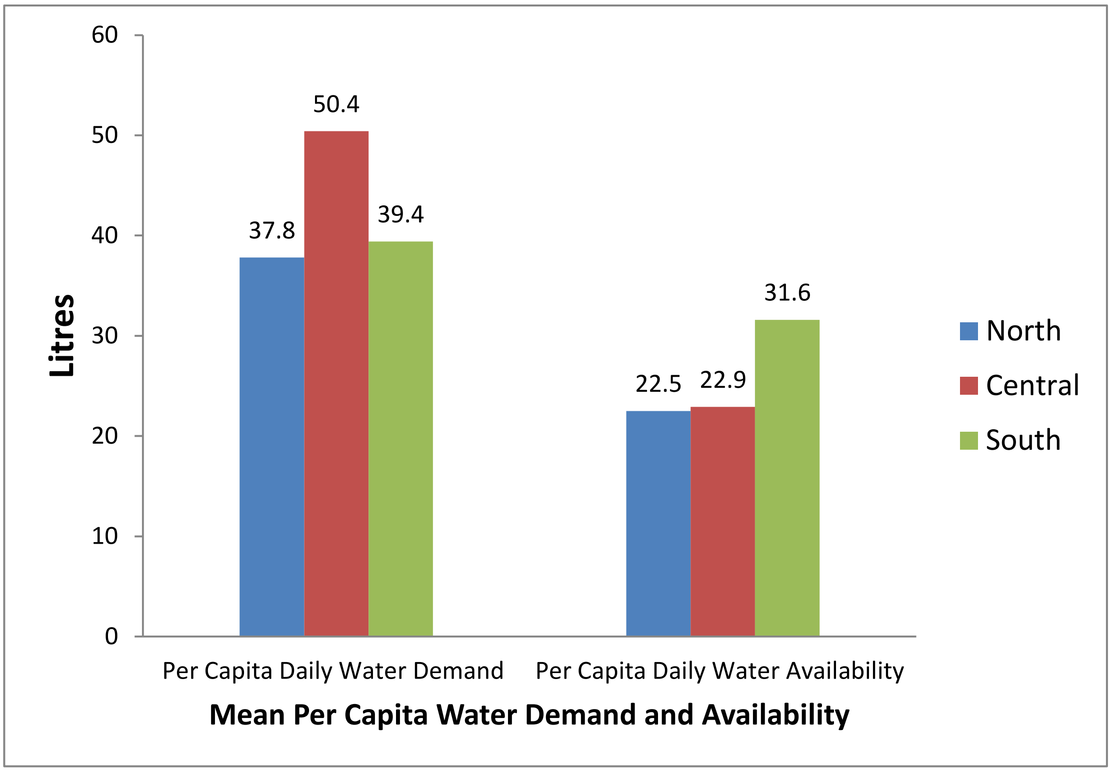
Figure 5.9 Mean Daily Household Water Demand and Availability of the Communities Studied across the Three Rainfall Zones of Rural Katsina State



During the FGD sessions, it was indicated that in the central zone, it was the presence of a large forest reserve called '*Dajin Rugu'*(meaning 'Rugu' Forest) that was being used for dry season grazing of livestock that raised the water demand level and, therefore, increased vulnerability. The high water demand level in central zone could be explained by the large herd size that took advantage of the forest reserve. This means that demand for water was not only affected by the households size but also by other water uses which could be internal as well as external.

When the water demand and availability data were compared with the data on household size of each of the three rainfall zones in order to evaluate the per capita water demand and availability of each zone (Table 5.7 and Figure 5.10), the result tended to be similar to the pattern of mean household sizes (which was also highest in the central and lowest in the northern zone). Generally, demand for water varies over the three rainfall zones in the study area where areas of larger households tend to have higher water demand than areas with lower households. This is very much expected because both human population and water resources are distributed unevenly across the globe and in many areas, densely populated regions do not overlap with those that are water rich.

Figure 5.10 Mean Daily Per Capita Water Demand and Availability of the Communities Studied across the Three Rainfall Zones of Rural Katsina State



The WHO has computed the likely quantity of water that will be collected at different levels of service in order to identify the per capita minimum amount of water that is available in meeting basic human health. Table 5.8 gives a summary of the computation made by the WHO in this regard.

Table 5.5 Daily Household Per Capita Water Demand across theThree Rainfall Zones of Rural Katsina State

Per Capita Water Demand (Litres)	Rainfall zone		
	North	Central	South
0-99	400(100%)	381 (95.3%)	398 (99.5%)
100-199	0(0%)	17(4.3%)	2(.5%)
200-299	0(0%)	2 (.5%)	0(0%)

Table 5.6 Daily Household Per Capita Water Availability across theThree Rainfall Zones of Rural Katsina State

Per Capita Water Availability (Litres)	Rainfall zone		
	North	Central	South
0-19	155(38.8%)	143 (35.8%)	69 (17.3%)
20-39	227(56.8%)	242(60.5%)	224(56%)
40-59	18(4.5%)	14(3.5%)	100 (25%)
60-79	0 (0%)	1(.3%)	3 (.8%)
80+	0(0%)	0(0%)	4(1%)

Table 5.7 Mean Daily Per Capita Water Demand and Per Capita Availability across the Three rainfall Zone and Different Communities of Rural Katsina State

Zone	Community Studied	Per Capita Daily Water Demand (litres)			Per Capita Daily Water Availability (litres)			
		Mean	Standard Deviation	Coefficient of Variation %	Mean	Standard Deviation	Coefficient of Variation %	WHO Access Class*
North	Walawa	38.4	11.2	29.2	28.8	8.4	29.2	Basic
	Gyarta	43.5	12.4	28.5	21.4	9..1	42.5	Basic
	Gurjiya	39.4	11.6	29.4	17.0	7.5	44.1	Basic
	Gwajo-Gwajo	30.1	11.9	39.5	22.9	9.1	39.7	Basic
Mean for the Zone		**37.8**	***12.7***	**33.6**	**22.5**	***9.4***	***41.7***	Basic
	Malamawa	80.6	45.3	56.2	23.5	8.3	35.3	Basic
	Kofa	40.4	8.6	21.3	25.7	7.6	29.6	Basic
	Kuraye	32.4	13.6	41.9	25.7	9.6	37.4	Basic
Central	Yarsanta	48.4	10.5	21.7	16.7	7.7	46.1	Basic
Mean for the Zone		***50.4***	***30.6***	***60.7***	***22.9***	***9.1***	***39.7***	Basic
	Ashraha	43.5	11.5	26.4	39.1	19.8	50.6	Basic
	Maigora	37.5	12.5	33.3	28.4	8.2	28.9	Basic
	Tudun-Jae	38.2	12.0	31.4	22.9	10.2	44.5	Basic
South	Damari	38.5	11.3	29.3	35.8	10.5	29.3	Basic
Mean for the Zone		**39.4**	***12.0***	**30.5**	***31.6***	***14.4***	***45.7***	Basic

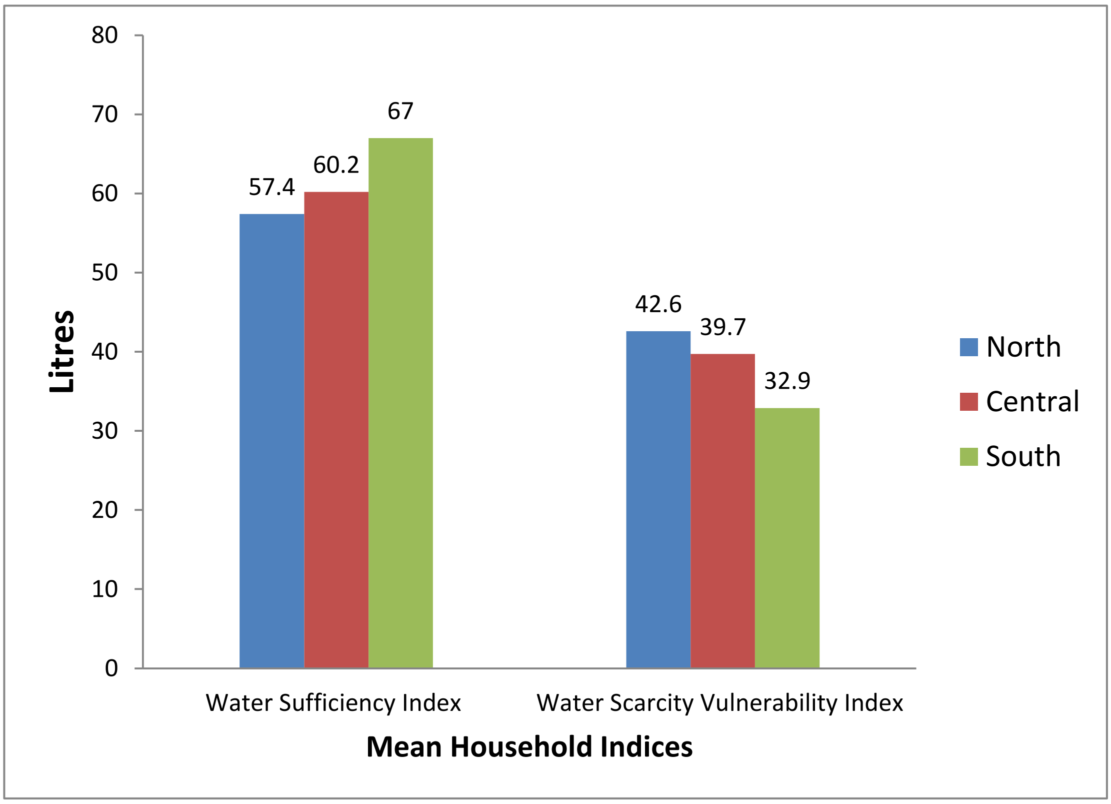
Source: Researcher, 2013

Table 5.8 Summary of Requirements for Water Service Level to Promote Health

Service level Access measure	**Service level Access measure**	**Service level Access measure**	**Service level Access measure**
No access (quantity collected often below 5 l/c/d)	More than 1000m or 30 minutes total collection time	Consumption – cannot be assured Hygiene –not possible (unless practiced at source)	Very high
Basic access (average quantityunlikely to exceed20 l/c/d)	Between 100 and1000m or 5 to 30minutes total collection time	Consumption – should be assuredHygiene – handwashing and basic foodhygiene possible; laundry/bathing difficult to assure unless carried out at source	High
Intermediate access (average quantityabout 50 l/c/d)	Water delivered through one tap on-plot(or within 100mor 5 minutes totalcollection time	Consumption – assured Hygiene – all basic personal and food hygiene assured; laundry and bathing should also be assured	Low
Optimal access (average quantity100 l/c/d andabove)	Water supplied through multiple taps continuously	Consumption – all Hygiene needs met or should be met	Very low

Source: WHO (2003)

Figure 5.11 Mean Patterns of Water Sufficiency and Water Scarcity Vulnerability Indices in the Communities across the Three Rainfall Zones of Rural Katsina State

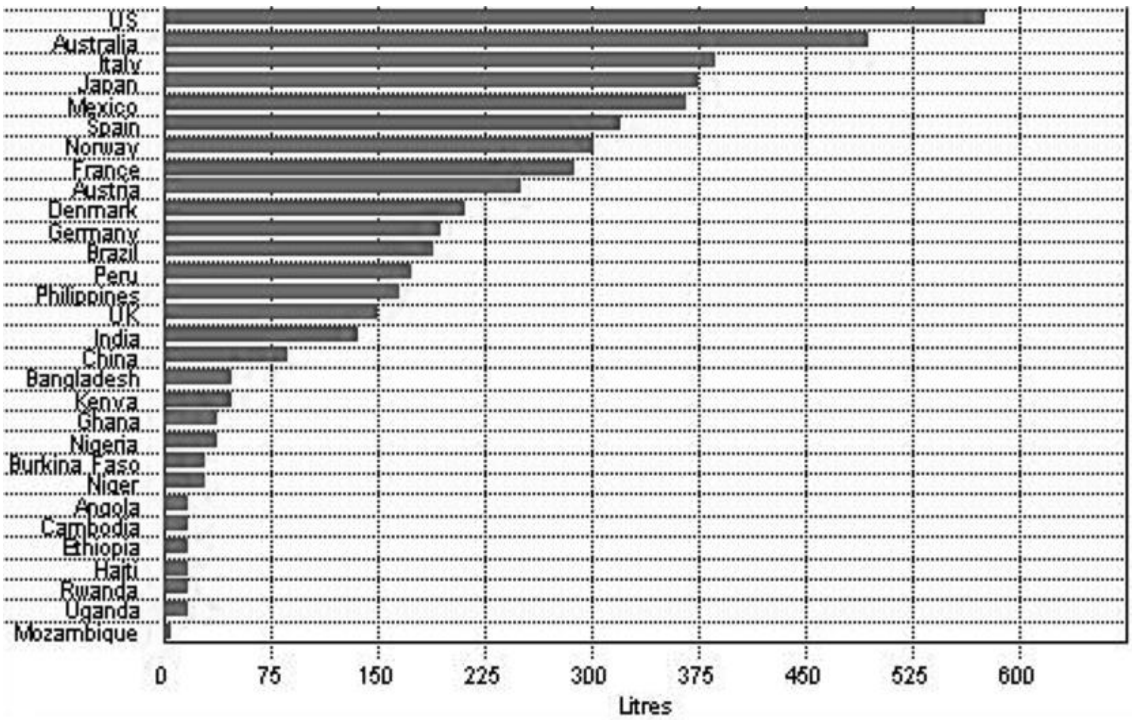


When the results of water demand and availability in the study area are comparing with WHO access to water criteria (Table 5.8), indication was that rural Katsina State water access range from basic access to intermediate access. When this status of water access in rural Katsina State was further evaluated in terms of clean water, ablution and livestock watering, then the WHO criteria table was found to under estimate the water access problem in rural Katsina State which was actually only basic access. At basic access level the households were, therefore, very vulnerable to water scarcity meaning requirements for basic hygiene could barely be satisfied in rural Katsina State.

The water sufficiency index values tended to increase from north to south zones (implying that the higher the rainfall amount the higher the water sufficiency index) as indicated in Figure 5.11 while the values of water scarcity vulnerability index tended to decrease from the north to south (implying that as rainfall amounts increase, the vulnerability to water scarcity decreases in the study area). This indicated that water sufficiency could be used to measure vulnerability to water scarcity in the study area.

A number of per capita water availability estimate have been provided by different organizations where FAO (2003) gave daily per capita water availability for domestic uses in diffrenrent countries of the world as (Mali 11 litres), China (88 litres), India (145 litres), Egypt (210 litres), France (290 litres) and USA (589 litres). In 2005, the United States Geological Survey gave estimate of 370 litres as daily per capita water availability in the USA (Kenny et al, 2005). Estimates of UNDP (2006) put daily per capita water availability of Nigeria at approximately 38% litres (Figure 5.12). Estimates of other values given by the UNDP (2006) for countries with fairly similar conditions as Nigeria include Uganda (19 litres), Kenya (42 litres), Ethiopia (18 litres), Rwanda (19 litres), Haiti (19 litres), Ghana (37 litres), Niger (36 litres) and Burkina Faso (35 litres).

Figure 5.12: UNDP Estimates of Daily Per Capita Water Avaiability (Litres) of Different Countries



Source: (UNDP, 2006)

In this study the per capita water availability was 26 litres per day which when compared to the UNDP (2006) estimate for Nigeria at 38 litres indicates deficiency. Further, the figure for rural Katsina State when compared to the WHO (2003) recommendation indicate basic access to water only for drinking and hygiene not taking into consideration other demands such as livestock watering which form part of water demand in rural Katsina. It was also important in this study to consider differences in per capita water availability by rainfall zones and the results was that the north was the least followed by central and then south. This picture was subjected to analysis of variance in per capita water availability and the results was that the computed F was 81.9 and critical F of 3.0 at $\alpha=0.05$. This meant that the observed differences in per capita water availability between the three rainfall zones and part of the rural Katsina environment.

The differences in per capita water availability by households and between rainfall zones were considered important in the determination of vulnerability to water scarcity and the study findings indicate that there is significant difference in per capita water availability and this difference varies by households and by zones thus a representative picture of per capita water availability in rural Katsina State. On this basis, therefore, it is important to measure vulnerability to the observed water scarcity condition in Katsina State as discussed below

5.3.2 Vulnerability to Water Scarcity

Since the study established water scarcity presence in rural Katsina State, it was necessary to examine the extent to which the households across the three rainfall regions in rural Katsina State were vulnerable to water scarcity. Vulnerability to water scarcity computation was approached from two view points. The first view point computed vulnerability to water scarcity on the basis of total water availability while the second view point computed vulnerability on the basis of sufficiency. Table 5.9 and 5.10 summarised the results of background data of water sufficiency index and water scarcity vulnerability index thus, Table 5.11 presents the results of the computations made for each of the 12 communities studied across the three rainfall zones while figure 5.11 presents summary of mean values of the two indices over the three rainfall zones. As each of the two indices was expressed as percentages, the values were expected to vary between 1 and 100 where a higher water sufficiency index value reflects higher extent of satisfaction of water supply availability of a household while higher water scarcity vulnerability index values reflect higher degree of risk of a household to facing the problem of water scarcity.

In the northern rainfall zone of rural Katsina State, the values of WSI varied between 20% and 92% with a mean of 57.4%; in the central zone, the values were between 25% and 86% with mean of 60.3% and; in the southern zone, the values varied between 06% and 97% with a mean of 67%. This incremental water sufficiency index condition tended to reflect the condition of water availability as already discussed and it was some measure of extent of satisfaction of water demand. The emerging pattern of water sufficiency index tended to decrease from south to north of Katsina State which tended to reflect the spatial distribution of rainfall amounts over the entire northwestern region of Nigeria within which Katsina State is located (Figure 5.15).

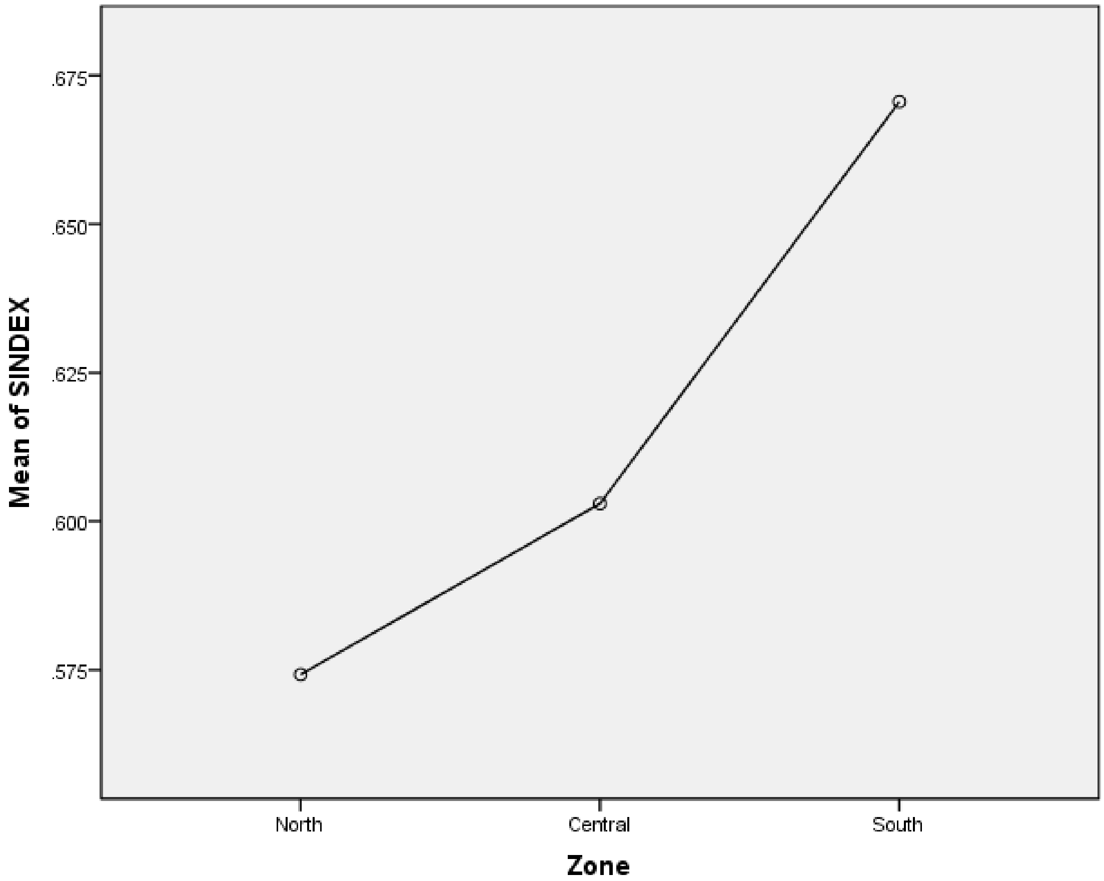
Table 5.9 Household Water Sufficiency Index across theThree Rainfall Zones of Rural Katsina State

Water Sufficiency Index	Rainfall zone		
	North	Central	South
0-0.29	22(5.5%)	5(1.3%)	15 (3.8%)
0.3-0.49	88(22%)	33(8.3%)	52(13%)
0.5-0.69	185(46.3%)	248(62%)	141 (35.3%)
0.7-0.89	101(25.3%)	114(28.5%)	149 (37.3%)
0.9+	4(1%)	0(0%)	43(10.8%)

Table 5.10 Household Water Scarcity Vulnerability Index across theThree Rainfall Zones of Rural Katsina State

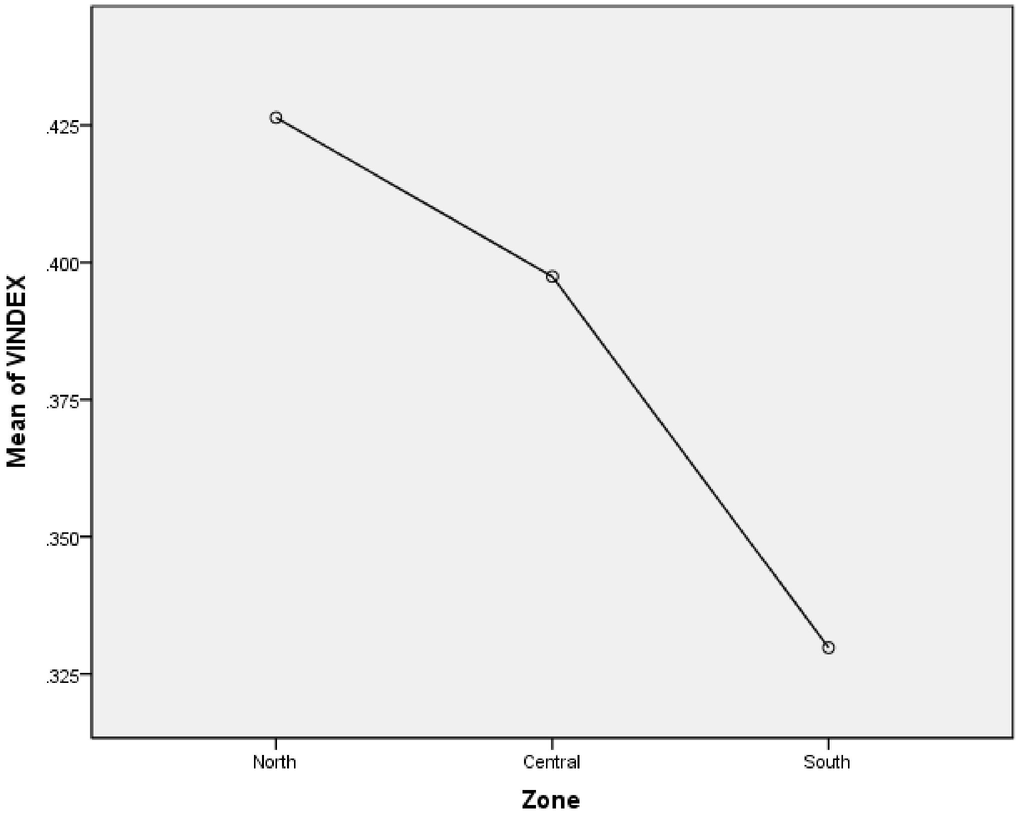
Water Scarcity Vulnerability Index	Rainfall zone		
	North	Central	South
No scarcity	0(0%)	0(0%)	0 (0%)
Low scarcity	0(0%)	0(0%)	8(2%)
Moderate scarcity	16(4%)	3(.8%)	80(20%)
High scarcity	133(33.3%)	176(44%)	152 (38%)
Acute scarcity	251(62.8%)	221(53.3%)	160(40%)

Figure 5.13 Patterns of Water Sufficiency Index in the Communities across the Three Rainfall Zones of Rural Katsina State



The patterns of WSI values (figure5.13)were exactly opposite those of the WSVI (figure5.14), being highest in the northern and lowest in the southern rainfall zone implying that areas of lower rainfall amounts in the study area had higher vulnerabilities to water scarcity. The ANOVA test results used in assessing the significance of the observed variations (Table 5.12) indicated that the differences in both the WSI and WSVI over the three rainfall zones were statistically significant at 95% confidence limit.

Figure 5.14 Patterns of Water Scarcity Vulnerability Index in the Communities across the Three Rainfall Zones of Rural Katsina State



In the northern zone, the mean WSVI values varied between 08% and 80% with a mean of 42.6%; central zone, 14% to 75% with a mean of 39.7% and; the southern zone, 03% to 94% with a mean of 32.9%. These WSVI scores implied increase in vulnerability from south to the northern rainfall zones and stress in water scarcity mitigations measures need to take this pattern in to account. This tends to conform to the general geography of water availability in Africa where there is a tendency to have water scarcity increase with the distance away to the equator especially to the north. Descriptive statistics of Water Sufficiency Index (WSI) and Water Scarcity Vulnerability Index (WSVI) values for the various communities in rural Katsina State are shown in table 5.11while Table 5.12 shows Summary of ANOVA results testing for significance of differences in Mean Values of Water Sufficiency Index (WSI) and Water Scarcity Vulnerability Index (WSVI) values for the three rainfall zones in rural Katsina State.

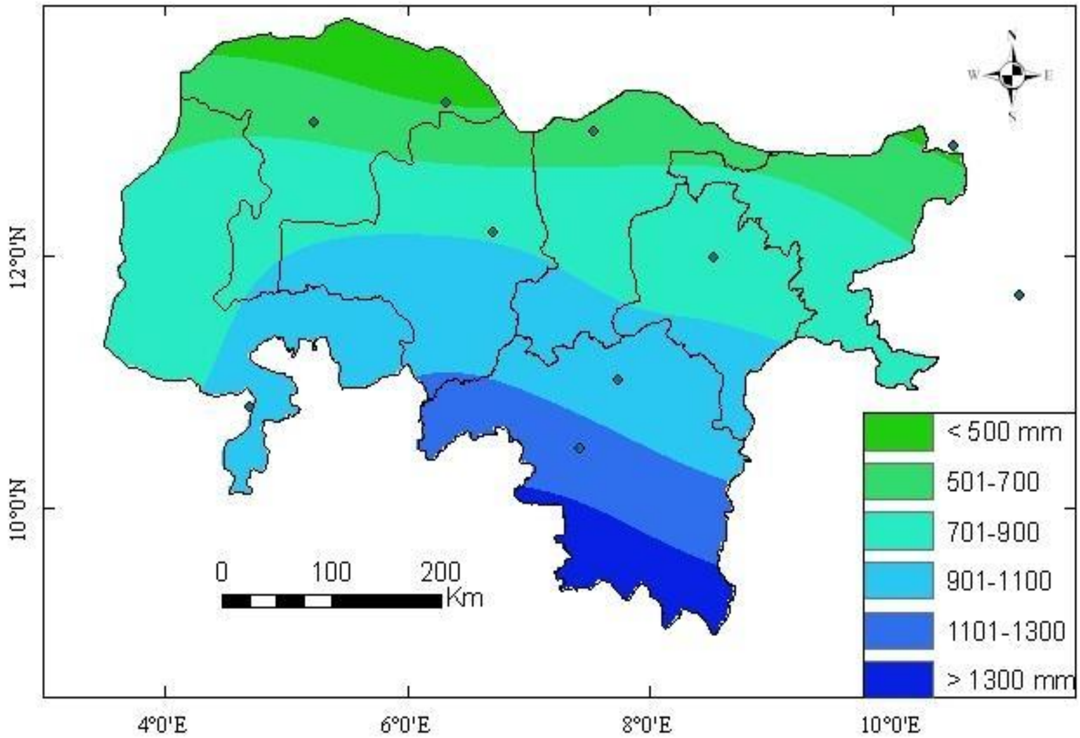
Table 5.11 Summary Results for the various Communities in the Study Area on Water Sufficiency Index and Water Scarcity Vulnerability Index

Community Studied		Min	Max	Mean	SD	Variance	COV %
Walawa	WSI	25	92	67.8	15.2	2.3	22.4
	WSVI	08	75	32	15.2	0.2	47.5
Gyarta	WSI	22	88	57.7	16.0	2.6	27.7
	WSVI	13	78	42	15.9	0.3	37.9
Gurjiya	WSI	20	75	44.7	12.6	0.2	28.6
	WSVI	25	80	55	12.5	0.2	22.7
Gwajo-Gwajo	WSI	29	85	59.3	13.2	0.2	29.5
	WSVI	15	71	41	13.2	0.2	32.1
Summary for the	WSI	***20***	***92***	***57.4***	***16.5***	***0.3***	***28.7***
Northern Zone	WSVI	***08***	***80***	***42.6***	***16.5***	***0.3***	***38.7***
Malamawa	WSI	25	83	61.3	12.6	0.2	20.7
	WSVI	17	75	39	12.6	0.2	32.3
Kofa	WSI	25	80	59.7	11.6	0.1	19.4
	WSVI	20	75	40	11.6	0.1	29.0
Kuraye	WSI	30	86	64.9	13.8	0.2	21.4
	WSVI	14	70	35	13.8	0.6	39.4
Yarsanta	WSI	25	83	55.2	12.4	0.2	22.5
	WSVI	17	75	45	12.5	0.1	27.8
Summary for the	WSI	***25***	***86***	***60.3***	***13.0***	***0.2***	***21.6***
Central Zone	WSVI	***14***	***75***	***39.7***	***13.1***	***0.2***	***32.9***
Ashraha	WSI	06	90	51.6	19.6	3.8	38.0
	WSVI	10	94	48	19.6	0.4	40.8
Tudun-Jae	WSI	41	93	71.4	12.5	0.2	17.6
	WSVI	07	59	28	12.5	0.2	44.6
Damari	WSI	34	97	74.4	17.4	0.3	23.5
	WSVI	03	66	26	17.4	0.2	66.9
Maigora	WSI	34	94	70.7	15.6	0.2	22.1
	WSVI	06	66	29	15.6	0.2	53.8
Summary for the	WSI	***06***	***97***	***67.1***	***18.8***	***0.4***	***28.0***
Southern Zone	WSVI	***03***	***94***	***32.9***	***18.7***	***0.4***	***56.8***

Source: (Researcher, 2013)

Note: WSI = (Water Availability ÷ Water Demand) x 100 ;
WSVI = (1 – Water Availability ÷ Water Demand) x 100
SD = Standard Deviation;
CV% = SD ÷ Mean X 100

Figure 5.15 South-North Pattern Decrease in Annual Rainfall Amounts over Northwestern Nigeria



Source: (El-Tantawi, A. 2012)

Table 5.12 Summary of ANOVA Results for the Three Rainfall Zones in the Study Area on Water Sufficiency and Water Scarcity Vulnerability Indices

ANOVA					
SINDEX (Sufficiency Index)					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.9	2	.9	36.9	.000
Within Groups	31.6	1197	.02		
Total	33.6	1199			
VINDEX (Vulnerability Index)					
Between Groups	1.9	2	.9	37.1	.000
Within Groups	31.7	1197	.02		
Total	33.6	1199			

In the literature review, the study could not identify an index based on household level data and this made it extremely difficult to compare the values obtained in this study with those of other research workers. The index developed in this study was, therefore, unique and the closest approximation was found in the work of Heap et al (1998) and Birkman (2006) which were used for comparative analysis.Heap et al (1998) provided the following classification based on water stress:

RWS < 0.1	no water stress
0.1 < RWS < 0.2	Low water stress
0.2 < RWS < 0.4	moderate water stress
0.4 < RWS	high water stress

Birkman (2006) on the other hand provided the following classification of vulnerability using a ranking scale of 0 (no damage) to 1 (total damage) based on number of people:

0.3- people up to 100 affected (low vulnerability)

0.6-from 101-1000 people affected (medium vulnerability)

0.7-0.9- more than 10000 people affected (high vulnerability)

The study computed WSVI values of 1.2% to 62.1% (Table 5.13) from which the the following classification was derived given the classifications of Birkman (2006) and Heap et al (1998):

0	No Scarcity
<5%	Low Scarcity
6% - 15%	Moderate Scarcity
16% - 35%	High Scarcity
Above 35%	Acute Scarcity

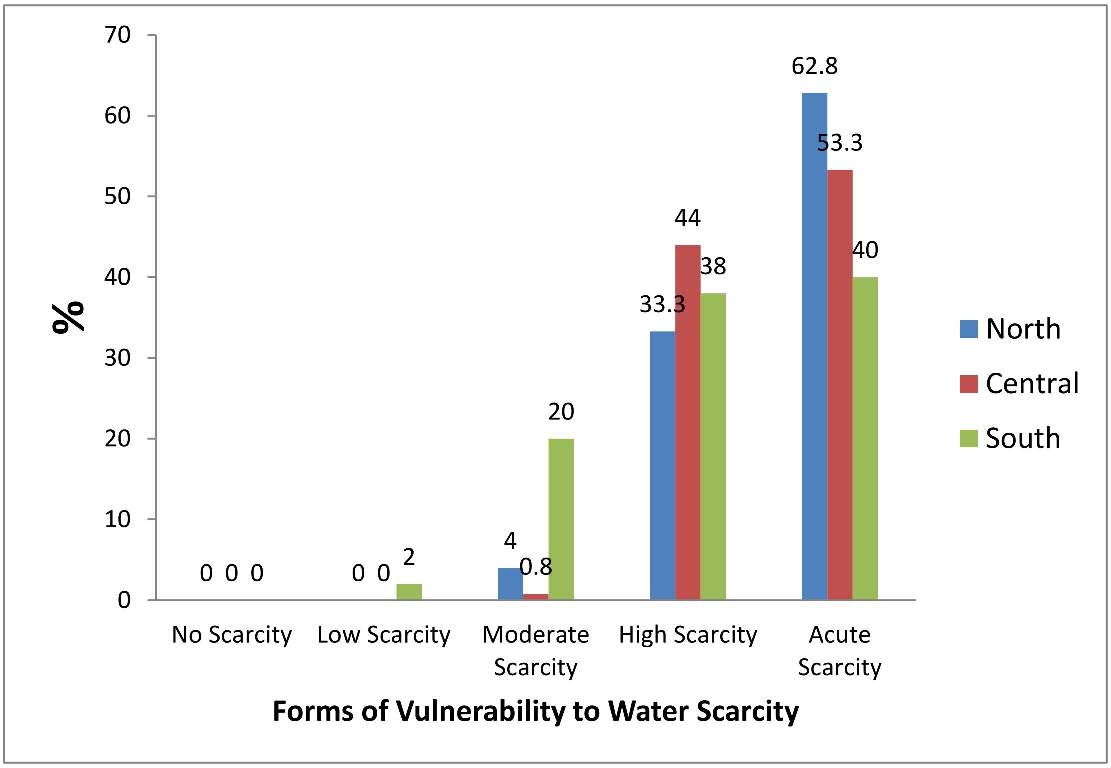
The study used the above classification to compute WSVI values for communities in the 12 LGAs included in the sample data and it was the WSVI value that was used to identify the proportions of the communities belonging to specific category of water scarcity vulnerability. The results obtained are summarised in Table 5.13 and Figure 5.16 and indications were that none of the communities studied belonged to the ‘No Scarcity’ category implying that the problem of water scarcity affected all the communities in the study area. In the northern and central zone, no community belonged to the low scarcity category, but in the southern zone, 2% included in this category. In the moderate scarcity category, the scores were 4%, .8% and 20% for the North, Central and South zones respectively. In the case of High Scarcity category, 33.3%, 44% and 38% respectively for the North, Central and South Zones belong to it. In the northern zone, 62.8% of the households were in the acute scarcity category while in central and southern zones, 53.3% and 40% respectively were in this category. The general picture was that Katsina State was a water scarce region but the scarcity vulnerability varied by rainfall zones.

Table 5.13 Proportion of Communities under Different Forms of Vulnerability to Water Scarcity in Each Community across the Three Rainfall Zones of Rural Katsina State

Zone	Community Studied	% of Households Under Various Forms of Vulnerability to Water Scarcity				
		No Scarcity	Low Scarcity	Moderate Scarcity	High Scarcity	Acute Scarcity
North	Walawa	0	0	1	40	59
	Gyarta	0	0	2	33	65
	Gurjiya	0	0	2	24	74
	Gwajo-Gwajo	0	0	1	31	69
Mean for the Zone		***0***	***0***	***4***	***33.3***	***62.8***
Central	Malamawa	0	0	1	43	56
	Kofa	0	0	.3	40.8	59
	Kuraye	0	0	1	48	51
	Yarsanta	0	0	.3	44.3	55
Mean for the Zone		***0***	***0***	***.8***	***44***	***53.3***
South	Ashraha	0	2	13	35	50
	Tudun-Jae	0	1	24	36	39
	Damari	0	1	16	40	43
	Maigora	0	1	19	40	40
Mean for the Zone		***0***	***2***	***20***	***38***	***40***

Source: Researcher, 2013

Figure 5.16 Proportions of Households under Different forms of Vulnerability to Water Scarcity across the Three Rainfall Zones of Rural Katsina State



The results were as in table 5.12 indicating that all variations between the rainfall zones were not chance event and were, therefore, related to rainfall zoning which in turn affected water availability. The available water could affect vulnerability in terms of quantity available but also in terms of households' size and its associated water uses. Since the study established that rural Katsina State was largely vulnerable to water scarcity, it was important to have some measures of vulnerability that could be used in designing appropriate mitigation measures. The vulnerability measures were, therefore, considered as indicators to be used in decision making on water scarcity.

5.4 Indicators of Vulnerability to Water Scarcity

An indicator of vulnerability to water scarcity in this study was identified in terms of its possible role in making the households in rural Katsina susceptible to the impacts of water scarcity. Table 4.1 above provides the parameters used to measure vulnerability to water scarcity from the perspectives of the households in rural Katsina State. Each parameter was analysed to have some measure of its role in vulnerability to water scarcity. The analyses started with statistical descriptive tools especially frequency distributions and graphical representation for indication of aggregations and dispersion. Further analyses were largely statistical inferential measures of differences especially using the chi-squares test.

5.4.1 Expenditure on Water

Expenditure profile is an important variable to measure vulnerability to water scarcity since it affects the disposable income of households used for acquisition of water. This in rural Katsina State which is water scarce area, water acquisition was normally through purchase of water from vendors which involves incurring additional costs of treating and maintenance of water. The acquisition of water also involves diversion of available labour in the household thus, reducing productivity and income of the household. It was on the preceeding arguments that the study considered expenditure on water as a possible factor in vulnerability to water scarcity.

A frequency analysis of expenditure on water as illustrated in figure 5.17 and figure 5.19 gave indications on the mean daily expenditure and the actual household daily expenditure on water, respectively. The picture was that over 60% of the respondents across the three rainfall zones expend less than 330 Naira (2 US Dollars per day) while between 4% and 19% of them expend between 330 Naira and 500 Naira (about 2- 3 USD) daily. When compared with what was specifically expended on water supply, the daily household expenditure profile (Table 5.14 and Figure 5.19) indicated generally that about half of the households across the three rainfall zones spend about 100 Naira (about 0.6 USD) per day, which was far less than the general expenditure of less than 2 USD per day. The implication was that a large percentage of rural Katsina State residents were spending far less on water acquisition and this could mean either there was less money for daily household expenditure therefore an indication of high poverty situation or that there was lack of water from the vendors and, therefore, less expenditure. The low expenditure on water could as well mean that the respondents were sourcing water from points of no payment such as rivers or streams and ponds which could be a health risk.

The expenditure on water when considered by rainfall zones (Figure 5.19), the result was that daily household expenditure on water supply across the three rainfall zones declined from south to north suggesting that households in the northern zone were spending comparatively lower amount than those in the central and southern zones. This was expected given that households in the northern zone had comparatively lower income level and smaller household sizes than those of the central and southern zones. The explanation for expenditure on water disparity could have been that the lower the income level, the lower the amount made available for water acquisition. It was also possible that the larger the households size the greater the demand for water and, therefore, the higher the expenditure on water. Since households sizes tended to decrease from south to north, it was logical, given the households size, for expenditure to increase from north to south.

From the above discussions, it was notable that a large portion of rural areas of Katsina residents was spending far less on water acquisition mostly due to high poverty level. It was also noted that high poverty could affect not only water availability in the household and, therefore, vulnerability to water scarcity, but also affected expenditure on other household demands. Expenditure on water was also affected by the households size where the larger the size, the greater the expenditure. Household sizes tended to decrease from south to north and the expenditure also decreased from south to north indicating some relationship which could be on the basis of water availability as controlled by rainfall conditions.

Table 5.14 Daily Household Expenditure on Water Supply across theThree Rainfall Zones of Rural Katsina State

Daily Expenditure on Water Supply	Rainfall zone		
	North	Central	South
0-100	328(82%)	192(48%)	208 (52%)
101-200	64(16%)	149(37%)	140(35%)
201-300	8(2%)	48(12%)	40 (10%)
301-400		8 (2%)	3(1%)
401-500		3 (1%)	3 (1%)
600+			3(1%)

Table 5.15 Daily Household Expenditure on Water Treatment across theThree Rainfall Zones of Rural Katsina State

Daily Expenditure on Water Treatment	Rainfall zone		
	North	Central	South
5 Naira	60(15%)	11(3%)	5 (1.3%)
10 Naira	80(20%)	106(26.5%)	69(17.3%)
15 Naira	29(7%)	22(6%)	23 (5.8%)
20 Naira	19(4.8%)	69 (17%)	100(25%)
25 Naira	5(1.3%)	3 (.8%)	5 (1.3%)
30 Naira	6(1.5%)	21(5.3%)	15(3.8%)
40 Naira	7(1.8%)	10(2.5%)	4(1%)
50 Naira	3(0.8%)	17(4.3%)	5(1.3%)
60 Naira	2(0.5%)	1(0.3%)	1(0.3%)
70 Naira	2(0.5%)		1(0.3%)
90 Naira	1(0.3%)		1(0.3%)
N/A	186(46.5%)	137(34.3%)	169(42.3%)

Figure 5.17 Daily Household Expenditure Profiles of the Communities across the Three Rainfall Zones of Rural Katsina State

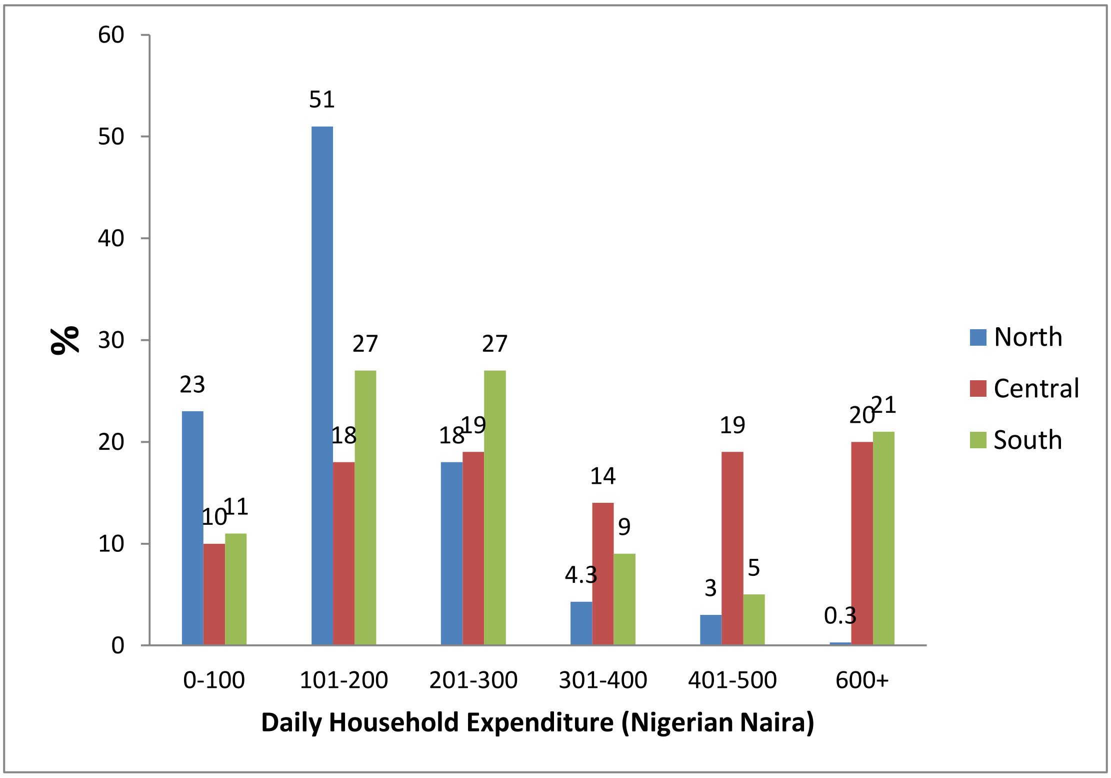


Figure 5.18 Areas of Major Daily Household Expenditure of the Communities across the Three Rainfall Zones of Rural Katsina State

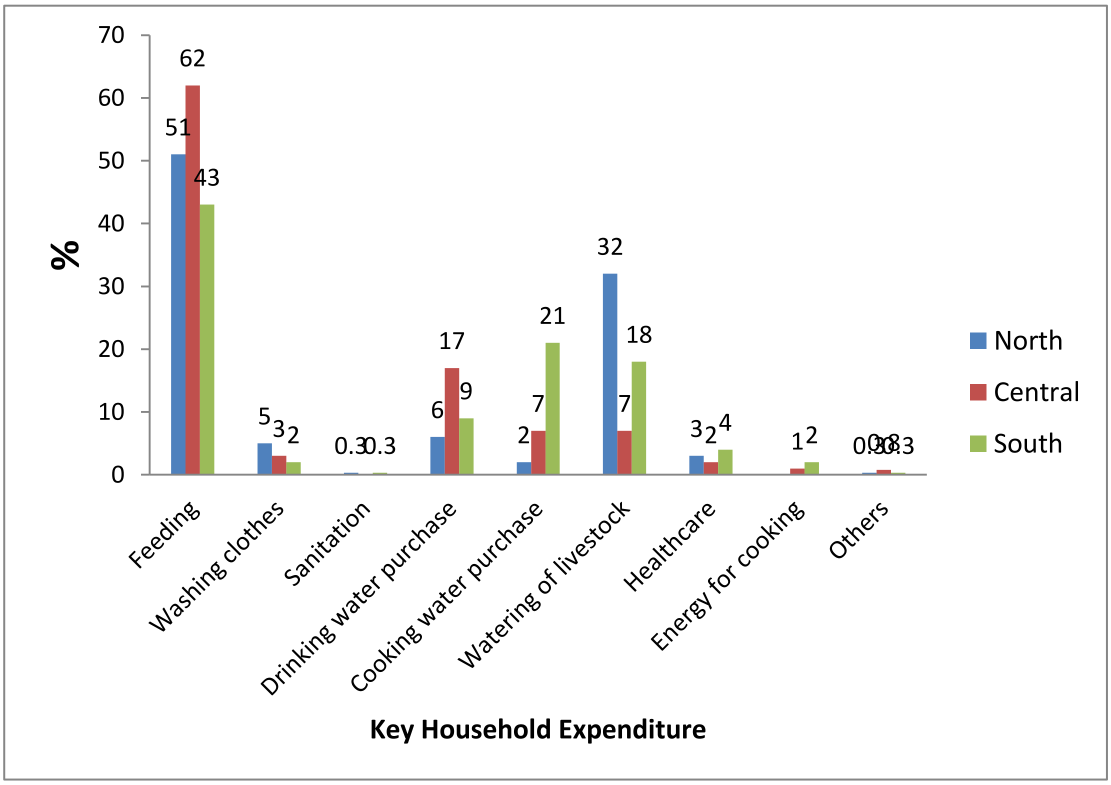
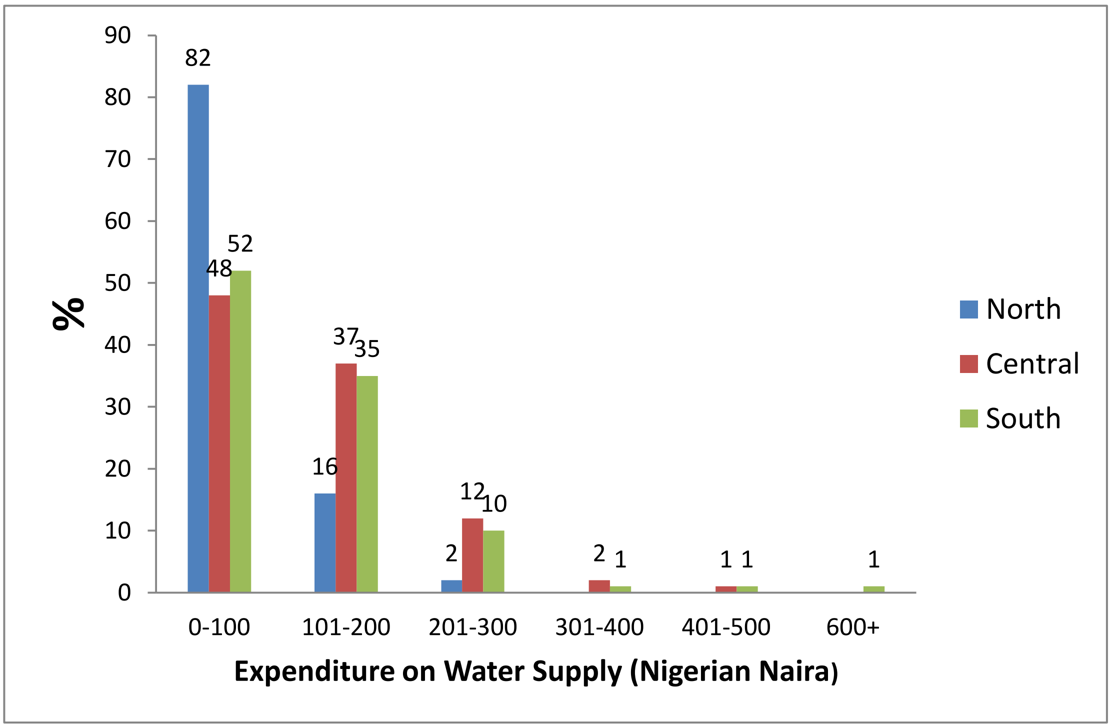


Figure 5.19 Daily Household Expenditure on Water Supply of the Communities across the Three Rainfall Zones of Rural Katsina State



Expenditure on water was not only on acquisition but also on quality as measured by water treatment. In this study, less than 25% of the respondents in each of the three rainfall zones treated water before using it (Figure 5.20) indicating high heath risk in water use. The main treatment methods used included boiling, filtering and use of alum but very little amount of money was expended on such treatment (Table 5.15 and Figure 5.21) and also on maintenance of water resources facilities (Figure 5.22). This indicated that the respondents had low capacity for treating water before use perhaps the reason for widespread occurrence of water related diseases in the study area. It could be seen from Table 5.16 and Figure 5.23 that the diseases most common across the three zones were bilharzia, cholera, guinea worm and typhoid fever, all of which were water related, though there were marked difference in the proportion of respondents that indicated such diseases across the three zones.

In one-way ANOVA where the computed f was 28.7 and the critical f was 3.00 at $\alpha=0.05$, the observed differences in expenditure on water was found to be statistically significant and, therefore, representative a reflection of expenditure on water in rural areas of Katsina State. It was also important to consider differences in treatment of water by zones where chi-square test at 95% confidence level was used. The computed chi-squares was 93.0 while the critical chi-squarewas 21.0 indicating significant difference. This could have been due to significant differences in rainfall conditions affecting water availability and, therefore, vulnerability to water scarcity.

Figure 5.24 represents statistics on hospital reported cases of water borne diseases across the three rainfall zones of the state. It could be seen from the figure that diarrheal cases were highest in the central zone, followed by the north and then the south rainfall zones. For typhoid cases however, they were highest in the south and least in the central zones with the south zone in between the two. Other diseases were in general not reported. The sample data analysis on diseases was based on chi-square test in which the computed statistic was 607.1 and the critical chi-square was 18.3 (at 95% confidence level) indicating that the observed differences in occurrence of water borne diseases affecting the households studied across the three rainfall zones were not chance events and therefore those differences could be due to significant physical differences.

Figure 5.20 Methods of Water Treatment across the Three Rainfall Zones of Rural Katsina State

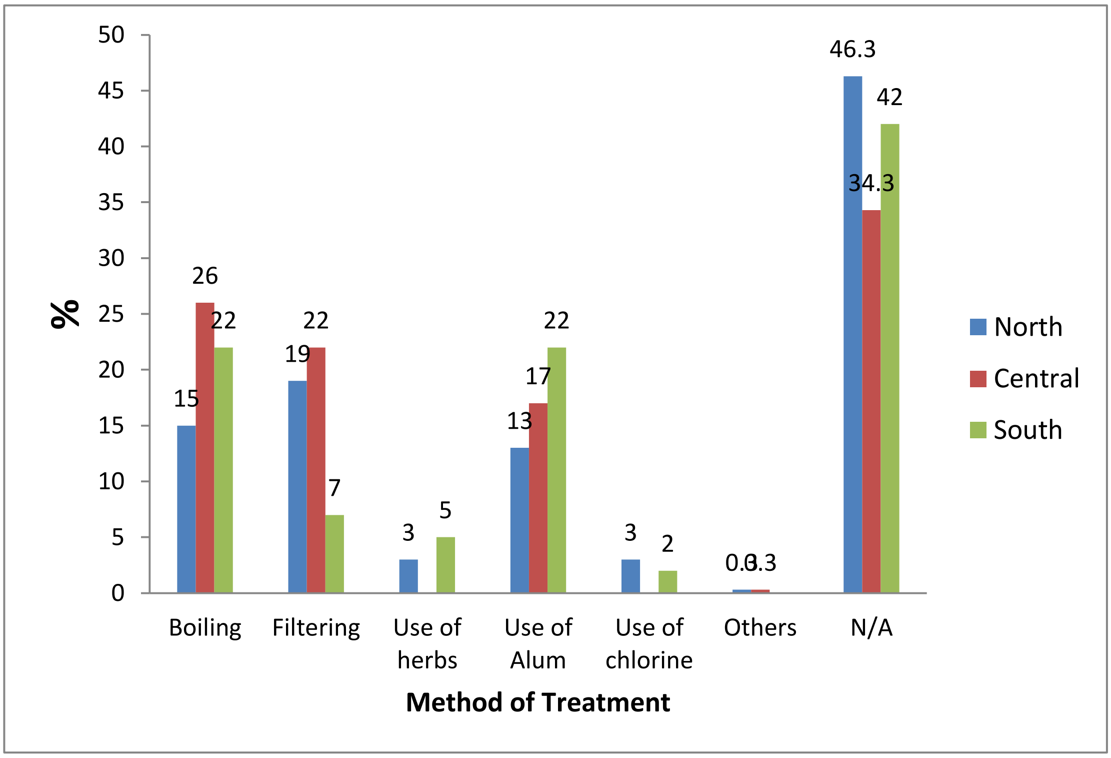


Table 5.16 Water Borne Diseases across theThree Rainfall Zones of Rural Katsina State

Water Borne Diseases	Rainfall zone		
	North	Central	South
Bilhazia	72(18%)	16 (4%)	152 (38%)
Cholera	132(33%)	92(23%)	80(20%)
Guinea worm	28(7%)	92(23%)	56 (14%)
Diarrhea		16 (4%)	
Typhoid fever		184(46%)	60 (15%)
Others	168(42%)		52(13%)

Figure 4.21 Amount of Money Spent Daily on Water Treatment by the Households across the Three Rainfall Zones of Rural Katsina State

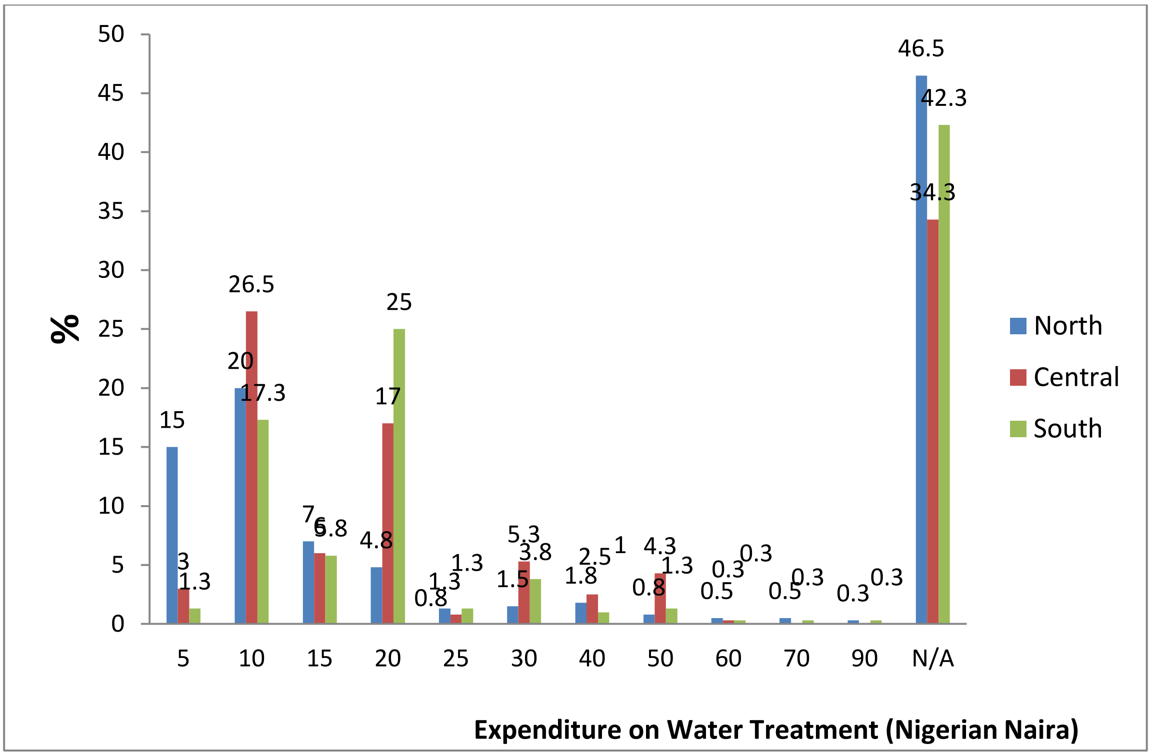


Figure 5.22 Amount of Money Spent Daily on Maintenance of Water Facilities across the Three Rainfall Zones of Rural Katsina State

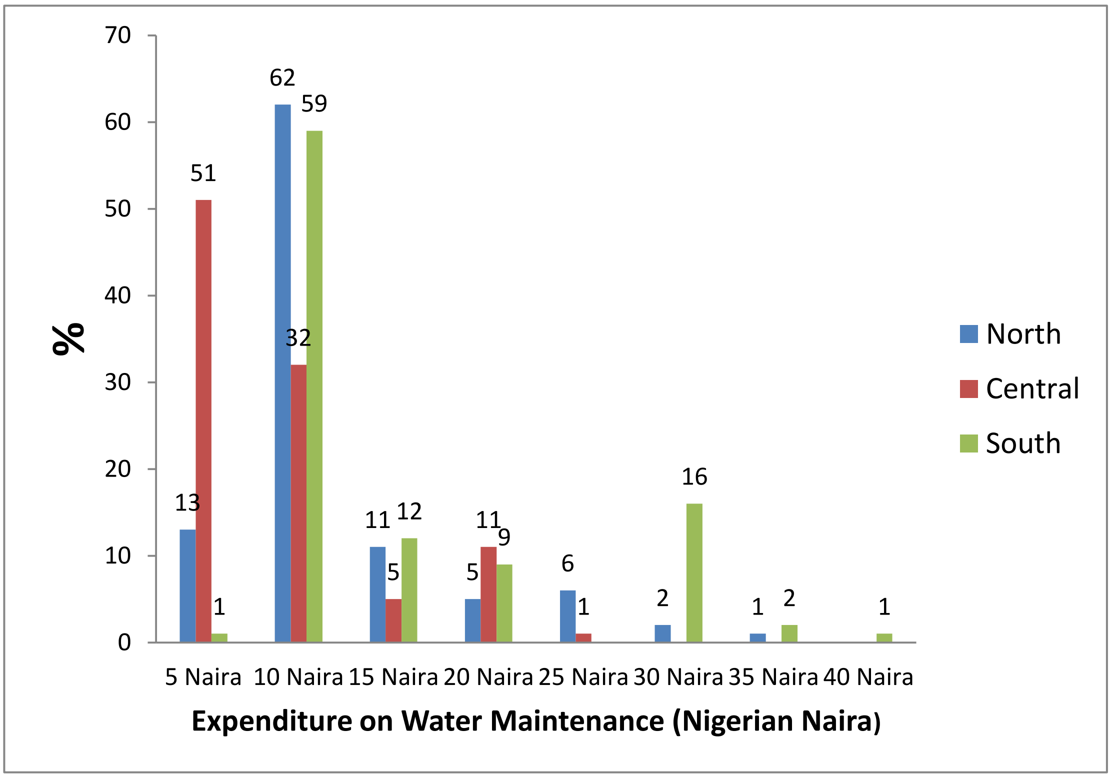


Figure 5.23 Occurrence of Water Borne Diseases in Communities across the Three Rainfall Zones of Rural Katsina State

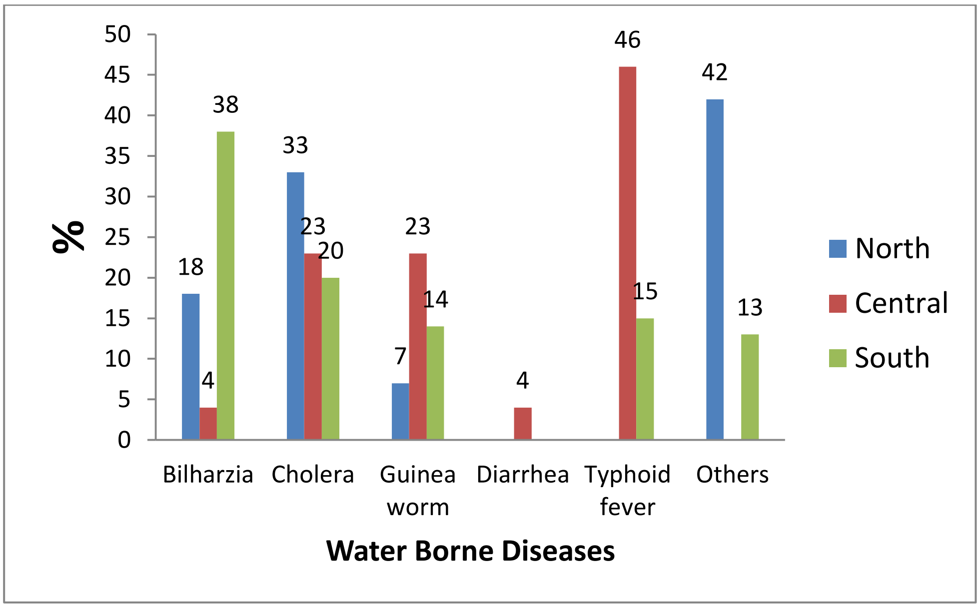
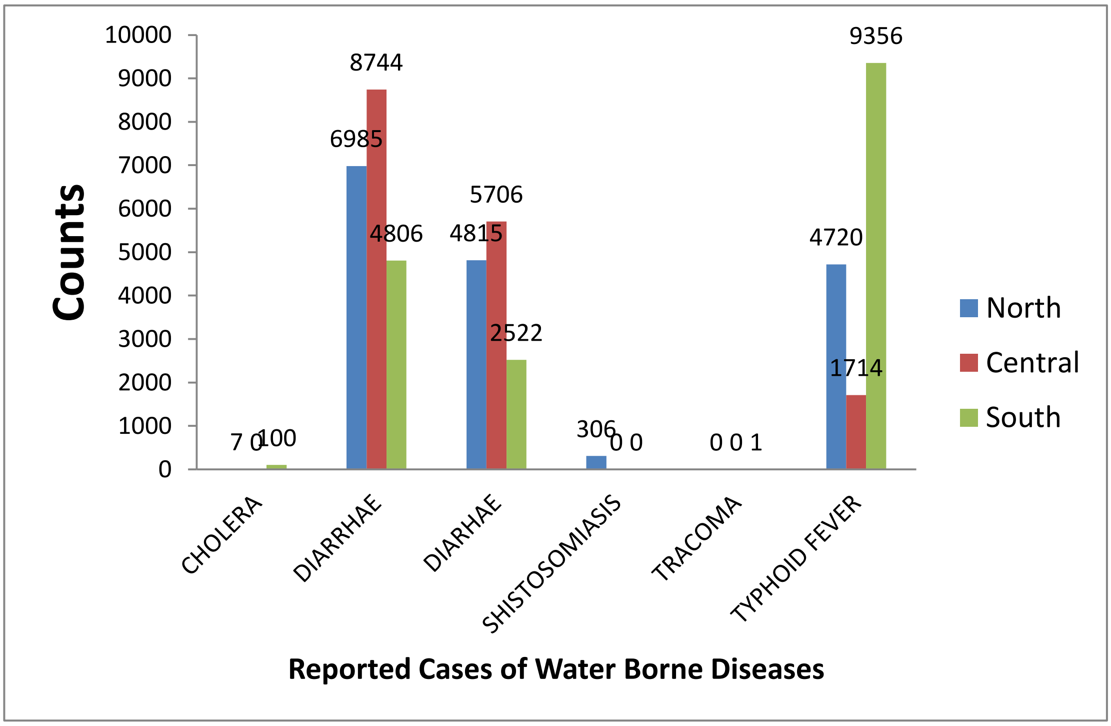


Figure 5.24 Reported Cases of Water Borne Diseases in Communities across the Three Rainfall Zones of Katsina State, over 2011-2013



Source: (Katsina State Primary Health Care Development Agency, February 2014*)*

5.4.2 Training on Water Resources Management

In this study, water resources in rural Katsina State were considered scarce and yet the demands were unlimited. This could lead to degradation of the scarce resources if proper management practices were not in place. It was, therefore, important to have some measure of water management skills in the communities and this was measured through types of training on water resources management. The trainings received by the households were considered crucial in reducing households' vulnerability to water scarcity. Figure 5.25 shows that only about 6% of the respondents in north and central zones ever received training in water resource management and this meant that over 90% of the households had not received any form of training on water resources management. For the few that received training, the main areas in which they had received the training (Table 5.17 and Figure 5.26) were conservation, purification, rainwater harvesting and drilling, most of which were geared toward meeting the immediate needs of the households.

Table 5.17 Types of Training Received on Water Resources Management across theThree Rainfall Zones of Rural Katsina State

Types of Training Received on Water Resources Management	Rainfall zone		
	North	Central	South
Water Conservation	8(2%)	4(1%)	
Water Exploration	4(1%)		
Water Drilling	4(1%)	12(3%)	
Water Purification	8(2%	8 (2%)	
Policy Making	1(0.3%		
Rainwater Harvesting	1 (0.3%)	4(1%)	
N/A	373(93%)	373(93%)	400(100%)

For those who had received training, about 2% received training in the six areas. Those in the central zone received training on only four areas (conservation, purification, rainwater harvesting and drilling). When those who had received training were asked to indicate whether it had been beneficial to them, very few of them (Fig 5.27) indicated that it was indeed beneficial to them. The explanation for this situation could be that the people who had received training had little capacity to comprehend issues in water management or it could be that the trainings were not appropriate for managing the scarce water resources in rural Katsina State. The result was then subjected to chi-square test where the computed chi-square was 43.3 and the critical chi-square was 21.0 (at 95% confidence level) indicating significant differences in types of training by rainfall zones and the differences could be due to significant physical differences.

Figure 5.25 Training received on Water Resources Management across the Three Rainfall Zones of Rural Katsina State

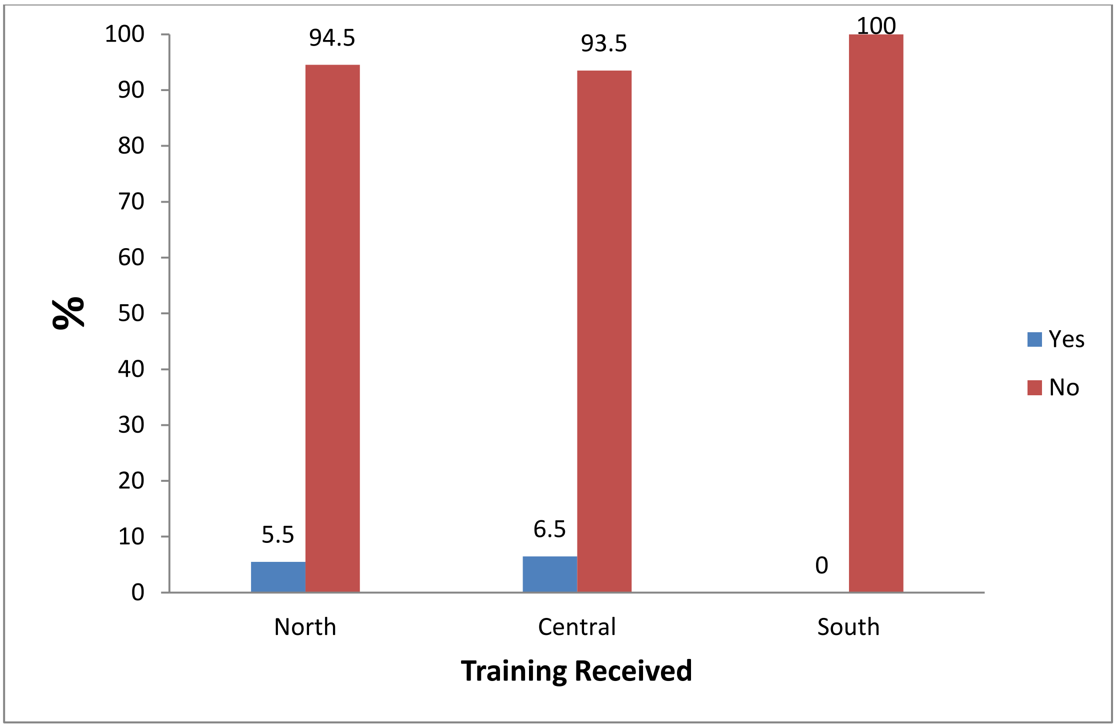


Figure 5.26 The Main Areas of Trainings Received on Water Resources Management across the Three Rainfall Zones of Rural Katsina State

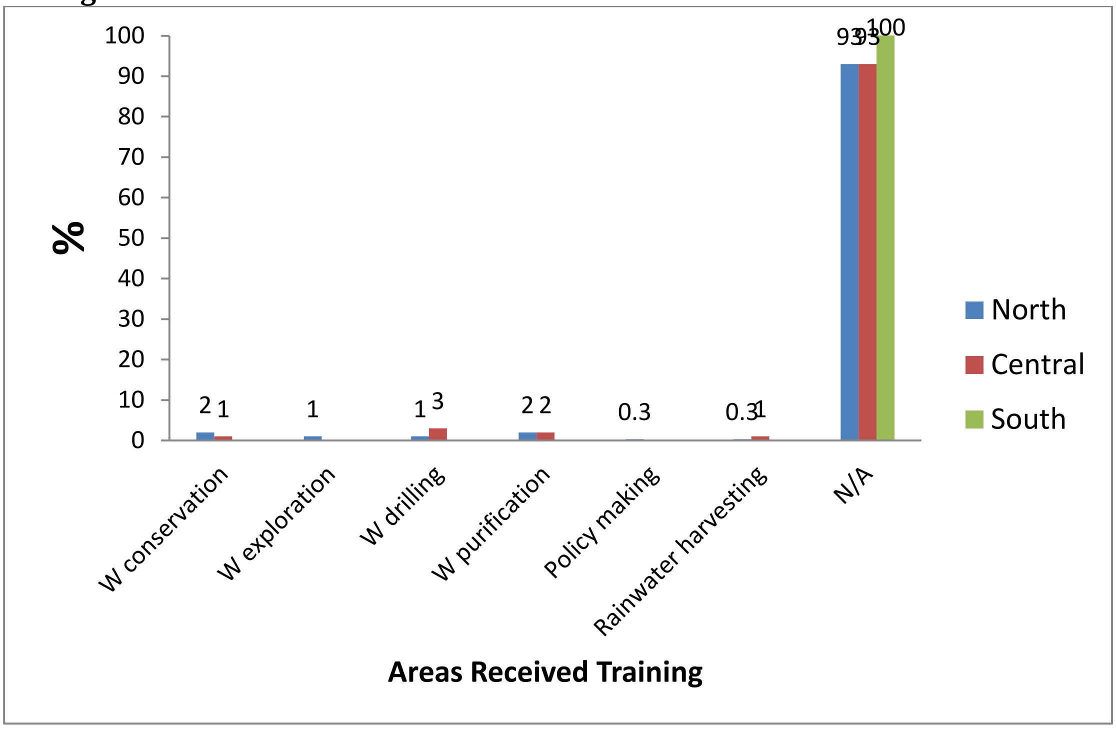


Figure 5.27 Whether the Trainings Received were ever Beneficial across the Three Rainfall Zones of Rural Katsina State

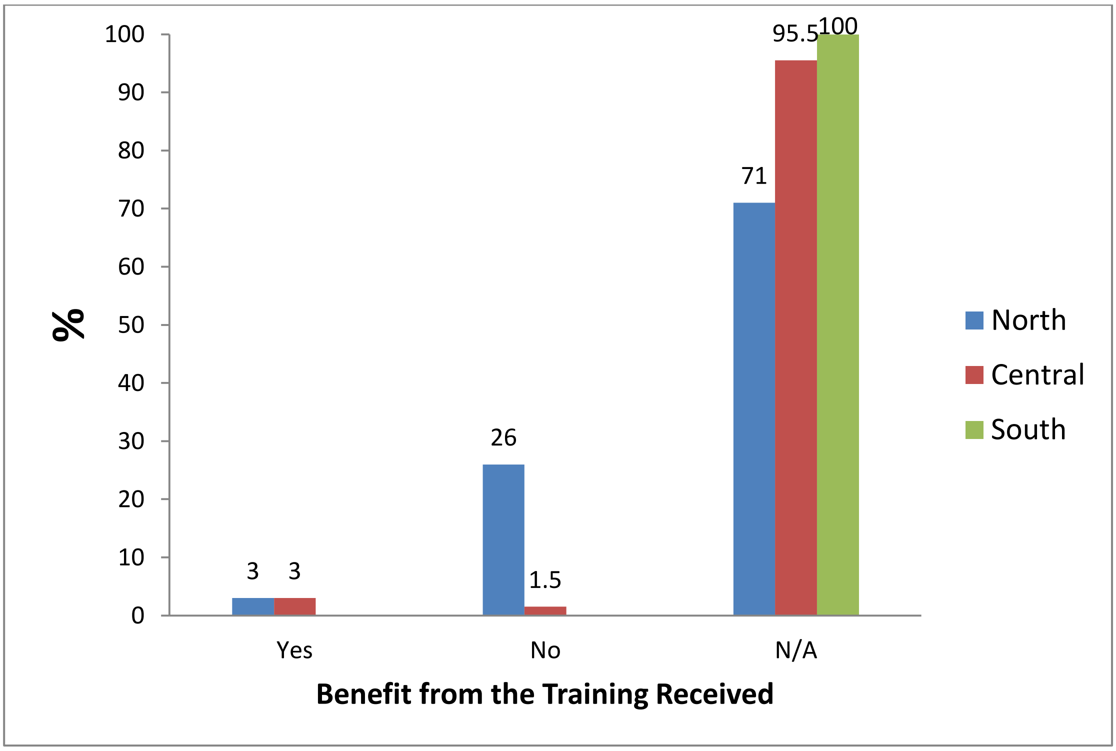
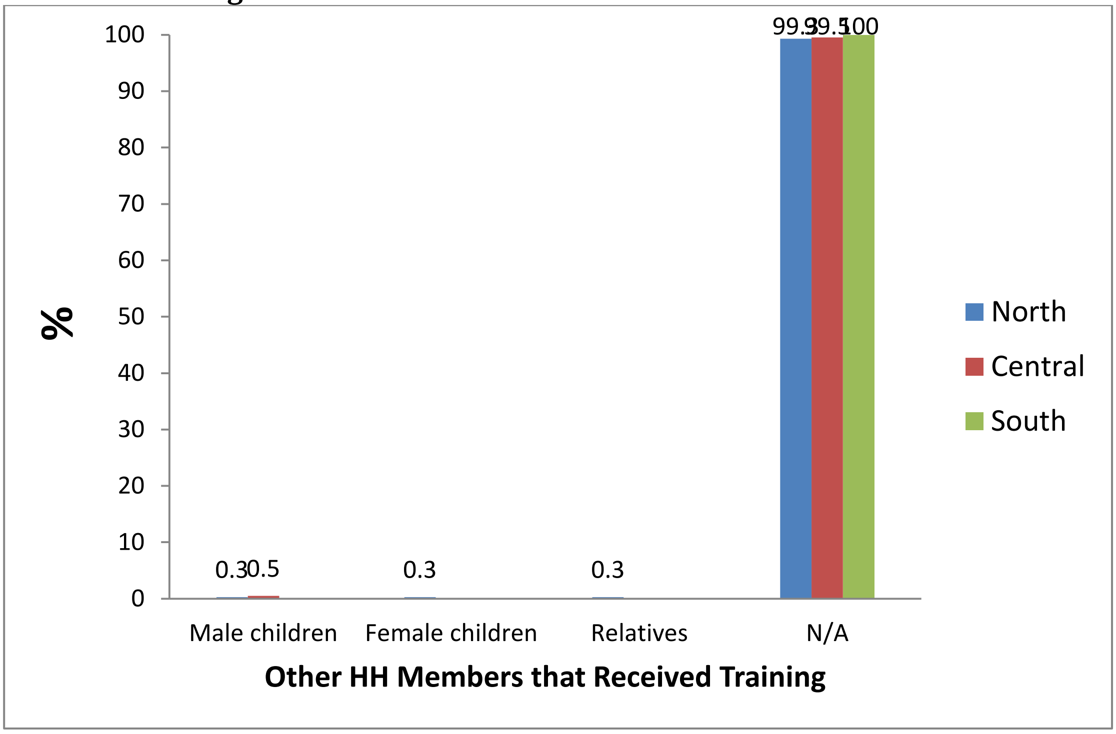


Figure 5.28 Other Household Members that have Received Training on Water Resources Management across the Three Rainfall Zones of Rural Katsina State



5.4.3 Knowledge of Water Scarcity

Knowledge on water scarcity can greatly influence the extent to which an individual or a household is vulnerable to the problem. It was, therefore, important in this study to determine perceptions on water scarcity in rural Katsina State. Frequency analyses of the sample data showed a tendency to be largely on general awareness on water scarcity as a problem in rural Katsina State (Figure 5.29 and Figure 5.30). Generally, between 72% and 95% of the respondents across the three zones were of the opinion that water scarcity was a problem affecting their households while 90-95% was of the opinion that water scarcity was a problem affecting their communities. This was an indication of widespread water scarcity problem in the rural Katsina State and, therefore, need for remedial measures. The remedial measures were expected to result in changes in water supply issues and in this study majority of the respondents (90-95%) indicated having witnessed changes in water supply issues in their community within the last 5-10 years (Figure 5.31). This could mean that either the water supply issues were being addressed for the well being of the community or were not being addressed leading to detioration in water supply situation.

Table 5.18 Knowledge on Kinds of Changes in Water supply Situations across theThree Rainfall Zones of Rural Katsina State

Knowledge on Kinds of Changes in Water supply Situations	Rainfall zone		
	North	Central	South
Depth of wellls increasing	165(41%)	80(20%)	27(7%)
Water yield from wells decreasing	88(22%)	72(18%)	168(42%)
Distance to reach water source increasing	76(19%)	140(35%)	76(19%)
Rivers drying up too quickly after rains	36(9%)	56 (14%)	88(22%)
Rainy periods getting shorter	27(7%)	12(3%)	
Others		2(8%)	
N/A	8(2%)	8(2%)	40(10%)

Table 5.19 Source of Knowledge on Water Scarcity across theThree Rainfall Zones of Rural Katsina State

Source of Knowledge on Water Scarcity	Rainfall zone		
	North	Central	South
Personal knowledge	197(49%)	96(24%)	152(38%)
From elders	52(13%)	104(26%)	20(5%)
Interaction with friends	27(7%)	64(16%)	40(10%)
Family source	20(5%)	4 (1%)	44(11%)
Peer group discussion	24(6%)	4 (1%)	4 (1%)
Village level interaction	20(5%)	72(18%)	96(24%)
Government activities	4(1%)	32(8%)	8(2%)
Media programmes	12(3%)	12(3%)	20(5%)
Others	44(11%)	12(3%)	12(3%)

Figure 5.29 Knowledge of Whether Water Scarcity is a Problem Affecting Households across the Three Rainfall Zones of Rural Katsina State

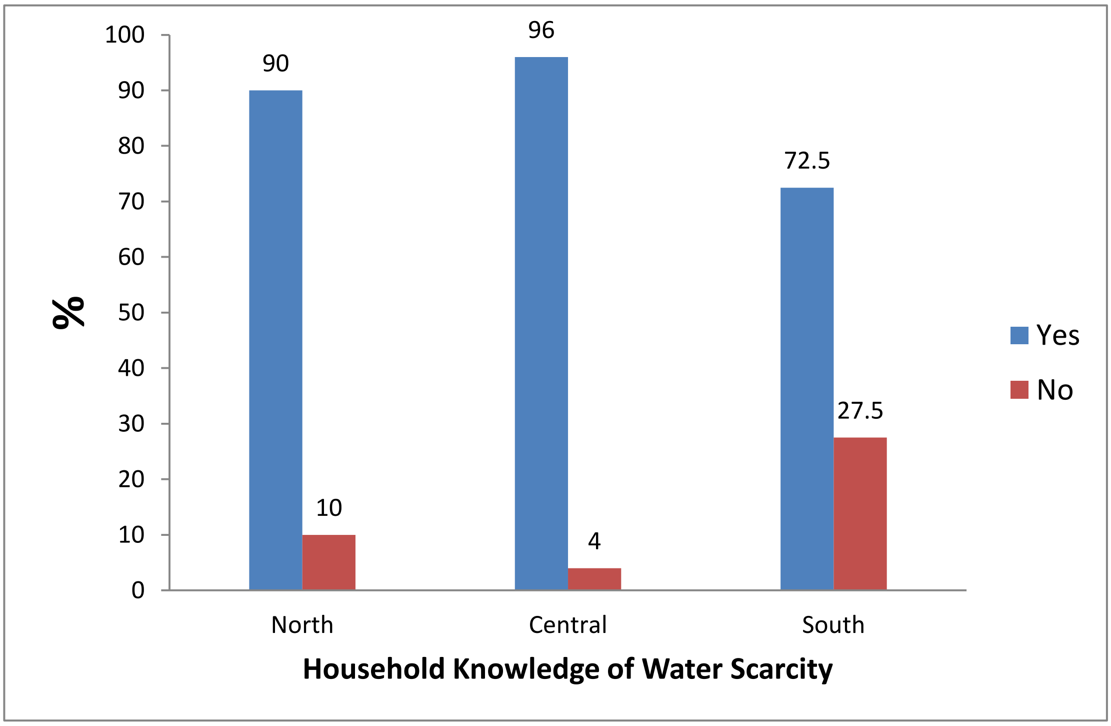


Figure 5.30 Knowledge of Whether Water Scarcity is a Problem Affecting Communities across the Three Rainfall Zones of Rural Katsina State

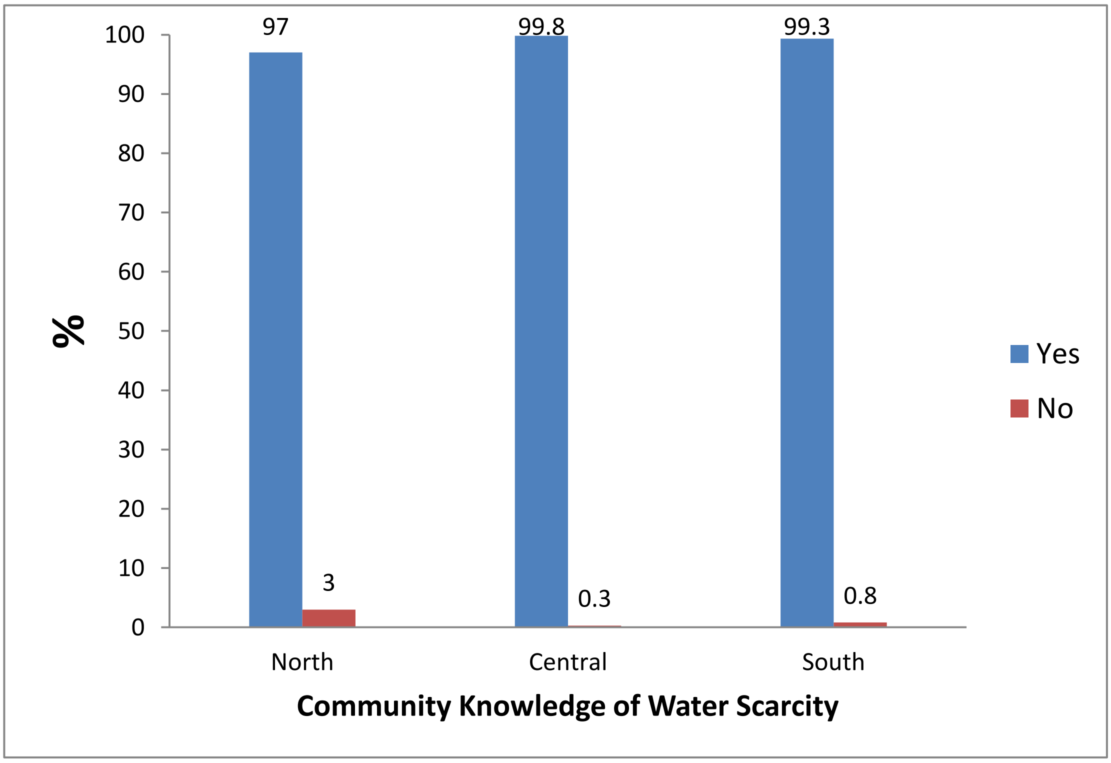
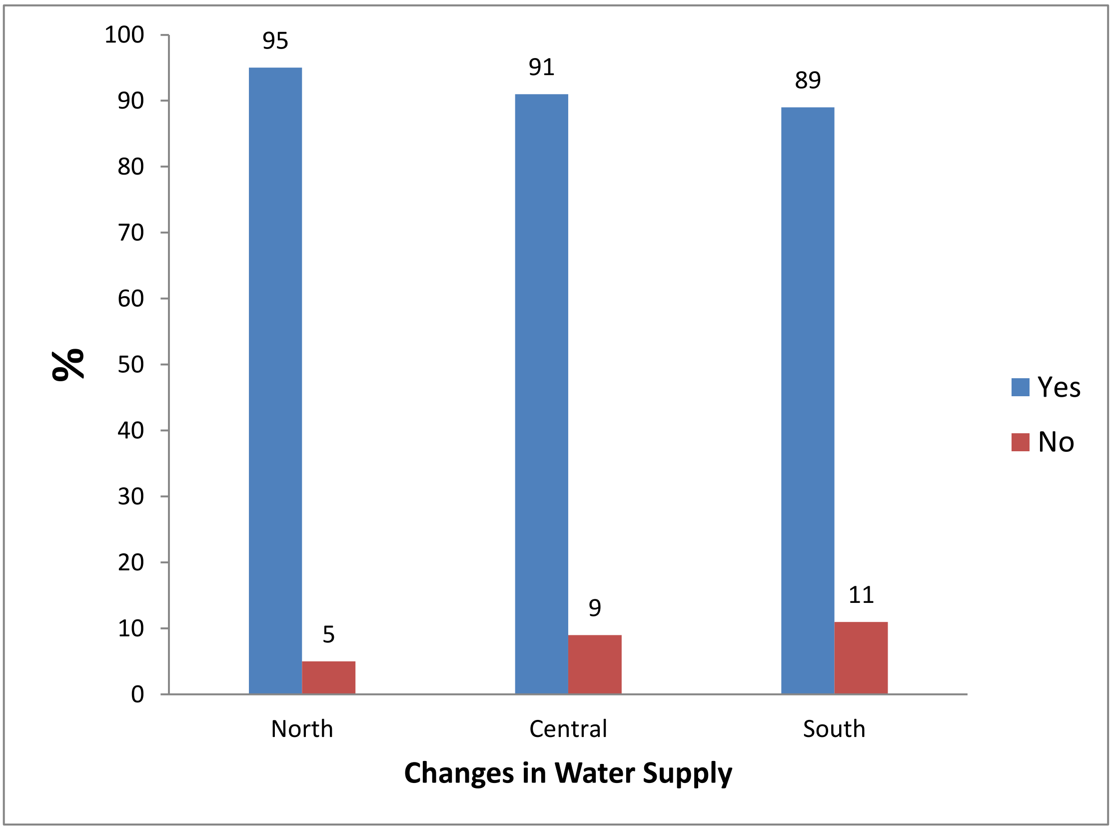
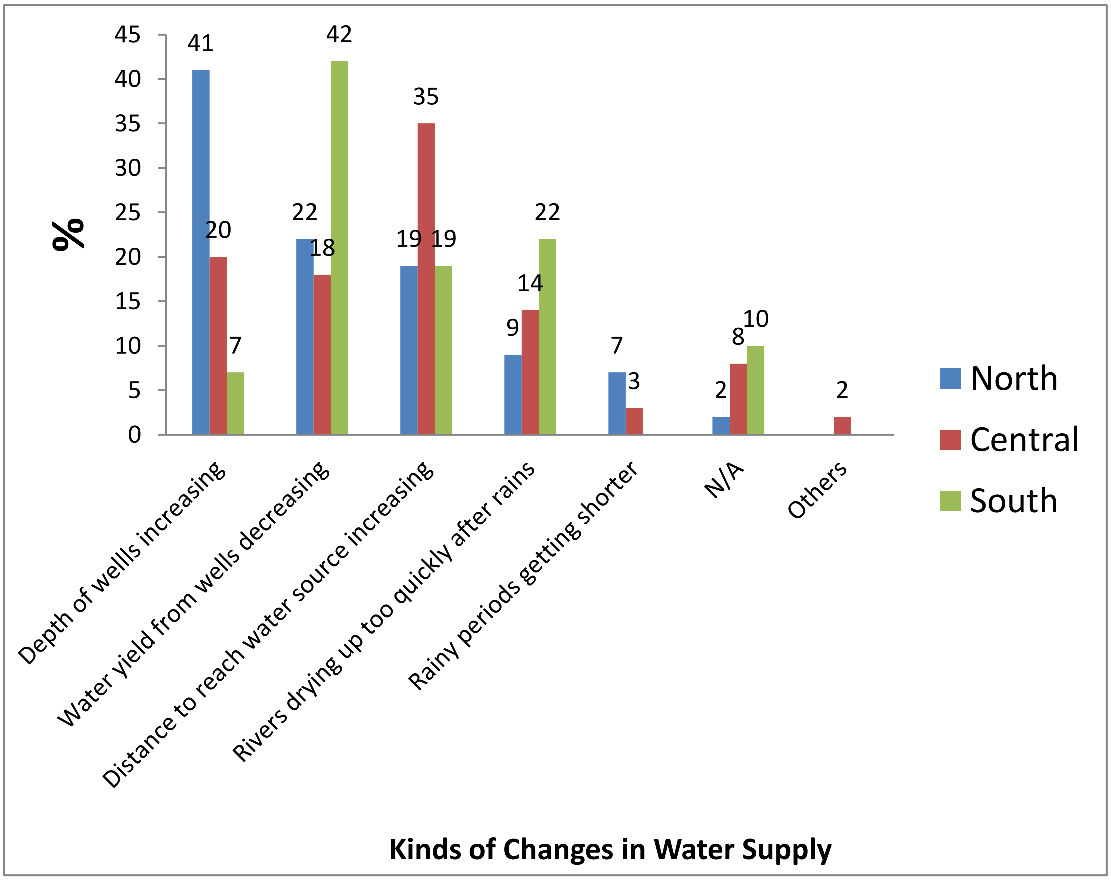


Figure 5.31 Knowledge of Changes in Water Supply within the last 5-10 years across the Three Rainfall Zones of Rural Katsina State



The observed responses to whether there had been changes in water supply issues clearly varied with 41% in the north, 20% in the central and 7% in the south indicating that the depths of their wells had been increasing implying lowering of the water table most likely due to changes in underground water recharge conditions. Further interrogation in this view through the FGDs, indicated that well digging, deepening and rehabilitation were important occupational activities in rural Katsina State but especially in the northern and central zones. This could mean that there was constant struggle to meet the water demands given adverse water recharge conditions where 22% in the north, 18% in the central and 42% in the south, indicated decrease in water yields of their wells in the last 5-10 years (table 5.18 and Figure 5.32).

Figure 5.32 Knowledge of the Kinds of Changes Occurring in their Water Supply Situations across the Three Rainfall Zones of Rural Katsina State



Change in water supply situation was also indicated by increase in distance covered to reach water source, 19% in the north, 35% in the central and 19% in the south of the respondents indicating it was one of the observed changes. Field observations indicated that the longer distances covered in fetching water were accomplished through use of bicycles, motorcycles, donkeys, ox-driven cart and push carts meaning additional cost in water supply thus increase vulnerability to water scarcity.

In this study, physical decrease in the river water discharge was considered a possible indicator of climate change and the data anlyses results indicated general community perception of drying rivers (9% in the north and 14% in the central zones and 22% in the south). This could mean decline in rainfall amount and, therefore, low groundwater recharge. The possibility of rainfall decline was investigated in this study. The results were that, 3% of the respondents in central and 7% in the northern zone indicated decrease in rainy period as an indicator of changes in water supply across the state. This suggested decrease in length of rainy season was more pronounced in the northern than central and southern zones of the study area. Majority of the respondents in the north and central zones indicated that the length of rainy season was 4-5 months instead of the expected 6 months. This could mean shortening of the rainfall period in rural Katsina State save for the southern zone where majority (63%) indicated 6 months rainfall period (Figure 5.35).

The overall water levels in the water supply sources (wells, boreholes, streams, ponds) were considered as possible indicator of climate change and results of data analyses (Figures 5.33-5.34) though varying by zone indicated generally very low levels (19% in the north, 18% in the central and 39% in the southern zone). This could mean general water supply decline possibly due to changes in climate conditions. The results of low levels were attributed to decline in ground water level (67% in the north, 72% in the central and 55% in the south), over exploitation of groundwater (15% in the north, 16% in the central and 20% in the south) and drying up of streams (17% in the north, 9% in the central and 24% in the south). The FGDs indicated that streams dry up too quickly and levels of water in wells and boreholes going down too easily were the major problems faced as soon as rains ceased.Boreholes in particular tended to start yielding very low amount of water as soon as dry season sets in, with someone made to pump severally before a borehole could release water. This situation could magnify vulnerability to water scarcity especially with those of low income level.

The described differences on knowledge of water scarcity problem in rural Katsina State was tested for significance using the chi-square test and the computed chi-square was 75.0 and the critical chi-square was 15.5 at 95% confidence level. This means that the observed differences in knowledge on kinds of changes in water supply situations in the studied communities across the three rainfall zones were not chance events and, therefore, those differences could be due to significant physical differences.

Figure 5.33 Assessments of Water Levels in the Various Supply Water Sources across the Three Rainfall Zones of Rural Katsina State

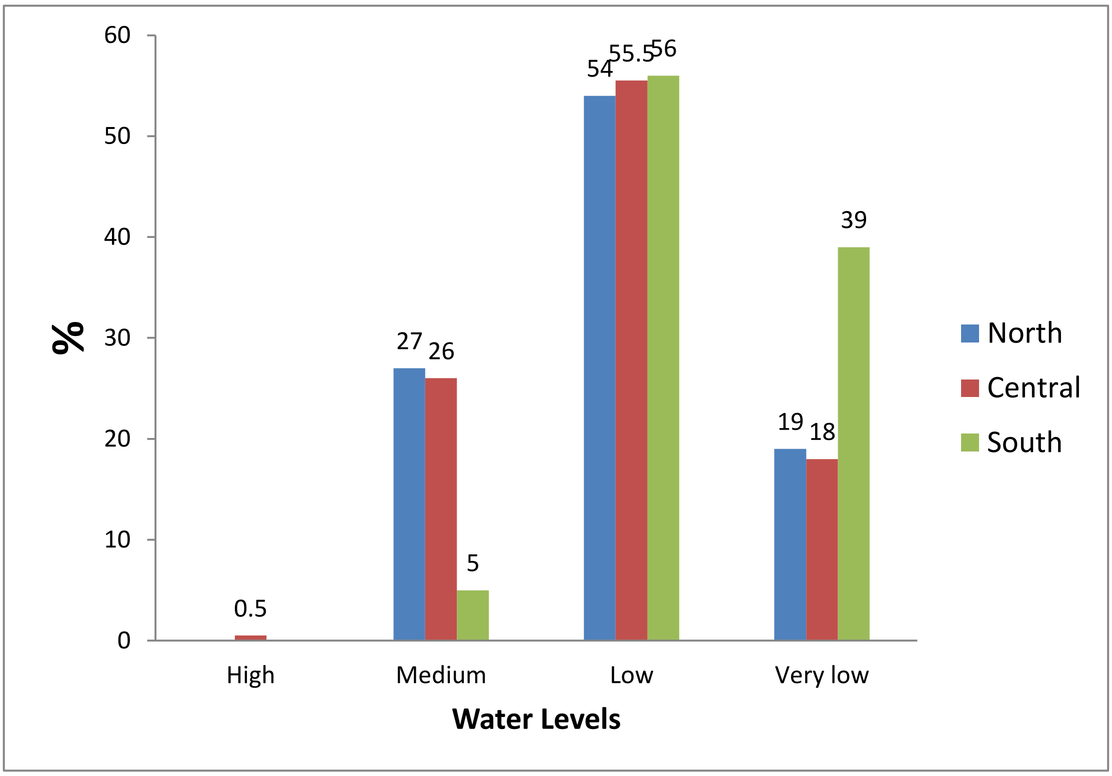


Figure 5.34 Perceptions of the Causes of Changes in Water Levels in the Various Supply Water Sources across the Three Rainfall Zones of Rural Katsina State

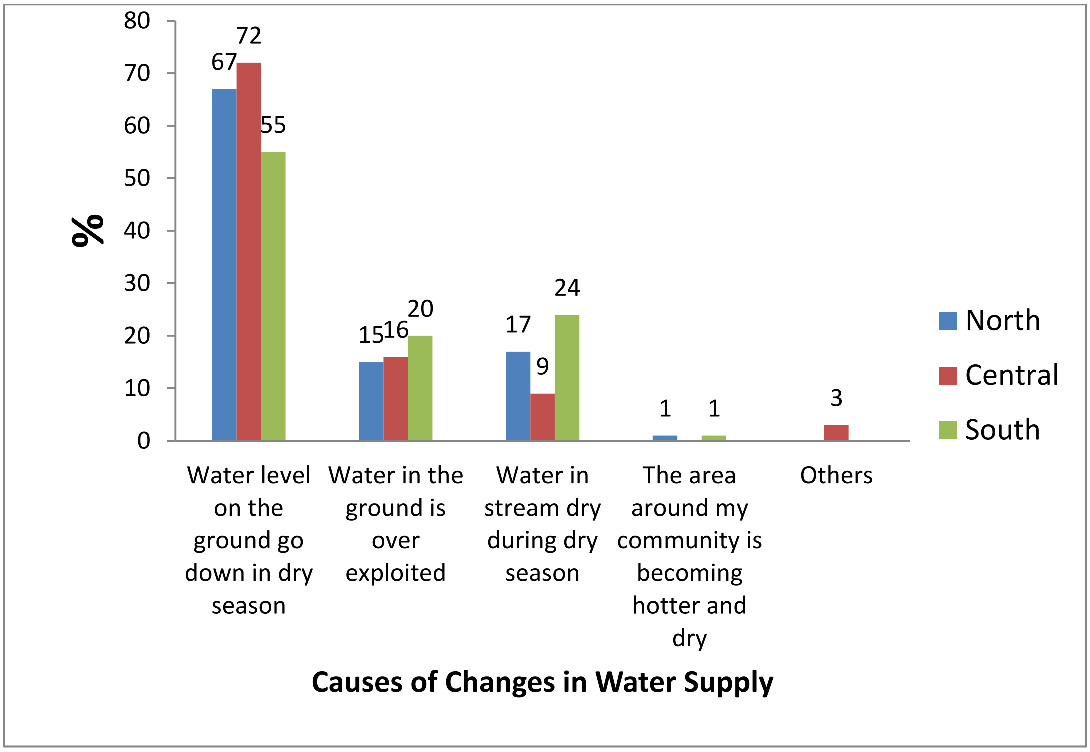
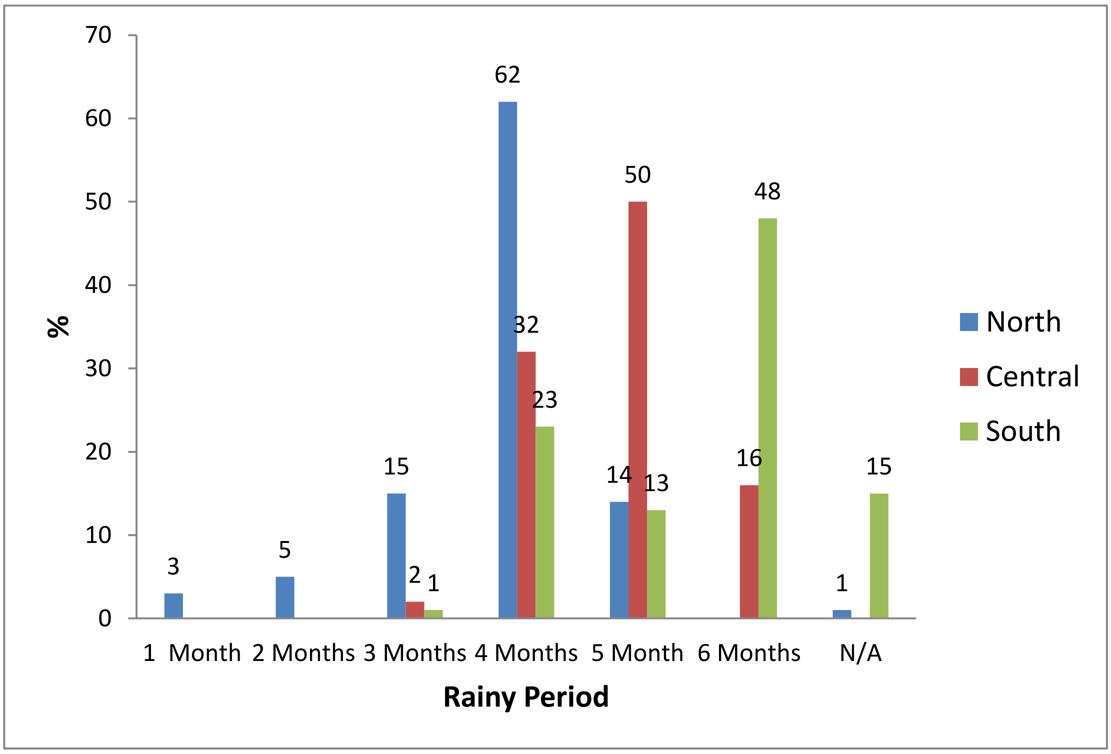
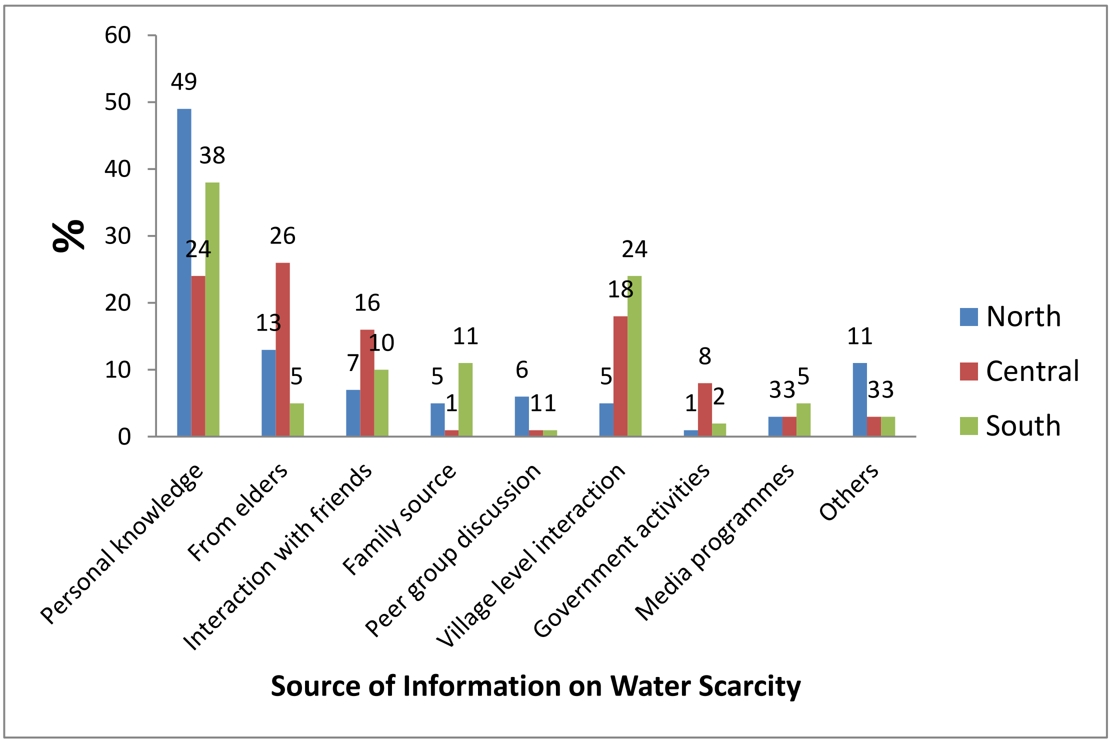


Figure 5.35 Assessment of the length of Rainy Season across the Three Rainfall Zones of Rural Katsina State



Since knowledge on water scarcity problem was generally high indicating general awareness of the problem, it was important to interrogate the source of the knowledge. Data analyses results indicated (Table 5.19 and Figure 5.36) that personal knowledge was the main source (49% in the north, 38% in the central and 24% in the south) of the respondents and this was followed by elders (13% in the north, 26% in the central and 5% in the south), village level interactions (5% in the north, 18% in the central and 24% in the south) and friends (7% in the north, 16% in the central and 10% in the south). In general, knowledge acquisition was largely experiential and less formal with only about 10% of the respondents across the three rainfall zones indicating other sources (school, electronic media, and printed materials). This suggested limited and local sources of information on water scarcity across the three rainfall zones and this could mean low uptakes of new ideas in water scarcity. This situation was tested for significance using chi-square test and the computed chi-square was 292.0 while the critical chi-square was 33.9 at 95% confidence level. This meant that the observed differences in the sources of knowledge on water scarcity problem being faced by the households studied across the three rainfall zones were not chance events and, therefore, could be due to significant differences in knowledge acquisition. This need to be viewed from educational level perspective and the conservative nature of communities in rural Katsina State.

Figure 5.36 Source of Knowledge on the Problem of water Scarcity across the Three Rainfall Zones of Rural Katsina State



5.4.4 Access to Water Sources

Access to water resources (defined in terms of issues like water supply sources available, distance covered to reach the source and quantity of water that is available) is an issue that can determine the extent of vulnerability to water scarcity. Across the three rainfall zones, data analyses results indicated variations in the water sources available to the households (Table 5.20 and Figure 5.37) where open wells, shallow wells on streams, running water in streams and community boreholes were the main water supply sources for domestic uses. Of these water sources, surface water flows could only occur during the rainy seasons in the study area. This implied that ordinary open wells, shallow wells on streams and community boreholes were the main water supply sources across the three rainfall zones for most times in the year.

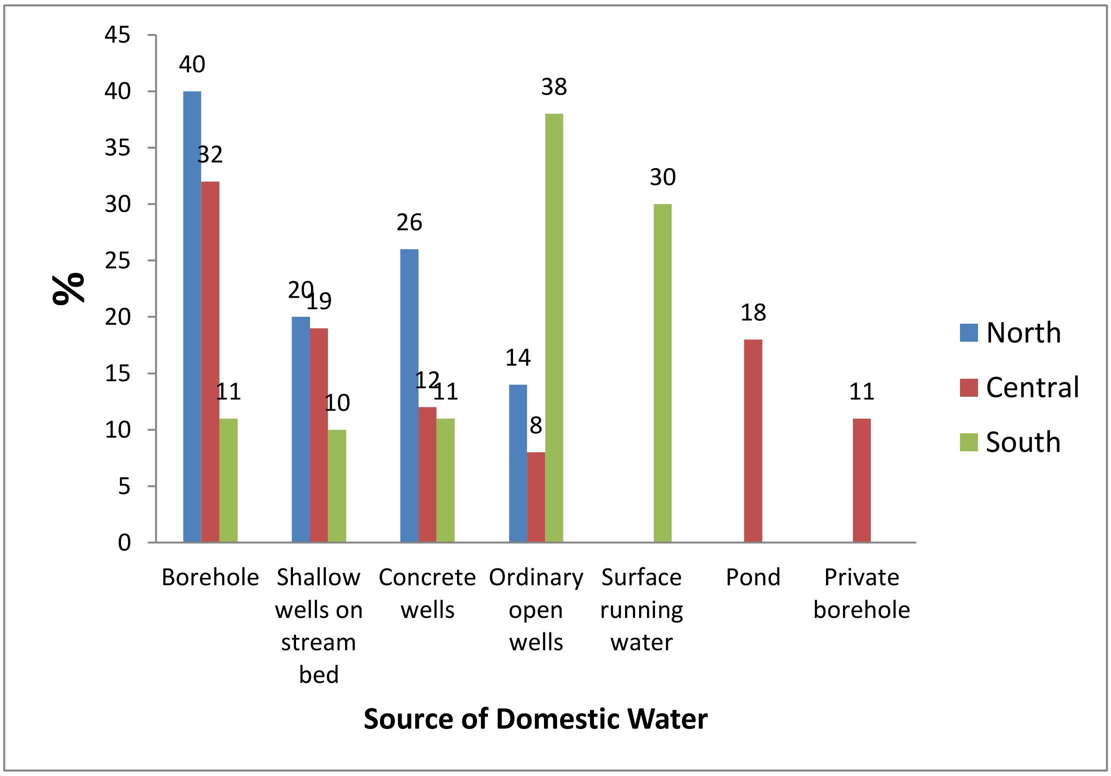
Table 5.20 Source of Water for Domestic Use across theThree Rainfall Zones of Rural Katsina State

Source of Water for Domestic Use	Rainfall zone		
	North	Central	South
Borehole	160(40%)	128(32%)	44(11%)
Shallow wells on streams bed	80(20%)	76(19%)	40(10%)
Concrete wells	104(26%)	48(12%)	44(11%)
Ordinary open wells	56(14%)	32 (8%)	152(38%)
Surface running water			120 (30%)
Pond		72(18%)	
Private borehole		44(11%)	

Table 5.21 Source of Water for Watering Livestock across the Three Rainfall Zones of Rural Katsina State

Source of Water for Watering Livestock	Rainfall zone		
	North	Central	South
Borehole	92(23%)	72(18%)	28(7%)
Shallow wells on streams bed	104(26%)	120(30%)	68(17%)
Concrete wells	112(28%)	20(5%)	36(9%)
Surface running water	12(3%)	40 (10%)	180(45%)
Others	80(20%)	148(37%)	88 (22%)

Figure 5.37 Source of Water for Domestic Use of the Households across the Three Rainfall Zones of Rural Katsina State



It was important to determine the main sources of water so as to have some measure of vulnerability to water scarcity in terms of water availability and possible exposure to water-borne diseases. Analyses of the sample data revealed that 20% of the respondents in the north, 19 in the central and 10% in the southern zones indicated shallow wells on streams as their source of domestic water supply while 26% of the respondents in the north, 19% in the central and 10% in the southern zone indicated concrete wells as their major domestic water supply source. Other sources of water included private boreholes and ponds (11% and 18% respectively in the central zone) and surface running water with 30% in the south. In general, it is clear from the table 5.20 and figure 5.37 that the respondents generally had unimproved water sources in meeting their domestic water supply needs.

The private boreholes were constructed by individuals to exploit money-making opportunities created by the water scarcity. Lack of adequate boreholes to meet water supply requirements, a measure of water scarcity, was expoited by indivuals in the Kofa community where water vendors (the ‘Mai Ruwa’ in Hausa) take advantage of this situation. Water from the vendors cost 10 Naira per 25-litre container (the yellow jerry can on plate 5.7) at the source but cost 20 Naira at the household level. Although many research reports have indicated the main rural water sources across the Sub-Saharan Africa as water in streams, wells, and to some extent, communal boreholes (World Bank Group, 1997; 2002, 2009; WHO, 2001; Onyenechere, 2004; Peter and reed, 2004; Ishaku, 2011), these sources vary in quality, accessibility and cost acquisition. Vulnerability to water scarcity is expected not only to be an issue of water availability but also an issue of quality and accessibility.

In field observations and FGDs, it was established that water extraction could be a hindrance in accessing water. In rural areas of Katsina State, water extraction systems included hand pump, motorised pump and solar powered pump of which hand pump was the most common. This variation in extraction system was possibly affected by cost of acquisition, ease of operation and maintenance and water extraction time and, therefore, access to water.

When differences in sources of water and access to water were subjected to statistical test using chi-square (computed chi-square = 990.6 and the critical chi-square = 21.0 tested at 95% confidence level), it was found that the observed differences in the sources of water for domestic use of the households studied across the three rainfall zones were not chance events and, therefore, significant.

Plate 5.1: Private Ordinary Open Well at Gurjiya Community, Daura LGA.

Plate 5.2: Shared Public Hand Pump Borehole Kofa Community, Kusada LGA

Plate 5.3: Fetching Water for Watering of livestock and Domestic Uses at Gyarta Community, Mashi LGA

Plate 5.4: Shared Public Open Concrete Well at Gyarta Community, Mashi LGA.

Figure 5.38 Source of Water for Watering Livestock of the Households across the Three Rainfall Zones of Rural Katsina State

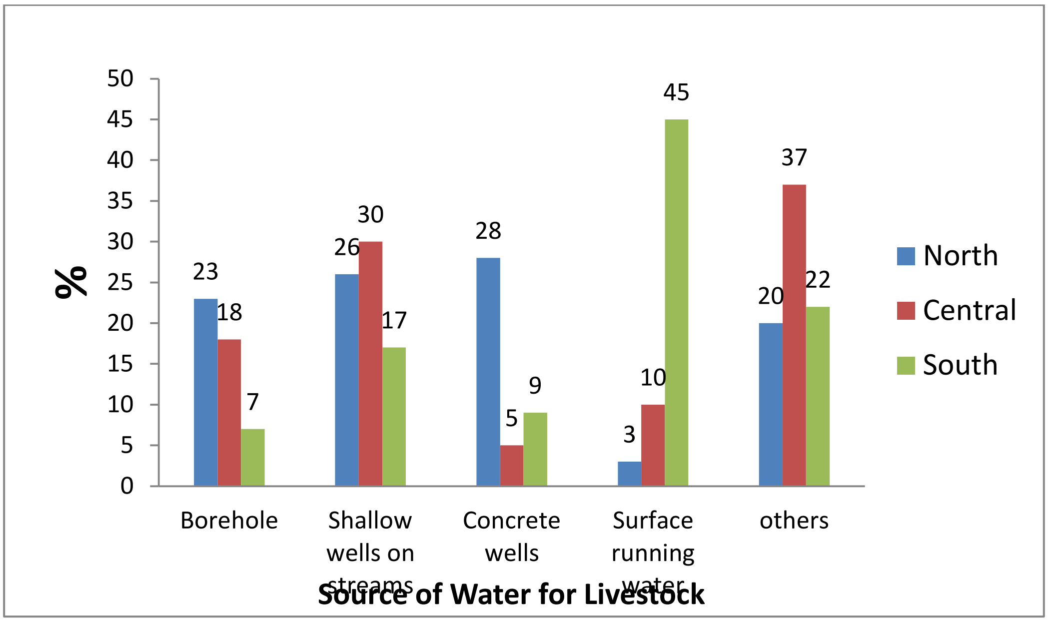


Table 5.21 and Figure 5.38 represents information on water supply source for livestock since this study considered livestock watering as one of the factors affecting vulnerability to water scarcity in terms of demand and availability. In rural Katsina economy, livestock keeping is an important element which is dictected by cultural norms, pasture availability and watering points. Since the WHO recommendation for households' water supply per day per person is 20 litres, it ignores other water demands such as livestock watering and which underestimated of total water demand and vulnerability to water scarcity. Analyses of the sample data indicated that the livestock tended to rely on water sources that were also used for domestic water supply (Table 5.21 and Figure 5.38). The general tendency was to have livestock relying mostly on concrete well (28% in the north, 5% in the central and 9% in the south) but also on shallow wells on streams (26% in the north, 30% in the central and 17% in the south), surface runnig water in river (3% in the north, 10% in the central and 44% in the south). Others mean ordinary open wells and ponds. Plates 5.3, 5.4 and 5.5 show livestock and human making use of water in ponds in two different communities for variety of purposes and this was reflected in the FGDs which indicated that there was no specific water location for livestock. The implication of this is that the demand for water could compromise water availability and water quality. On water availability, it was apparent that the WHO 20 litres per person per

day would not be appropriately representing the pressure on water resources and, therefore, indicates vulnerability to water scarcity in rural Katsina State.

The variation in terms of water sources for livestock describe in the preceeding paragraph was tested for significance difference using chi-square test and the computed chi-square was 652.5 while the critical chi-square was 15.5 at 95% confidence level. This meant that the observed differences in sources of water for watering of the livestock by the households studied across the three rainfall zones were not chance events and therefore representative of the water supply situation in rural Katsina State.

Plate 5.5: Competing for the same Water Source by Livestock and those Fetching Water for other Uses at Kuraye Community, Charanchi LGA

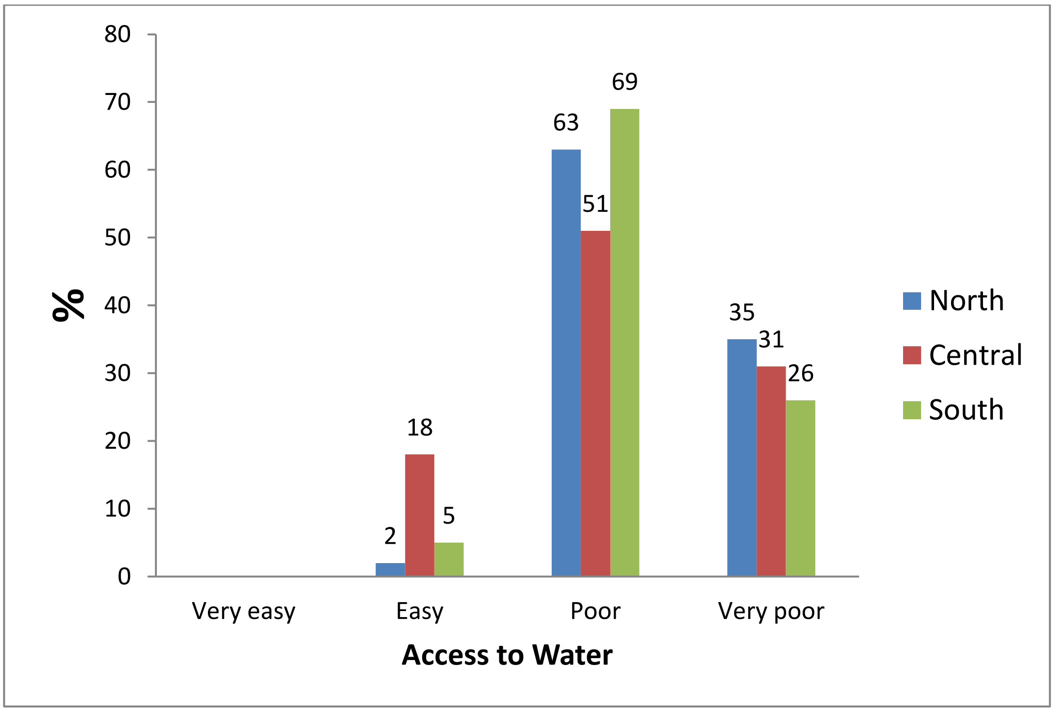
Plate 5.6: Pay-Per-Fetch Water Selling Point constructed by a Private Investor at Kofa Community, Kusada LGA

Plate 5.7: Children and a Woman Filling Containers using a Water Horse the Pay-Per-Fetch Water Selling point of Kofa Community, Kusada LGA

Plate 5.8: Long Queue of Containers Waiting for the Borehole to Yield Enough Water for Pumping at Walawa Community, Kaita LGA

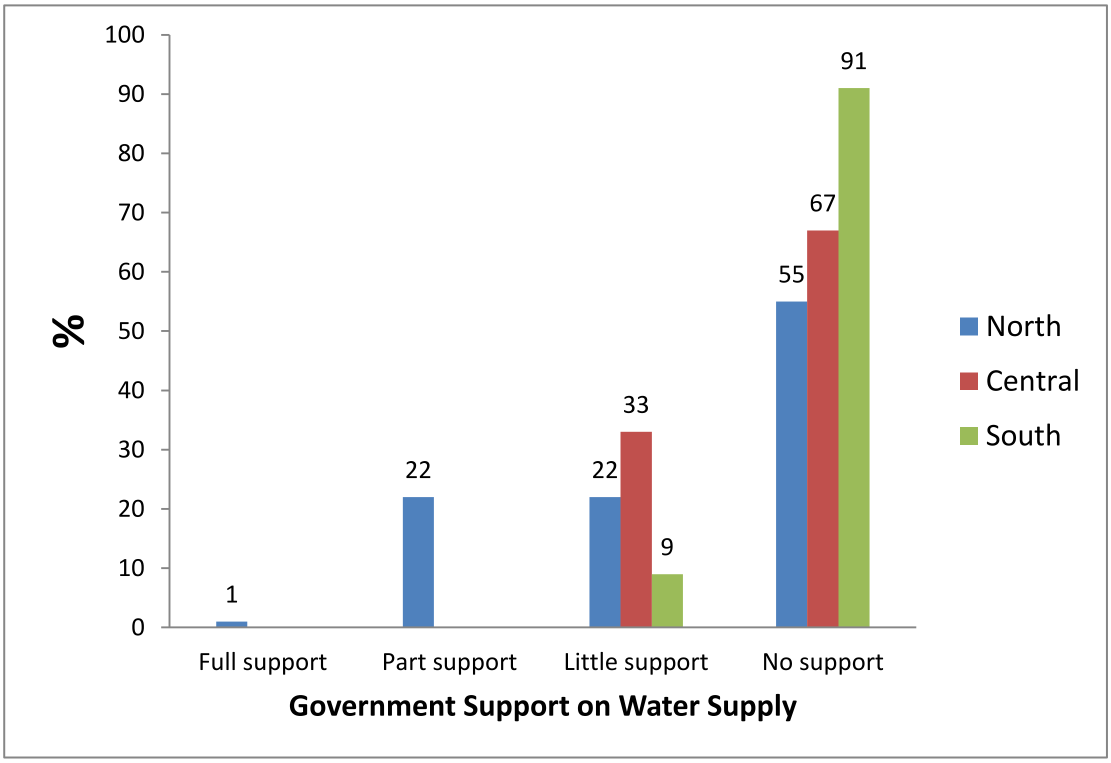
Plate 5.9: A Hand Pump borehole Feeding Water to 2 Taps at Walawa Community, Kaita LGA

Figure 5.39 Characterization of Access to Water Supply across the Three Rainfall Zones of Rural Katsina State



The general water supply situation was also analysed in terms of general characteristics and the results showed that the characteristics were generally poor across the three rainfall zones (51% - 69%) (Figure 5.39). This was not surprising given that the water scarcity vulnerability have been determined to vary from moderate to high status among the households across the study area. The implication is that the various interventions to alleviate water scarcity vulnerability had not been effective and there was need for more sustenable approaches. Analyses results also indicated general lack of support from the authorities (56%-91%) with only 9%-33% of the respondents (Figure 5.40) indicating having received support to alleviate water scarcity problem across the three rainfall zones. This lack of support from the authorities could mean more vulnerability to water scarcity and there was, therefore, need for intervention from the NGOs to assist in reducing vulnerability to water scarcity. Perhaps more serious issue other than the little support from the government was that the limited water sources were by international standards unimproved source meaning they could be a health hazard as well as a water scarcity characteristic thus increasing vulnerability to water scarcity. The lack of government support could also mean low priority to efficient management of limited water resources.

Figure 5.40 Nature of Government's Support Towards Water Supply across the Three Rainfall Zones of Rural Katsina State



According to the WHO (1996a) access to safe water is measured by the proportion of population with access to adequate amount of safe drinking water located within a convenient distance from the user's dwelling.

The UNICEF (2012) categorized water access in terms of:

(i) *Improved drinking water sources*, which include sources that, by nature of their construction or through active intervention, are protected from outside contamination, particularly fecal matter. It comprises piped water on premises such as piped household water connection located inside the user's dwelling, plot or yard. Other improved drinking water sources include public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs and rainwater collection.

(ii) *Unimproved drinking water* which include sources like unprotected dug well, unprotected spring, cart with small tank/drum, tanker truck, and surface water (river, dam, lake, pond, stream, canal, irrigation channels), bottled water.

The study showed that water access in rural Katsina State could be categorized as unimproved drinking water since most respondents relied on unprotected shallow streams, surface stream water and unprotected dug well. When access to water in rural Katsina State was compared to the WHO (1996b) proposal on rural water access as indicated below, the water access was found to fall under none of the categories meaning poor access to water.

a. *Access to Water*: Reasonable access implies that a person does not have to spend a disproportionate part of the day fetching water for the family's needs
b. *Adequate amount of water*: 20 liters of safe water per person per day
c. *Safe water*: Water that does not contain biological or chemical agents directly detrimental to heath. It includes treated safe water and untreated but uncontaminated water from protected springs, boreholes, sanitary wells e.t.c

Since access to water in rural Katsina State was found to be relatively poor, the water supply problem could be considered a crisis of governance according to UNDESA (2004). If water supply problem of rural Katsina State was a crisis of governance, it meant, therefore, that water security was relatively intence and vulnerability to water scarcity relatively high (UNDP, 2013). All water resources require efficient, sustainable management and where water is scarce, as in rural Katsina State, there is need to ensure that all sectors, agricultural, industrial and municipal users have equitable, reliable and sustainable access to water and are using water efficiently. The study indicated that many residents of rural Katsina did not have equitable, reliable and sustainable access to water, meaning increased vulnerability to water scarcity.

Water security is a basic idea in social, economic, environmental and health considerations, but it is largely a governance issue where many factors intervene including unclear and overlapping responsibilities, inefficient institutions, insufficient funding, centralized decision-making, limited public awareness and ineffective regulations and enforcement. Across the study area, there were several institutional bodies with overlapping responsibilities for provision of water supply infrastructure (Plates 5.10 to 5.15). These included Federal institutions such as the Sokoto Rima Basin Development Authority, state institutions such as the State Rural Water and Supply Agency (RUWASSA) and, local government institutions such as the Water and Sanitation Departments.

The overlapping roles and resulting ineffectiveness of the agencies led to lack of effective coordination in provision and maintenance of water supply facilities across the three zones. This resulted in generally low perception on quality of water supply infrastructure across the three rainfall zones and through FGDs, it was found that almost all the water supply institutions had no programme for infrastructure maintenance. The communities were expected to maintain the facilities and where a community had no such capacity to manage and maintain the water supply infrastructure (which was practically the case in all the communities studied), their degree of vulnerability to water scarcity would have increased. This situation was further evaluated by involving officials of the Water and Sanitation Departments of the Local Government Councils across the 12 LGAs where it was found that three water tankers were available for each LGA and yet FGDs indicated that none of the communities had received water through such tankers.

Plate 5.10: An Abandoned Borehole Site, Constructed by Sokoto Rima River Basin Development Authority in Asharaha Community, Funtua LGA

Plate 5.11: A Partially Functioning Borehole Constructed under the National Assembly Constituency Outreach Project Scheme at Kuraye Community, Charanchi LGA

Plate 5.12: A Non-Functioning Solar Powered Borehole Constructed by the Energy Commission of Nigeria at Kuraye Community, Charanchi LGA

Plate 5.13: A Non-Functioning Motorised Borehole Constructed Under World-Bank Funded Community and Social Development Project at Gwajo Gwajo Community, Maiadua LGA

Plate 5.14: A Functioning Solar Powered Borehole Constructed by the Katsina State Rural Water Supply and Sanitation Agency at Gwajo Gwajo Community, Maiadua LGA

Plate 5.15: A Non Functioning Solar Powered Borehole Constructed under the Millenium Development Goals Office of the President at Gwajo Gwajo Community, Maiadua LGA

Plate 5.16: Fetching Water from a Pond at Kuraye Community, Charanchi LGA

Plate 5.17: Livestock Drinking Water Directly from a Pond at Kuraye Community, Charanchi LGA

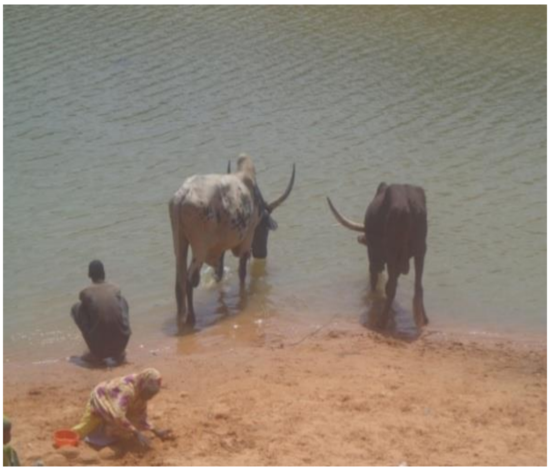


Plate 5.18: Fetching Water and Washing of Clothes from a Pond at Kuraye Community, Charanchi LGA

Plate 5.19: Water in a Shallow Well on Stream Bed to Water Livestock in Yarsanta Community, Safana LGA.

Plate 5.20: Drawing Water using 'Guga' from an Ordinary Open Well at Mallamawa Community, Matazu LGA

Plate 5.21: Drawing Water from a Shallow Well on Stream Bed to Water livestock in Walawa Community, Kaita LGA

Another issue related to water access which was considered as one of the factors influencing water scarcity in the study area was the distance the respondents covered to reach water supply source. From the FGDs, it was noted participants often travel day long distances away from the communities in search of water and this could influence degree of vulnerability to water scarcity. This was particularly so where the water facility provided in a community had broken down and the households were left with no option. The long Journey in search of water meant using alternative sources such as streams and ponds where the quality of water could not be guaranteed thus, more exposure to vulnerability to water scarcity.

The frequency analyses results indicated that households in the central zone were more likely to cover longer distance (1720 meters on average) followed by those in the northern zone (1300 meters on the average) and lastly those in the southern zone (1080 meters on the average). Though there were clear variations in the mean distances covered by households across the three zones, it was obvious from the results that they generally covered long distances (at least 1km on average) to reach water source which largely means spending time more collecting water and also reduced consumption meaning that distance enhances the vulnerability of the households to water scarcity in the study area.

Where long distances were to be covered in search of water it was necessary to have some means of transport and, therefore, an added cost apart from time lost in water acquisition. The means for transporting water was, therefore, considered a possible factor in vulnerability to water scarcity. Within the municipal authority areas households were normally connected to water supply system while in rural areas this was lacking. The households in rural areas were, therefore, expected to make efforts to reach water sources depending on location resulting in different households having different water conveying methods. Analyses of sample data revealed different water conveying methods (Table 5.22 and Figure 5.41) including using bicycle (5% in the north, 24% in the central and 19% in the south), on foot (44% in the north, 25% in the central and 41% in the south) and wheel barrow or push cat (39% in the north, 41% in the central and 17% in the south). These methods were necessary involving much human effort which could, therefore, limit the amount available in the households and, therefore, increase vulnerability to water scarcity. Other water conveying methods included use of motorcycle, donkey, ox-driven cart or motor vehicle accounting across the zones for less than 20% of the responses. Apart from much effort involved in conveying water, the methods could also mean low income levels.

Table 5.22 Water Conveyance Method across the Three Rainfall Zones of Rural Katsina State

Water Conveyance Method	Rainfall zone		
	North	Central	South
Bicycle	20(5%)	96(24%)	76(19%)
Foot	176(44%)	100(25%)	164(41%)
Donkey	20(5%)	8(2%)	28(7%)
Ox-driven cart	12(3%)	4 (1%)	16(4%)
Motorcycle	8(2%)	24(6%)	44 (11%)
Wheel barrow	156(39%)	164(41%)	68(17%)
Motor vehicle	8(2%)	4(1%)	4(1%)

Table 5.23 Access Road across theThree Rainfall Zones of Rural Katsina State

Access Road	Rainfall zone		
	North	Central	South
Bush path	24(6%)	144(36%)	32(8%)
Foot path	284(71%)	148(37%)	196(49%)
Rural feeder road	60(15%)	100(25%)	160(40%)
Tarred road	32(8%)	8 (2%)	12(3%)

The results of frequency analyses were subjected to test of difference using the chi-square test where the computed chi-square was 158.9 and the critical chi-square was 21.0 at 95% confidence level indicating that the observed differences in the methods used to convey water to households were not chance events and, therefore, typical in water sourcing in rural Katsina State. The problem of water sourcing was further interrogated by considering the access roads across the three rainfall zones. The results (Table 5.23 and Figure 5.42) indicated use of footpath (71% in the north, 37% in the central and 49% in the south), bush path (6% in the north, 36% in the central and 8% in the south), rural feeder roads (15% in the north, 25% in the central and 40% in the south) and, tarred road (7% in the north, 2% in the central and 4% in the southern zone). From the results, indication was that most households relied on non motorable surfaces as access road and this further indicated strength in water acquisition and, therefore, increased vulnerability to water scarcity. The observed differences in water supply access road used were found to be typical of access road types in rural Katsina State since the chi-square (242.5) was greater than the critical chi-square (12.5) at 95% confidence level.

Figure 5.41 Means of Conveying Water from Supply Source to Households across the Three Rainfall Zones of Rural Katsina State

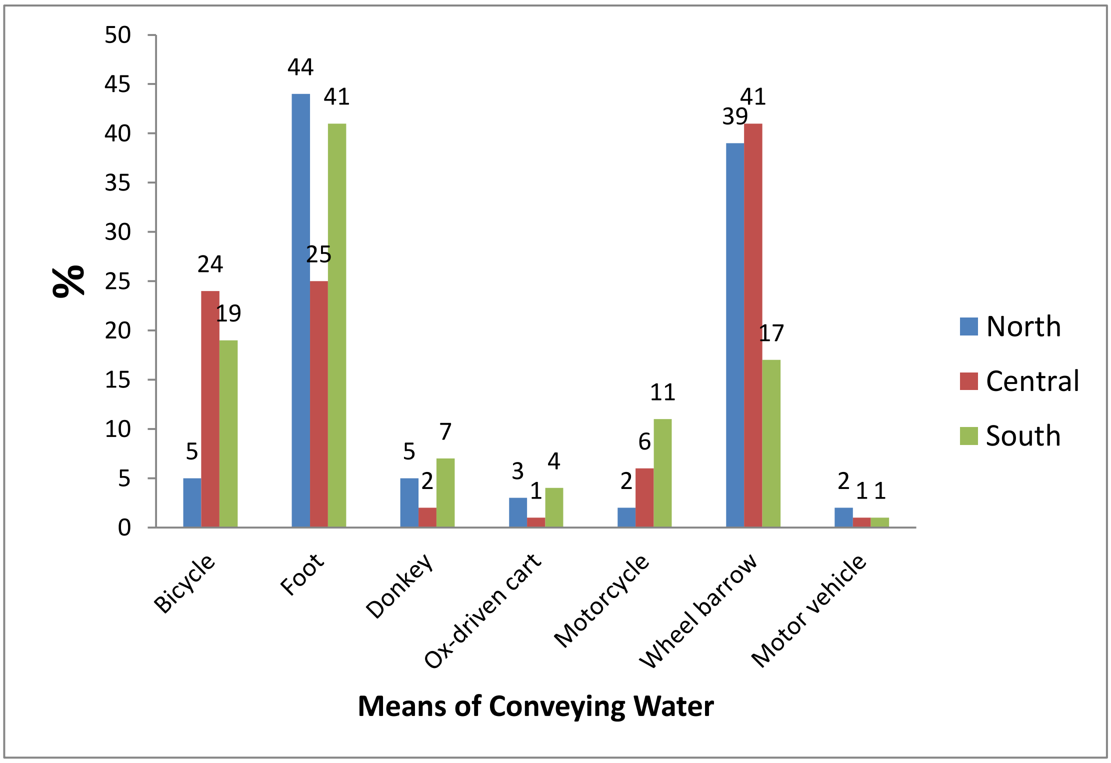
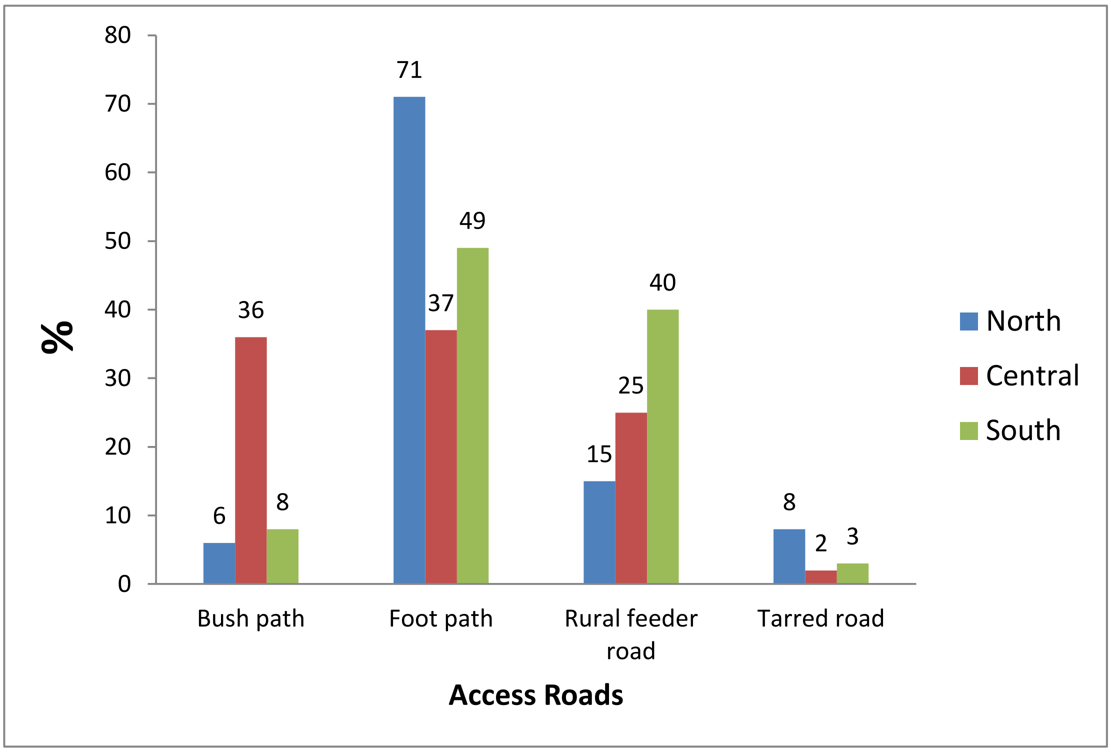


Figure 5.42 Access Roads Used to Reach Water Supply Sources across the Three Rainfall Zones of Rural Katsina State



5.4.5 Feeding, Hygiene and Sanitation Behaviour of Households

Feeding habits (what was consumed, how it was prepared for consumption, what was done after its consumption e.t.c.) as well as hygiene and sanitation practices of households were also important variables that can indicate the extent to which households were vulnerable to water scarcity. A variety of staple foods were identified (Figure 5.43) in the three rainfall zones which were assumed to relate to the varying climate conditions. In the north, the most common staple food was millet while in central zone the most common staple food was guinea corn and in the south the most common staple food was maize and beans or maize and cowpeas. The water requirements of cooking food using products of such crops was found to range from moderate to very high (Table 5.24 and Figure 5.44). This implied high demand for water during the cooking process despite the low availabilility of water to the households' thus aggravating vulnerability to water scarcity.

Table 5.24 Water Requirement for Cooking the Staple Foods across theThree Rainfall Zones of Rural Katsina State

Water Requirement for Cooking the Staple Foods	Rainfall zone		
	North	Central	South
Very high	96(24%)	52(13%)	128(32%)
High	116(29%)	104(26%)	104(26%)
Moderate	176(44%)	156(39%)	88(22%)
Low	12(3%)	88 (22%)	72(18%)
Very low			8 (2%)

The condition of high demand of water during cooking process was subjected to chi-square statistical test to check if the observed differences between the zones were random occurrences. The computed chi-square was (141.7) and the critical chi-square was 15.5 at 95% confidence level and this indicated that the observed differences in water requirement for cooking the staple foods across the three rainfall zones were not chance events and, therefore, part of the general water scarcity situation in rural Katsina State.

The sanitation which is a factor in water demand and quality in human settlement was used in this study from the facility perspective. Results of data anlyses indicated that sanitation facilities were basically in the form of pit latrines (Figure 5.45). Pit latrines if not well managed in terms of location, depth, cleanliness and, usage could be a health hazard in terms of water quality. The prevalence of pit latrine in the study area, therefore, could mean possible contamination of the wells and increased water demand for hygienic activities thus increased vulnerability to water scarcity.

Assuming the prevalence of pit latrine was a health hazard to households in rural Katsina State, it was important to consider the availability of healthcare facilities and results indicated (Figure 5.46) that they were mostly of basic care types (clinics, dispensaries and health centres). In such facilities it was expected that water requirement would be generally lower than in the middle care types (comprehensive health center, general hospital, specialist hospitals, e.t.c). It was, therefore, assumed, given the results, that sanitation and healthcare facilities being used by the households were less likely to aggravate vulnerability to water scarcity across the three rainfall zones.

Figure 5.43 Kinds of Staples Foods Most Consumed across the Three Rainfall Zones of Rural Katsina State

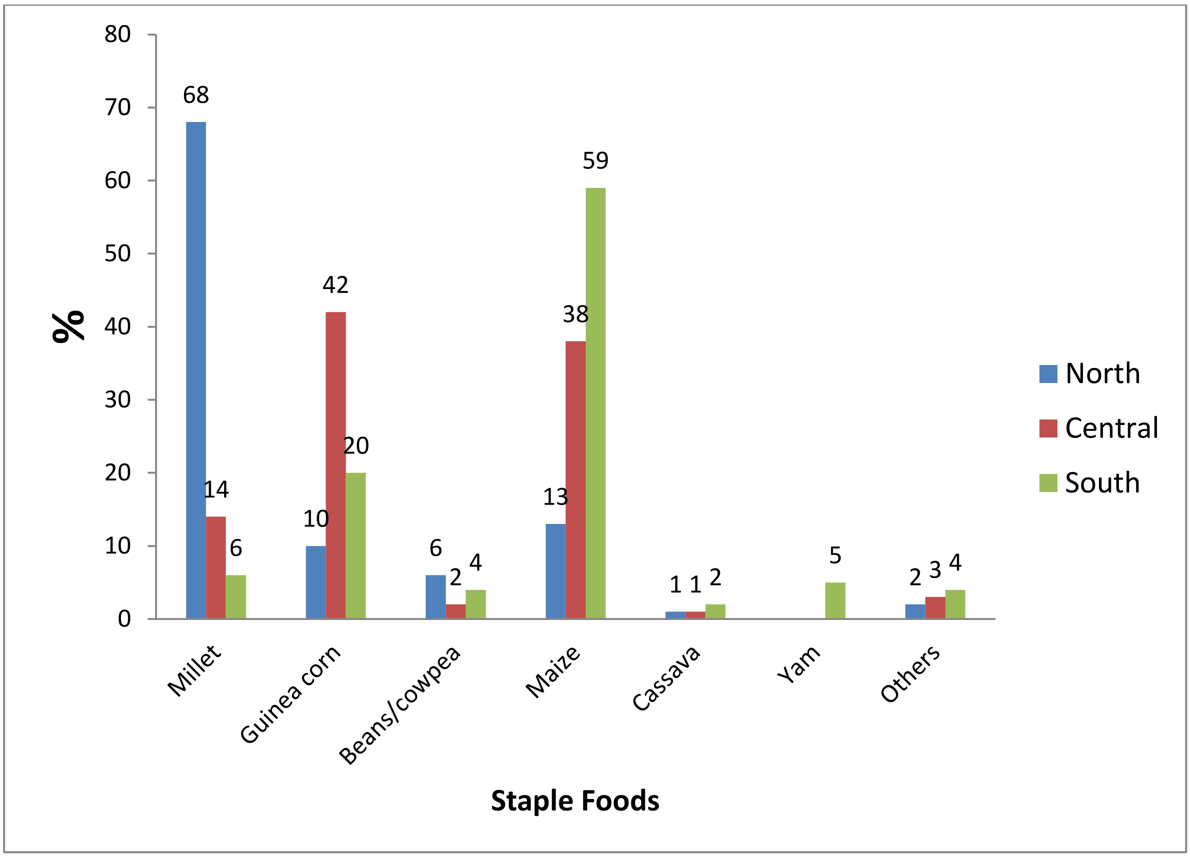


Figure 5.44 Water Requirement of Cooking the Most Staple Foods Consumed across the Three Rainfall Zones of Rural Katsina State

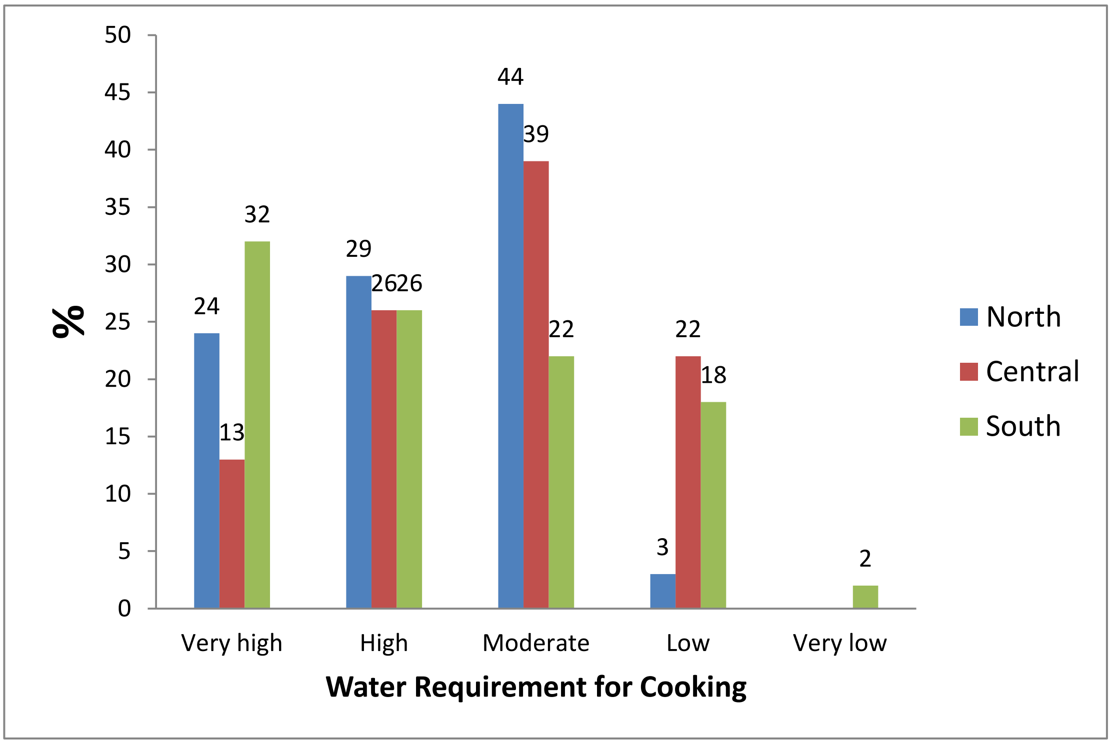


Figure 5.45 Sanitation Facilities Used across the Three Rainfall Zones of Rural Katsina State

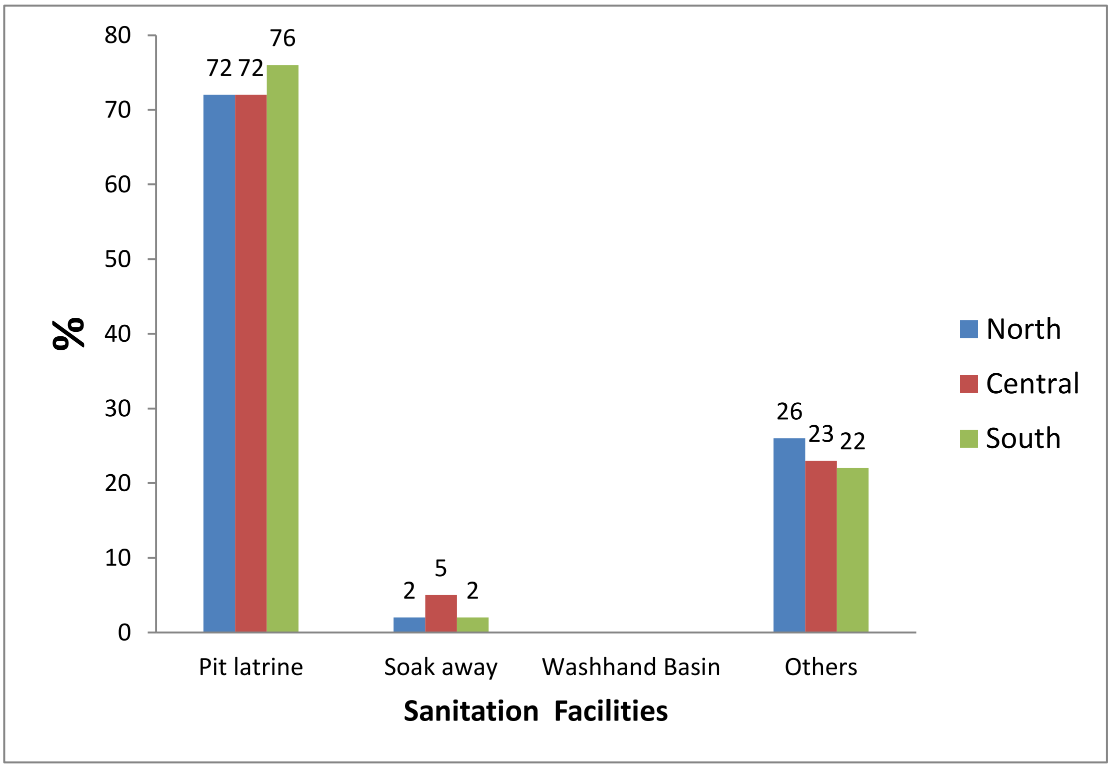
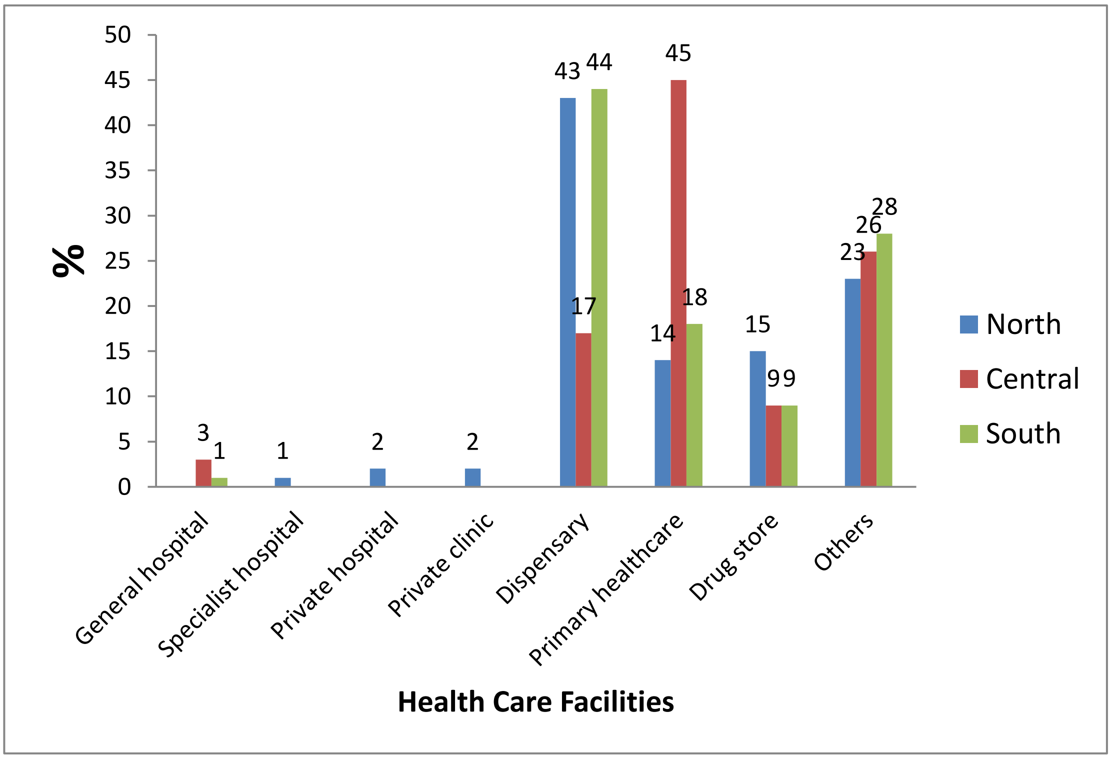


Figure 5.46 Healthcare Facilities Used across the Three Rainfall Zones of Rural Katsina State



5.4.6 Water Governance Issues

Water governance refers to the manner in which people deal with water and it is an integral part of governance (the mode of social organisation in which a society operates) in a much broader sense (Hoekstra, 2006). It involves a wide range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society (Rogers and Hall, 2003). Essentially, it includes both formal and informal structures, procedures and processes for managing water resources. For long, it has been realized that government alone cannot undertake all the tasks of water supply management and hence focused water sources management should be changed to ensure that more participation is brought in. Over the past several decades many changes have been introduced in water governance including varied policies and reforms, from devolution and participatory approaches, to increasing privatization, marketization and commodification (Bakker, 2007; 2010; 2011; Harris and Roa-Garcia, 2013).

Plate 5.22: Conveying Water on a Pushcart at Walawa Community, Kaita LGA

Plate 5.23: Conveying Water on a Bicycle at Walawa Community, Kaita LGA

Plate 5.24: Conveying Water on an Ox-Driven Cart at Walawa Community, Kaita LGA

Plate 5.25: Conveying Water on a Donkey at Gwajo Gwajo Community, Maiadua LGA

Plate 5.26: A Boy Fetching Water to be carried on His Head at Yarsanta Comunity, Safana LGA

Plate 5.27: Use of an Ox-Driven Cart to Convey both Water and Human Beings at Walawa, Kaita LGA

Hoekstra (2006) in dealing with the water governance issue noted that achieving effective water governance demands a broad approach, which essentially means coordination with other forms of governance. This study was of the view that for effective water governance it is not sufficient to question which instruments water managers have or which arrangements water managers can make to solve the water problems of today and of the future. It was, therefore, essential to address the broader question of how wisely societies as a whole manage water resources. Accordingly, this study investigated water governance issues relating to water quality monitoring, management of water supply facilities, funding and leadership.

Table 5.25 Water Quality Monitoring across theThree Rainfall Zones of Rural Katsina State

Water Quality Monitoring	Rainfall zone		
	North	Central	South
Individuals	164(41%)	76 (19%)	260 (65%)
Community leaders	160(40%)	76(19%)	68(17%)
NGOs	8(2%)		
Local Govt	64 (16%)		
State Govt	4(1%)		
N/A		248(62%)	72(18%)

The first major issue of water quality monitoring responsibility in the communities was investigated from the households perspective and results showed that across the three rainfall zones, individuals were the most likely to bare the responsibility (41% in the north, 19% in the central and 65% in the south), followed by community leaders (40% in the north, 19% in the central and 17% in the south) as illustrated in table 5.25 and figure 5.47. It was only in the northern zone that about 17% of the respondents indicated local government as being responsibility for water quality monitoring. The implication of this is that water quality monitoring was a non governmental issue and largely a community responsibility in rural Katsina State. This could mean lack of commitment from the authorities to reduce the health risk of the households or that water monitoring was not a priority in governance thus, vulnerability to water scarcity in rural Katsina State. Since the sample data analyses results indicated different responses in water quality monitoring across the three rainfall zones, it was necessary to check if the describe situation was a chance event. The tool used in this test was the chi-square test and the result was that the observed was significantly different from the expected and, therefore, representative water quality monitoring situation in Katsina state (χ^2computed = 616.4and χ^2 critical = 18.3 at 95% confidence level).

Figure 5.47 Responsibility for Water Quality Monitoring across the Three Rainfall Zones of Rural Katsina State

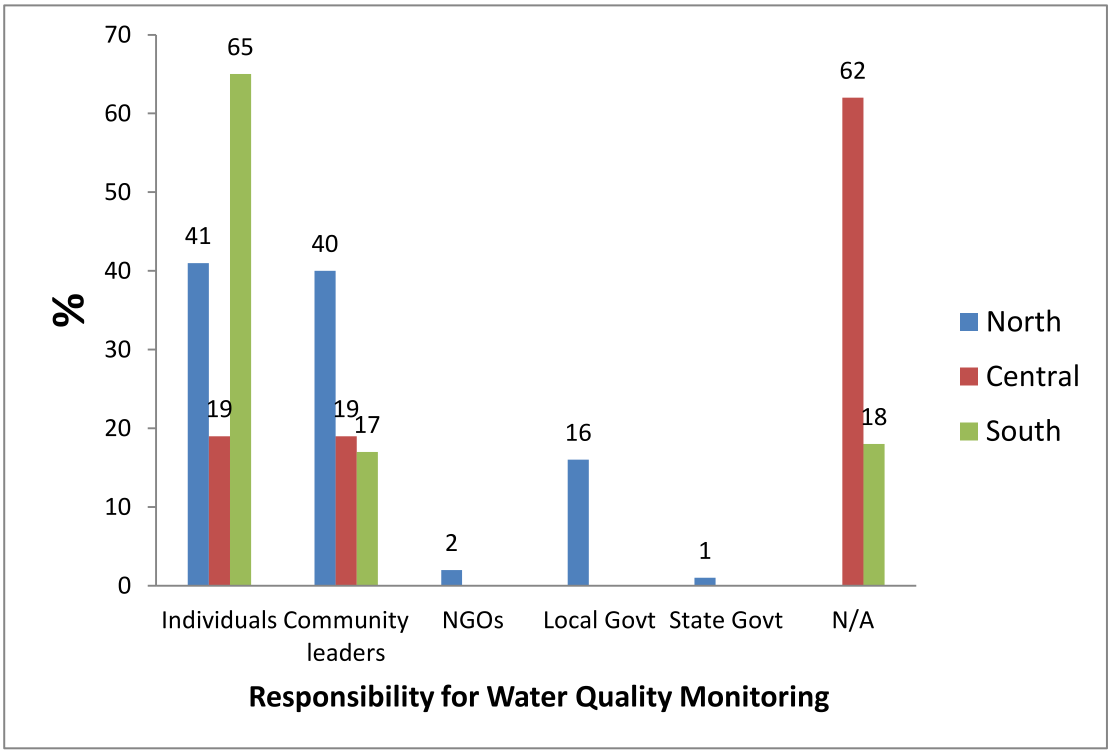
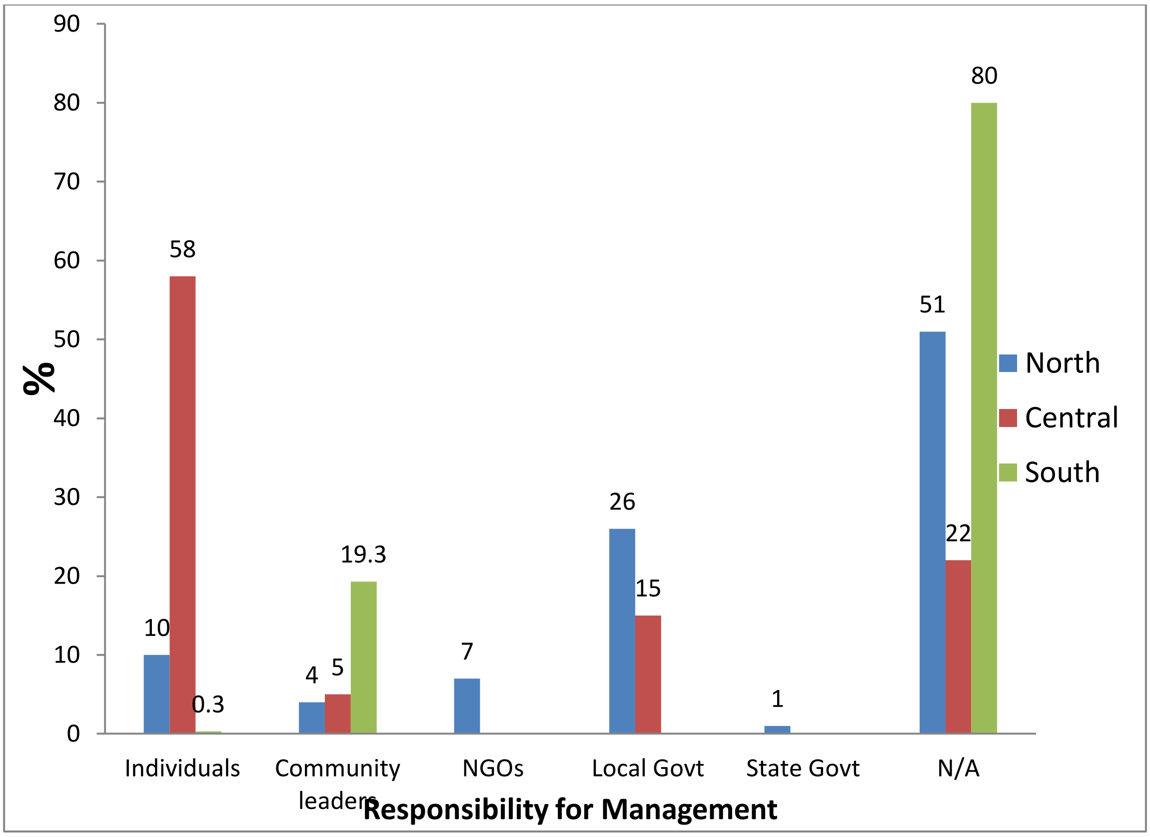


Figure 5.48 Responsibility for Management of Water Supply Facilities across the Three Rainfall Zones of Rural Katsina State



It was expected that in water quality monitoring, the management of the existing water facilities will be the responsibility of government. Results of sample data analyses indicated that management of water facilities was shared between local government, individual households and, NGOs (Figure 5.48). This, therefore, indicated clearly that the governments (Federal and state) had minimal role in management of water facilities and this could mean either lack of government interest in dealing with water scarcity problem in rural Katsina State or that water management was not a priority issue in governance. Since it has been established that rural Katsina State was largely water scarce, water monitoring was largely a community issue and, now that management was also not a government priority, it should be expected, therefore, that vulnerability to water scarcity would increase from a government perspective. FGDsfound that effective coordination was lacking to galvanize the support of stakeholders towards ensuring effective participation of all in water governance and this should have been the role of the government.

Table 5.26 Sources of Funding of Water Supply Facilities across theThree Rainfall Zones of Rural Katsina State

Sources of Funding	Rainfall zone		
	North	Central	South
Individuals	28(7%)	188 (47%)	30 (2.5%)
CBOs	4(1%)		
NGOs	44 (11%)	68(17%)	32 (8%)
Local Govt	128 (32%)	60 (15%)	12 (3%)
State Govt			
N/A	196(49%)	84(21%)	348(87%)

On funding of the water projects, it was necessary to establish the sources of funds and the results (Table 5.26 and Figure 5.49) were varied across the three rainfall zones. Most fundings were sourced from individual households (7% in the north, 47% in the central and 2% in the south) NGOs (11% in the north,17% in the central and 8% in the south) and local government (32% in the north, 15% in the central and 3% in the south). This indicated lack of funding from either the federal or state government and, therefore, supporting the previous assertion of lack of government involvement in alleviating vulnerability towater scarcity in rural Katsina State. In the central and northern zones, the local government authorities were playing some moderate roles in funding such infrastructure, but with the individuals' households comparatively playing an even better role in this regard in the central zone. The lack of federal or state government involvement in funding water projects could result in inability of the households to acquire appropriate new technology for water resources exploration and exploitation and management to assist in reducing vulnerability to water scarcity.

The result was subjected to chi-square test and the computed chi-square was 563.1 and the critical chi-square was 15.5 at 95% confidence level indicating that the observed differences in source of funding of water supply projects in communities across the three rainfall zones were not chance events and, therefore, those differences could be due to significant differences.

Figure 5.49 Sources of Funding of Water Supply Facilities across the Three Rainfall Zones of Rural Katsina State

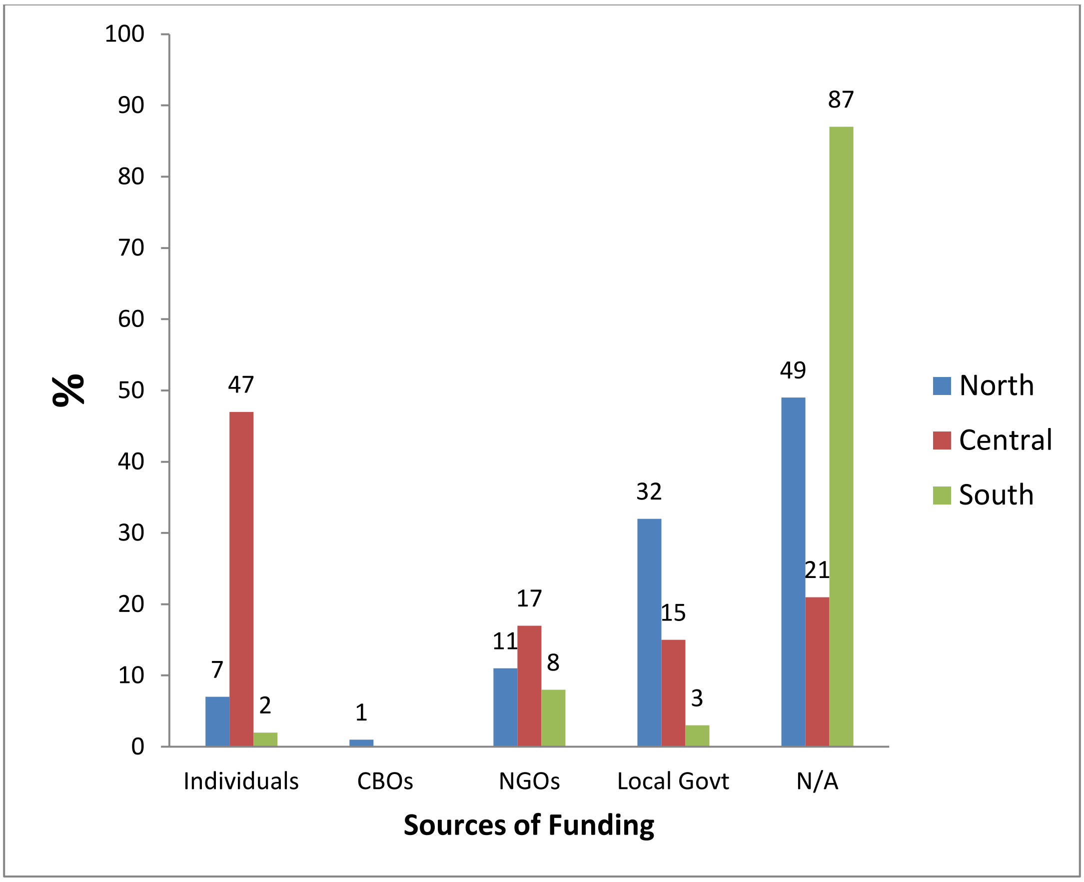
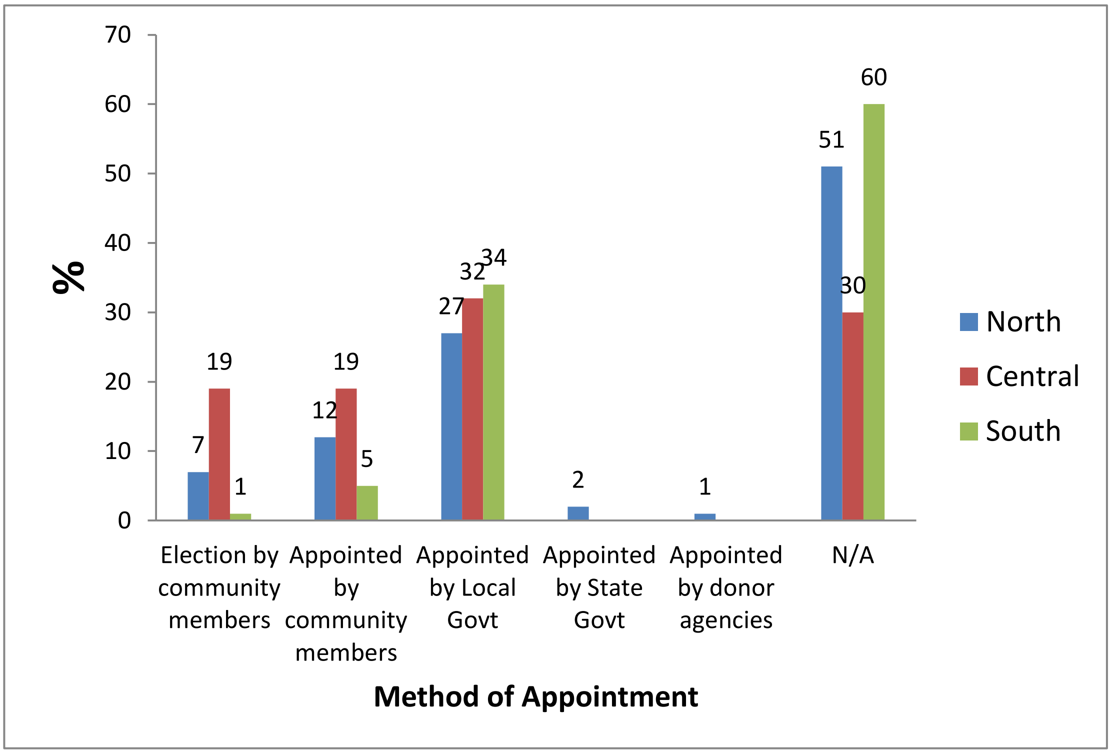


Table 5.27 Method of Choosing Management Team for Managing Water Supply Facilities across theThree Rainfall Zones of Rural Katsina State

Leadership	Rainfall zone		
	North	Central	South
Election by community members	28(7%)	76 (19%)	4 (1%)
Appointed by community members	48(12%)	76(19%)	20(5%)
Appointed by Local Govt	108 (27%)	128(32%)	136 (34%)
Appointed by State Govt	8 (2%)		
Appointed by donor agencies	4(1%)		
N/A	204(51%)	120(30%)	240(60%)

In water governance, service delivery is dependent on quality of leadership which can be measured in terms of method of choosing and managing. The survey results showed (Table 5.27 and Figure 5.50) more appointments by local government than elections by community members (27% in the north, 32% in the central and 34% in the south). What this implies is the lack of democratic participation in management by communities and this could mean less sustainability of water facilities. Since participation of government in quality monitoring, management, and funding of water facilities tended to be minimal, it would be unfair for government to play a major role in the appointment of members of water facilities management committees. Such a situation would result in less sustainability in water facilities and increase vulnerability to water scarcity in rural Katsina State. This view is supported by the work of Harris and Roa-Garcia (2013) who argued that the use of locally sourced teams for managing water resources would favor water conservation through reduction of the cost of maintainance of water systems. This idea is further supported by the work of Bakker (2007; 2011) who argued that community-based water systems could open up the possibility of rethinking and challenging nature society relations, and progressively turning from a community towards a commons perspective. It seems more government participation in the appointment of water facilities committee members would not only affect sustainability but also result in high cost of water provision thus increasing vulnerability to water scarcity.

Figure 5.50 Methods of Choosing Management Team for Managing Water Supply Facilities across the Three Rainfall Zones of Rural Katsina State



In many parts of the world nowadays, water activists hold what is popularly known as the "commons view" in which water is understood as a public good that is managed by the community and in which social equity and livelihoods are guaranteed (Bakker, 2003; Ostrom, 1990 and Shiva, 2002). The result of this study indicated that the "commons view" would accurately describe the water governance issue in rural Katsina State were the federal government and state government were clearly unable to provide acceptable water services. It would also be appropriate to first exploit the water resources of Katsina State for the benefit of the locals as was the view of Harris and Roa-Garcia (2013) in their workin Kathmandu.

Computed chi-square (346.1) and the critical chi-square (18.3) tested at 95% confidence level indicated that the observed differences in procedures of constituting the teams to manage water supply projects in the studied communities across the three rainfall zones were not chance events and, therefore, those differences could be due to significant differences.

Plate 5.28: An Example of an Open Well at Mallamawa, Matazu LGA, Damaged through Collapsing of its Sides

Plate 5.29: Multiple Uses of Water from an Ordinary Open Well in Maigora Community, Faskari LGA

Plate 5.30: An Example of an Abandoned Hand pump Borehole at Walawa Community, Kaita LGA

Plate 5.32: An Example of an Abandoned Hand pump Borehole at Walawa Community, Kaita LGA

Plate 5.31: An Abandoned Ordinary Open Well in Tudun-jae Community, Danja LGA.

Plate 5.33: An Ordinary Open Well Abandoned due to Collapse of its Sides at Mallamawa Community, Matazu LGA.

Plate 5.34: An Example of an Abandoned solar powered Borehole at Maigora Community, Faskari LGA

Plate 5.35: A Concrete Open Well Abandoned at Mallamawa Community, Matazu LGA.

Plate 5.36: A Concrete Open Well Abandoned due to Inability of the Mallamawa Community Members to be Funding the Cost of its Periodic Deepening at Matazu LGA

Plate 5.37: A Handpump Abandoned due to inability of the Community to be Funding the Cost at Kuraye Community, Charanchi LGA

Plate 5.38: A functioning Hand Pump Borehole at Maigora Community Faskari LGA

Plate 5.39: A functioning Motorised Borehole in Maigora Community, Maintained through Toll (Pay-Per-Fetch) Collection System

5.5 Adaptation to Water Scarcity

Adaptation has been defined by the IPCC (2007) as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. UNDP (2006) defined it as changing existing policies and practices and/or adopting new policies and practices so as to secure Millennium Development Goals in the face of climate change and its associated impacts. It has long been recognised that adaptation is critical to enable societies to deal with impacts of both natural and anthropogenic hazards, especially in low-income countries. Adaptation actions taken in advance could reduce the risks and limit the human development damage caused by hazards.

Adaptation can be planned (anticipative, with wide options) or unplanned (reactive with limited choices). A community's ability to develop and implement a comprehensive adaptation strategy towards an environmental problem like water scarcity may be called its adaptive capacity (or resilience). Adaptive capacity evolves over time and it is the factors which determine the process of adaptation which are important to understand rather than any measure of the adaptation potential (Adger *et al*, 2001). Yohe *et al* (2002) have shown that adaptive capacity (which can be planned or unplanned) is a function of various factors:

- the range of available technological options;
- the available resources and their distribution across the community's population;
- the structure of critical institutions and the criteria for decision-making;
- the human and social infrastructures;
- the access to risk-spreading mechanisms;
- the ability of decision-makers to manage credible information and their own credibility;
- the public's perception of the source of the impact and
- public's perception of the significance of the impact to its local manifestations

The larger the adaptive capacity, the wider are the adaptation options. The lower the adaptive capacity, the higher is the vulnerability. Adaptation by individuals or groups is constrained by the resilience of the human and natural systems in constant co-evolution, i.e. by their adaptive capacity to external shocks (Adger *et al*, 2001). Experiences from many countries (Otieno and Ochieng, 2004; Mukheibir, 2005; Muller, 2007) has shown that water scarcity adaptation can take two dimensions; *upply side management strategies and demand side management strategies*. In this study, the focus was on both the demand and supply sides management strategies at the household level in rural Katsina State. This, therefore, meant adaptation in terms of types of strategy, knowledge on adaptation to water scarcity, source of information on adaptation to water Scarcity, assistance towards adaptation to water scarcity.

5.5.1 Types of Adaptation Strategies

The adaptation strategies in response to water scarcity in rural Katsina State was found to revolved around getting water from alternative sources or limiting the water use in the household as illustrated in figure 5.51. The many strategies indicated in figure 5.51 could have been a reflection on the physical geographical differences or differences in socio-political responsibility. The adaptation strategies tended to vary by rainfall zones and different households adopting different combination of strategies in different hierarchical order (Table 5.28). In many cases, the more the number of strategies adopted in response to adverse condition, the more unstable is the situation or the more vulnerable is the respondent. In this study water scarcity adaptation strategies were assessed in terms of vulnerability to water scarcity.

One of the adaptation strategies that was identified from the sample data was rainwater harvesting, a strategy which has been noted as an old tradition in many parts of the world that are water stressed but also considered as a new technology that is growing in popularity in a number of countries including, Thailand, Kenya, New Zealand and Australia (Gould and Nissen-Petersen, 1999). The practice of water harvesting has not only been used as a adaptation strategy in water stressed that is currently being considered as one of the climate change adaptation strategy and its domestication had resulted in the need for legal provision as was the case in United States in 2009 were in the southwest. Colorado changed its water laws to allow rural residents to install rainwater harvesting systems (Johnson, 2009). In the Rooftop Caribbean, and in the Middle East, rainwater harvesting has long history over hundred years (Global Applied Research Network, 2003) and in South America the practice is wide spread in the rural areas of Honduras, Brazil, and Paraguay (United Nations Environmental Programme, 2000). It is, therefore, interesting to have some measure of the involvement of Nigerian government in encouraging this potential source of domestic water supply in the water stressed rural Katsina State.

Harvesting rainwater often requires proper planning and management, appropriate storage capacity and input from a broad spectrum of stakeholders. Rainwater harvesting is an alternative source to public water and it is growing in importance due to increased potential catchment surfaces and failure of the authorities to meet the challenges of providing “clean water for all”. In the study area it was found that less than 3% practiced rainwater harvesting and this could be attributed to either lack of encouragement from relevant authorities and, therefore, failure of governance, lack of storage capacity or lack of catcments. The results of data analyses in this study indicate that rainwater harvesting were being practiced at the local level and on a small scale, without proper planning and storage capacity. For the collection of rainwater from roof catchment and storage to be viable in rural Katsina State as a method of reducing water scarcity, there will be need for government involvement in terms of planning and capacity building. In the sample data only 3% of the households indicated practicing rainwater harvesting and this meant that there is room for further improvement in reducing vulnerability to water scarcity.

One of the facilities used in harvesting rainwater especially the resulting surface runoff is the check dam which is a sand-filled plastic bags embankment-like structure constructed to check surface runoff with the aim of creating a pool of surface water. Check dams are popular because they are inexpensive and easy to install, they may be permanent if designed properly. In the study area, the check dams were found to be temporary structures constructed during the rainy season only to provide surface water storage to meet household demands. Since the check dams were temporary structures, it will appear that there constructions did not involve proper planning since they were mainly community or households initiatives with little or no government involvement. The prevailence of check dams in rural Katsina State tended to vary from south to north where 23% of the respondents in the south, 15% in the central 10% in the north indicated using check dams as a tool in reducing vulnerability to water scarcity. This variation could be due to the fact that rainfall tended to decrease

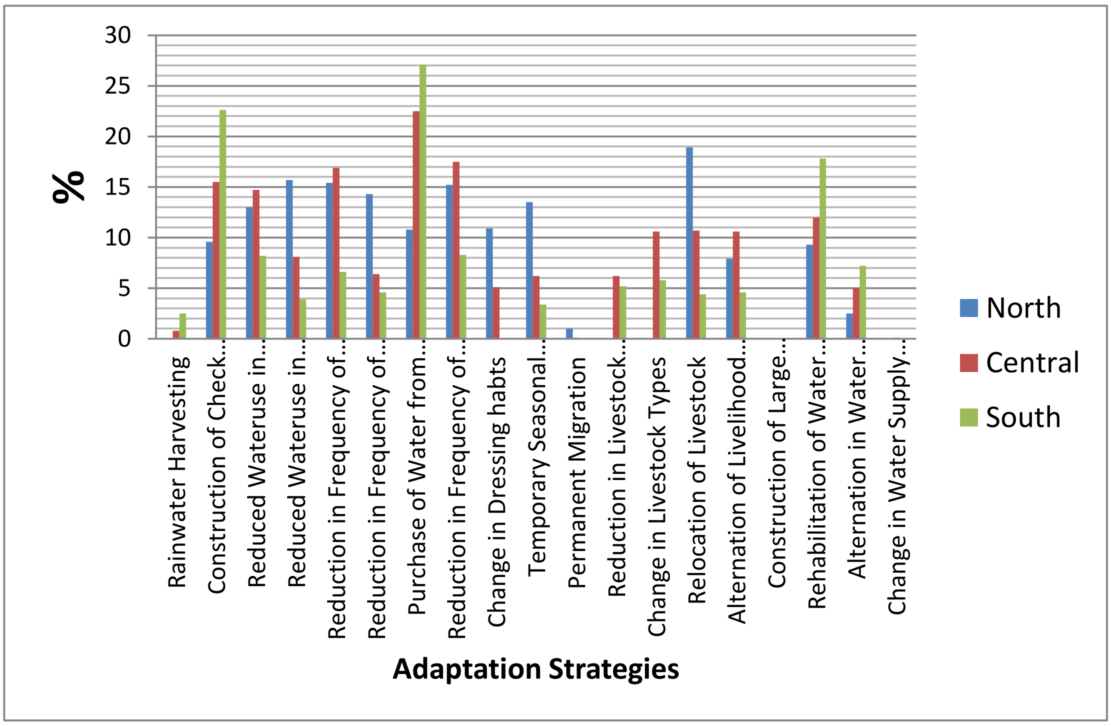
Table 5.28 Water Scarcity Adaptation Strategies in Rural Katsina State

Adaptation Strategies	Rainfall zone			Total
	North	Central	South	
Rainwater harvesting	1(0.1%)	10 (0.8%)	30 (2.5%)	41 (3.5%)
Construction of check dams	114(9.6%)	184(15.5%)	269(22.6%)	567(47.7%)
Reduced water use in cooking	155(13.0%)	175(14.7%)	98 (8.2%)	428(36.0%)
Reduced water use in bathing	187(15.7%)	96 (8.1%)	46 (3.9%)	329 (27.7%)
reduction in frequency of washing	183 (15.4%)	201 (16.9%)	79 (6.6%)	463 (39.0%)
reduction in frequency of bathing	170 (14.3%)	76 (6.4%)	55 (4.6%)	301 (25.3%)
Purchase of water from vendors	128 (10.8%)	267 (22.5%)	322 (27.1%)	717 (60.4%)
Reduction in frequency of animal watering	180 (15.2%)	208 (17.5%)	99 (8.3%)	487 (41.0%)
change in dressing habit	129 (10.9%)	61 (5.1%)	0 (0%)	190 (16.0%)
Temporary migration	160 (13.5%)	74 (6.2%)	40 (3.4%)	274 (23.1%)
Permanent migration	12 (1.0%)	1 (.1%)	0 (0%)	13 (1.1%)
Reduction in livestock numbers	0 (0%)	74 (6.2%)	62 (5.2%)	136 (11.4%)
Change in livestock type	0 (0%)	126 (10.6%)	69 (5.8%)	195 (16.4%)
relocation of livestock	224 (18.9%)	127 (10.7%)	52 (4.4%)	403 (33.9%)
Alternation of livelihood	94 (7.9%)	126 (10.6%)	55 (4.6%)	275 (23.1%)
Rehabilitation of old water source	111(9.3%)	143(12.0%)	211(17.8%)	465(39.1)
Alternation of water supply source	30(2.5)	59(5.0)	86(7.2)	175(14.7)
Change in location of water supply source	0 (0%)	1 (.1%)	0 (0%)	1 (.1%)
Construction of large water reservoirs/tanks	0(0%)	0(0%)	0(0%)	0(0%)

Source: Field data (2013)

from south to north and the potential for surface runoff will also decrease from south to north.

Figure: 5.51 Strategies of Adapting to Water Scarcity across the Three Rainfall Zones of Rural Katsina State



Many research workers (Ayeni, 2012; Abaje, 2009; Olajide, 2011) have shown that in Nigeria, like many other developing countries of the world, water supply to households is not only inadequate but also erratic and in many cases this has forced people to look for more costly and often unsanitary alternatives in form of water purchase from vendors. Commodities that humans require for their normal lives were naturally made items of trading with different people engaged in purchase and sell of such commodities. Water being an essential ingredient of survival is naturally expected to be an item for such trading. In water stress regions, water vendoring was a major trading activity in sub-Saharan Africa. Water from public supply sources (taps, boreholes, wells e.t.c) was usually free as no one pays to collect water from such sources. Water vendors, however, could obtain water from such sources in containers for sale to interested persons within a particular community and the water could be from unimproved sources which could also result to water borne disease. The vendors sourced water sometimes from private investors' boreholes taking advantage of water scarcity and ineffective water governance. Sourcing water from vendors and private boreholes not only increases the cost of water supply but can also be a source of water borne diseases if from unimproved sources thus, increasing vulnerability to water scarcity. Despite the fact that the south has more rainfall than central and north, the results of data anlyses indicated that the south tended to rely more on water vendors than the central and north respectively. This could have been due to lack of reliable alternative and thus the need to invest in rainwater harvesting. The results showed that 27% of the respondents in the south, 22% in the central and 11% in the north were purchasing water from water vendors as a strategy of coping with water scarcity. The comparatively lower rate of patronage of water vendors in the northern zone than the other zones could have been a reflection of the low income and water reserve base of the north, resulting from lower rainfall amount of the region.

Historically, people have moved from land degraded by natural disasters, war or over exploitation and for this there is concern about the potential for large-scale population movements resulting from a combination of resource depletion, irreversible destruction of the environment, and population growth as represented by the concept of environmental refugees introduced by UNEP in (El-Hinnawi, 1985). In the 1993 State of the World's Refugees, UNHCR legitimized the concept of environmental refugees by including environmental degradation as a root cause of refugee flows. Livestock are important consumers of water across rural Katsina State and herd density per household can sometimes reach a ratio of one member to 3 livestock. In times of increased water scarcity, the households are expected to make adjustments to cater for the needs of their livestock. The responses received across the study area in this regard showed that 19% in the north, 11% in the central and 4% in the south indicated relocation of livestock as a response strategy to water scarcity. This relocation involves movement of livestock towards the more humid and less water scarce regions of central and southern Nigeria during the dry season, temporary or even permanently thus becoming environmental (water scarcity) refugees. The relocation strategy could potentially divide the households as was the case among the Fulani pastoralist in the northern zone where the herders could move with the livestock leaving behind other members.

Carney (1998) explained livelihood in terms of capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base. The availability of ample, high-quality water influences rural livelihoods in many ways and the degree of a household or community's vulnerability to water scarcity becomes an important dimension of livelihood decisions. Accordingly, the study indicated that change in livelihoods could occur due to water scarcity (Figure 5.51) where about 8% of the respondents in north,11% in the central and 5% in the south concurred. The FGDs confirmed that water scarcity could result in livelihood change from water dependent farm activities in favour of non farm activities within and around a community (e.g. trading, produce marketing, commercial motorcycles riding). The other potential response to water scarcity indicated in the FGDs was migration on temporary or permanent basis to locations where opportunities for other livelihood options abound.

In a study conducted in Kenzamba, Zimbabwe, by Zingi and Chitongo (2013), it was observed that due to water scarcity, the people of the area embraced conservation farming in order to increase yields from cereals and maize, natural resource exploitation such as gold panning, petty trading, saving club and repair work as in non-agricultural activities as adaptation strategies. Studies of livelihoods and coping with droughts in arid lands have identified a broad range of strategies for dealing with water scarcity (e.g. Deitz *et al*, 2004; Watts, 1983). In arid regions, dry season migration is an established practice in some farming and livestock-raising communities. In other areas where drought occurs with relative frequency, households have strategies for dealing with the impacts of water scarcity, including arranging for some family members to spend time in other areas during water shortages. While some coping strategies can be pursued without significantly reducing household assets, other coping strategies delve more deeply into those reserves. Typically, many options are pursued before people move as refugees without assets or destinations.

Figures 5.43 and 5.44 indicated that the staple foods of the study area were of the kind that required moderate to high amounts of water in cooking. In times of water scarcity, reducing the amount of water spent in cooking through reduction in frequency of cooking was cited as one way of minimising the problem of water scarcity. Reduction in the amount of water use in cooking was cited by (Figure 5.51)

13% of the respondents in the north and 14% in the central and, 8% in the south. This indicated that reduction in the amount of cooking was a relatively low priority strategy in dealing with water scarcity whose prevalence in the community tended to be relatively similar even though central zone tended to have a higher adoption level. In the FGDs sessions, it emerged that in times of scarcity, bathing frequently could be a luxury than a necessity and from the sample data, result was that 16% of the respondents in the north, 8% in the central and 4% in the south indicated reducing the quantity of water used in taking bath as strategy during water scarcity and this was mainly through reduction in frequency of bathing (about 14% in the north, 6% in the central and 4% in the south) as shown in Figure 5.51.

Washing of clothes was one of the major activity on which households typically expend large quantities of water. Figure 5.51 shows that 15% of the respondents in the north, 17%in the central and 7% in the south indicated that they do reduce the frequency of washing their clothes. One thing that became obvious during the fieldwork stage was that most of the rural dwellers in the study area do not seem to be keeping their clothes very clean all the time. Two reasons were given when inquiries were made on what was responsible, namely the fact that in rural areas, first, most of the times people do engage in labour-related activities (for example farming, animal rearing and wood collection) which makes it not worthwhile keeping clothes clean all the time. Secondly, the amount of water available to household was generally in low quantity thus limiting the frequency of use. Even the dressing type that required frequent washing of clothes has necessitatedsome changes in dressing habits when water becomes scarce. With the exception of the southern zone, there were indications that dressing habits could be changing where 5% of the respondents in central and 11% in the north indicated changing their dressing habits. From these reasons, it became obivious that in response to water scarcity, the respondents were willing to change some age old traditions or habits to limit water use. It would be useful if support could be forth coming from government and other non-governmental organizations in the potential adaptation transition to reducing vulnerability to water scarcity.

Plate 5.40: Sachet Water Making Facilities of a Private Firm at Kofa, Kusada LGA

Plate 5.41: Bags of Produced Sachet Water at Kofa Kusada LGA

Movement of people and livestock on short term basis between one region to another in response to many push factors (especially seasonal stressors like scarcity of water and animal pasture, and off-farm unemployment) is one factor that has made temporary migration an important feature of population movement in Nigeria. In the study area, 14% in the north, 6% in the central and 3% in the south of the households surveyed across the three rainfall zones indicated temporary seasonal migration as one of the adaptation strategies to water scarcity. Temporary migration seemed to have been an integral part of the socio-economic landscape of rural Katsina State and this is supported in the internal migration in Nigeria survey report of the 2010 where internal migration of people between localities was considered as one of the most important processes shaping settlements, socio-cultural attributes, economic and political structures of the national territory while water scarcity was reported as not an important factor.

Water scarcity fits in what is referred to as push factor and in the study area especially towards the north, there was a tendency to move away from the severe water scarse area to water sources in other geographic areas. Invariably, such movements have tended to create socio-economic and environmental impacts. In this study it was possible that most of the respondents were not permanently moving away from their areas as a means of adjustment to water scarcity because they had not considered the situation as very serious enough as to cause them harm. The report of IPCC (2007) did show that depending on the assessment of vulnerability and the potential harm, some individuals and household groups may choose to avoid the threat of potential losses by migrating, others may experience some losses and include that information in their migration decision, and still others may suffer very severe losses. Experiences and perceptions of vulnerability influence decisions about migration as well as potential to move as a refugee.

Plate 5.42: Changing the location of a well from inside to in front of House at Tudun Jae Commonuty in Danja LGA

Plate 5.43: Changing location of a collapsed well within the same area at Tudun Jae Commonuty in Danja LGA

In centralized or pipe borne water supply system, when supply becomes unreliable and in effective, households tend to adopt different response strategies depending on supply, needs and adaptive capacity (Pattanayak et al, 2005; Zérah, 2000; Hurlimann, 2011). Notable among the strategies are increased water conservation (Bruvold and Smith, 1988; Flack and Greenberg, 1987; Roseth, 2006) and water recycling (Bruvold, 1972; Bruvold, 1988; Dolnicar and Schäfer, 2009; Friedler et al, 2006; Hurlimann, 2008; Marks et al, 2006; Po et al, 2005). In times of water scarcity, households tend to search for alternative water sources and in this study, 3% of the respondents in the north, 5% in the central and about 7% in the south indicated making changes. The small proportion of respondents indicating change could have been partly due to limited choices of water sources and partly due to generally limited knowledge on water conservation and recycling in the study area thus, increasing scarcity adaptation strategy but this was limited as shown in figure 4.51 where less than 1% of the households across the three rainfall zones undertook such changes. The limited changes tend to contradict other research findings where, response tended to be common and varied as in the work of Allon and Sofoulis (2006), Askew and McGuirk (2004), Head and Muir (2007) and Clarke and Brown (2006).

One notable observation made during the fieldwork stage of this study was that many water supply infrastructure especially boreholes and wells in the communities were out of repair, malfunctioning or completely abandoned. Solution suggested by the respondents was rehabilitation of old water supply source (18%, in the south, 12% in the central and 9% in the north) as shown in figure 5.51. In the FGDs it was found that there were widespread cases of wells collapsing due the nature of geologic formations in the central and southern zone. This tended to result in abrupt disruption in the wells' operations due to excavations works before they could yield any water. As a strategy of adapting to water scarcity, therefore, the respondents do excavate such wells and use concrete or hard rocks to stabilize the inner parts of the collapsed well.

Plate 5.44: Using an Old Vehicle Tyre to Gauge the Mouth of an Open Well to Prevent it from Widening at Tudun Jae Community, Danja LGA

Plate 5.45: Concreting Inner Part of a Well at Tudun Jae Community in Danja LGA to Prevent its Widening and Ensure Higher Water Yield

The differences in the adaptation measures from the sample data between the three rainfall zones were tested for significance using the Kruskal-Wallis H test where the computed H for n > 5 was a chi-square of 3.2 while the critical chi=square at 95% confidence level with df of 2 was 5.9. This meant that the observed differences in adaptation measures by rainfall zones were not significant and, therefore, could not be attributed to rainfall variations. What this implies is that the differences in water scarcity adaptaion measures could not be attributed to rainfall variation alone given the sample data and any difference could be due to other factors not included in the sample data.

Plate 5.46: Plastic Water Tanks Provided at Walawa Commonuty in Kaita LGA to help Store Water Supplied to the Community using Water Tanker

Plate 5.47: Open concrete Surface Tank Provided to Store Water Conveyed to Kofa Commonuty in Kusada LGA, as part of government's assstiance towards Adapting to Water Scarcity

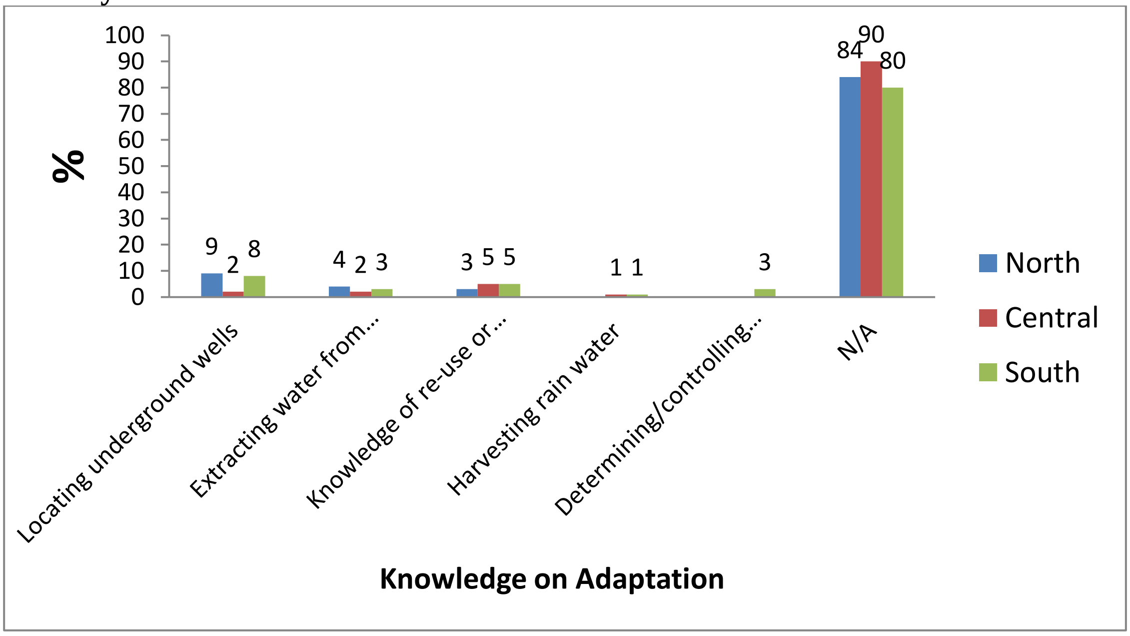
5.5.2 New knowledge Acquired on Adaptation to Water Scarcity

Human societies have always explored various ways to adapt to changes in hydrological regimes and processes but the adaptation and coping strategies used by most people are highly varied and local studies are needed for development policies to be effective (Hanjra and Qureshi, 2010; Basu and Shaw, 2013). Human adaptation to a changing environment is not a new phenomenon, but it is the urgency in the race against time for appropriate actions and policy on adaptation for sustainability in societies at risk from climate change impacts that is crucial (Coulthard, 2008). In the context of climate change, adaptation is taken to be a modification of behaviour believed to either alleviate adverse impacts or to realise new opportunities in response to observed or expected changes in climate and associated extreme weather events (Adger et al, 2004; 2006). In the light of continuing environmental stresses, mankind may end up acquiring new knowledge systems necessary in raising adaptive capacity to stressors such as water scarcity.

Table 5.29 Knowledge on Adaptation across theThree Rainfall Zones of Rural Katsina State

Knowledge on Adaptation	Rainfall zone		
	North	Central	South
Locating underground wells	36(9%)	8 (2%)	32 (8%)
Extracting water from underground wells	16(4%)	8(2%)	12(3%)
Knowledge of re-use or eliminating waste	12 (3%)	20(5%)	20 (5%)
Harvesting rain water		4 (1%)	4(1%)
Determining/controlling water quality			12(3%)
N/A	336(84%)	360(90%)	320(80%)

Figure 5.52 New Knowledge Acquired on Strategies of Adapting with Water Scarcity across the Three Rainfall Zones of Rural Katsina State



In this study, some new knowledge systems that the people had acquired due to persistence of water scarcity in rural Katsina State were investigated. The results were in table 5.29 and figure 5.52 indicated little new knowledge acquisitions. Acquisition of new knowledge on re-use of water (3% in the north, 5% in the central and 5% in the south), extraction of water from the ground (4% in the north, 2% in the central and 3% in the southern zones), and location of underground water (9% in the north, 2% in the central and 8% in the south) were generally minimal and that the respondents had not in general acquired much new knowledge on adaptation to water scarcity. This result supported a recent research report (CDKN, 2013) on climate change adaptation information and knowledge communication which noted that information and knowledge being generated through research on adaptation as having had limited success in uptake at the local level; especially amongst the most vulnerable in the community. One of the reasons for this was a lacuna in communicating learning from scientific research at the grassroots level in appropriate ways and a lack of engagement with local institutions. Lack of appropriate information and knowledge transfer model was one of the factors identified in the problem of vulnerability to water scarcity in rural Katsina State thus, conforming to what was pointed out in the CDKN (2013) report.

Computed chi-square was 60.2 and the critical chi-square was 18.3 tested at 95% confidence level indicated that the observed differences in local knowledge of changes in water supply situation across the three rainfall zones were not chance events and, therefore, those differences could be due to significant differences.

5.5.3 Source of Information on Adaptation to Water Scarcity

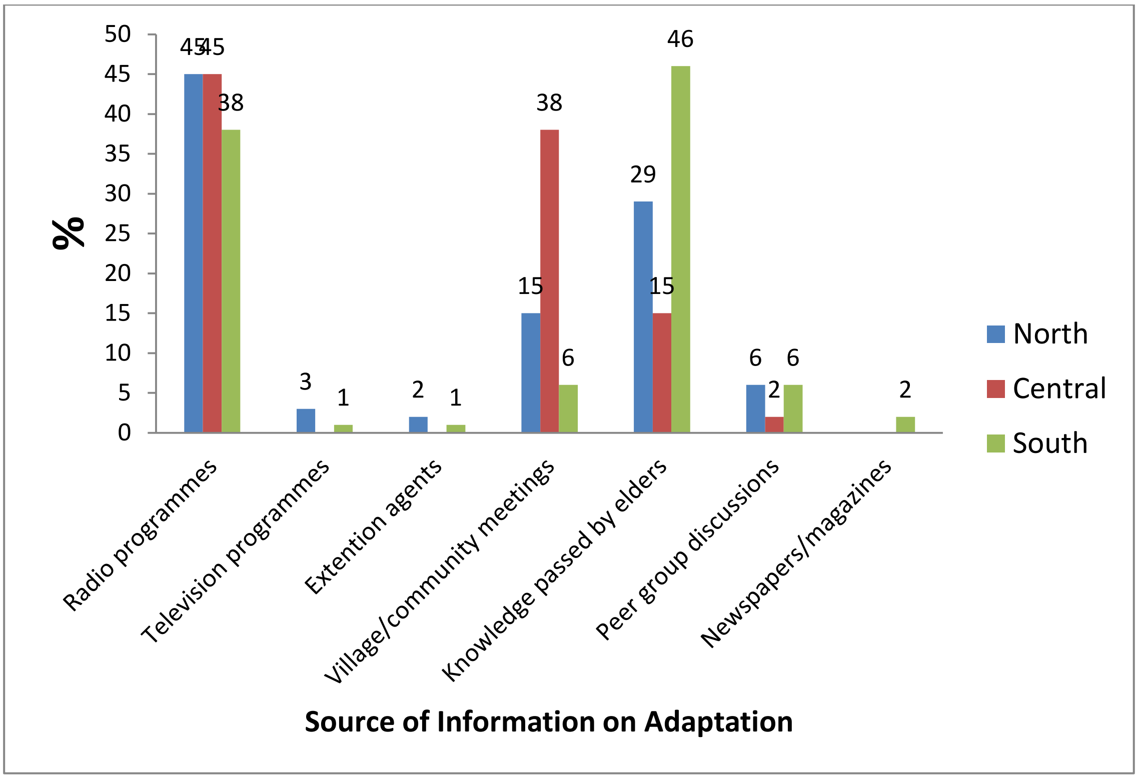
One of the primary ways for countries to help people not only to cope with climate-related stresses like water scarcity, but also adapt to a “new normal” life of less predictability is to develop and make available more and better information about the stresses (Panda, 2007). There is the need for improved provision and access of information for adaptation, especially to communities that are vulnerable to environmental stresses (Nagaraja and Mariswamy, 2008; Raj, 2010). Access to improved information sources would increase the peoples’ ability to make informed decisions about what to do and not do. This is because information plays a critical role in enabling adaptation. The UNFCCC guidelines for developing National Adaptation Program of Action (NAPAs) call for a synthesis of all existing climate change information, as well as specific climate change vulnerability assessments, to determine urgent and immediate adaptation needs (UNFCCC, 2007). This study respondend to this defined need and the results were as in table 5.30 and figure 5.53.

Table 5.30 Source of Information on Adaptation across theThree Rainfall Zones of Rural Katsina State

Source of Information on Adaptation	Rainfall zone		
	North	**Central**	**South**
Radio programmes	180(45%)	180 (45%)	152 (38%)
Television programmes	12(3%)		4(1%)
Extention agents	8 (2%)		4 (1%)
Village/community meetings	60 (15%)	152(38%)	24(6%)
Knowledge passed by elders	116 (29%)	60 (15%)	184(46%)
Peer group discussions	24(6%)	8(2%)	24(6%)
Newspapers/magazines			8(2%)

The radio has long been identified as a possible and appropriate vehicle for information transfer especially in the rural areas due to its wide reach and availability and this came out clearly in the study results where 45% of the respondents in the north, 45% in the central and 38% in the south respectively indicated radio programmes as the main source of information. Other sources of information on water scarcity included knowledge passed by elders (29% in the north, 15% in the central and 46% in the south), community meeting (15% in the north, 38% in the central and 6% in the south) and, peer group discussion (6% in the north, 2% in the central and 6% in the south). The radio, elders, community meeting and peer influence were identified in the study as the main sources of information and could, therefore, be used in improving capacity to adapt to changing water scarcity situations in rural Katsina State. The study also identified some peripheral information sources as television programmes, extension agents and print media which constitute less than 3% of the responses in each of the three zones. This observation was consistent with the observations made by other schorlars to the effect that radio was the most important source of information on adaptation to environmental stressors for most rural dwellers (Bandelli, 2011). Computed chi-square was 231.3 and the critical chi-square was 21.0 tested at 95% confidence level indicated that the observed differences in the sources of information on water scarcity adaptation strategies being adopted by the households in the studied communities across the three rainfall zones were not chance events and therefore those differences could be due to significant physical differences.

Figure 5.53 Source of Information on Strategies of Adapting with Water Scarcity across the Three Rainfall Zones of Rural Katsina State



5.5.4 Assistance in Adaptation to Water Scarcity

As an important strategy towards helping communities to adapt to water scarcity, the FAO (2014) recommended that at the National level, countries should develop a vision for future development as to better define political-economy objectives and efficient water allocation between sectors and to put in place the institutional structure, enabling environment and incentive frameworks for socio-economic efficient and productive water use. In this regard, the priorities for improving management of water resources that need to be given attention include strengthening governance and institutions; integrated approaches to water resource management; decentralization and participation; supply-side management; demand-side management and the incentive framework. On this premise, this study investigated the type of assistance communities received in dealing with the problem of water scarcity in rural Katsina State (Table 5.31 and Figure 5.55).

Table 5.31 Source of Assistance on Adaptation across theThree Rainfall Zones of Rural Katsina State

Source of Assistance on Adaptation	Rainfall zone		
	North	Central	South
Community assistance	72(18%)	48 (12%)	84 (21%)
Local Governmentt	32(8%)	64(16%)	12(3%)
State Government	8 (2%)		
Self family	12 (3%)	8(2%)	
Donor agencies			
N/A	276(69%)	280(70%)	304(76%)

Results of data analyses in this study indicated that there was little assistance from government or NGOs as shown in figure 5.56 where 18% of the respondents in the north, 12% in the central and 21% in the south received any assistance from community associations and only 8% of the respondents in the north, 16% in the central and 3% in the south received any assistance from local government. It was informative that none of the responsedents indicated receiving any assistance from the federal and state governments and this implied minimal government role in alleviating vulnerability to water scarcity in rural Katsina State with about 60% to 70% of the respondents indicating no government assistance in solving the problem of water scarcity.

Table 5.32 Adopting Adaptation Strategies across theThree Rainfall Zones of Rural Katsina State

Adopting Adaptation Strategies	Rainfall zone		
	North	Central	South
Periodic supply of water using water tankers	76(19%)		
Construction of open concrete well	4(1%)		
Construction of motorized borehole	24 (6%)	56(14%)	20(5%)
Construction of solar powered borehole	28 (7%)	20(5%)	4(1%)
Construction of hand pump borehole	32(8%)	60(15%)	92(23%)
N/A	236(59%)	264(66%)	284(71%)

In case of any assistance to adapting to water scarcity from either federal or state governments, the main areas were in construction of boreholes, provision of solar pumps or hand pumps, periodic supply of water using tankers and construction of open concrete wells at the communal level. It was clear from the table 5.32 and figure 5.56 that in general low proportion of the households across the three zones were adopting water scarcity adaptation strategies through government assistance. Figure 5.57 gives details on the reasons given by the respondents for not adopting the government water scarcity adaptation strategies. A close look at the figure indicated that between 5% -7% of the respondents in the three zones were not using the adaptation strategies available because they were too far while 9% of the respondents in the north, 16% in the central and 5% in the south were not using the strategies because they were regularly not available and only 12% of the respondents in the southern zone indicated other factors (mainly not available at all). Majority of the respondents (75% in the north, 90% in the central and 95% in the south), however, indicated never receiving any encouragement or an incentive for adaptation to water scarcity situations from either the community or government institutions thus high vulnerability to water scarcity.

In places where attempts had been made to store water, the facilities were in the form of large plastic water tanks and large open concrete surface storage tanks which were occationaly refilled using water tankers, from the storage facilities, communities were served through rationing on first come first serve basis thus highlighting the water scarcity situation in the study area. The FGDs unfortunately established that the water storage facilities were not supplied with water and were more or less “white elephant” projects thus, a waste of funds and mis-directed efforts in water scarcity alleviation.

Figure 5.54 Responses Received on Whether the Government has Been Offering Assistance Towards Adapting to Water Scarcity across the Three Rainfall Zones of Rural Katsina State

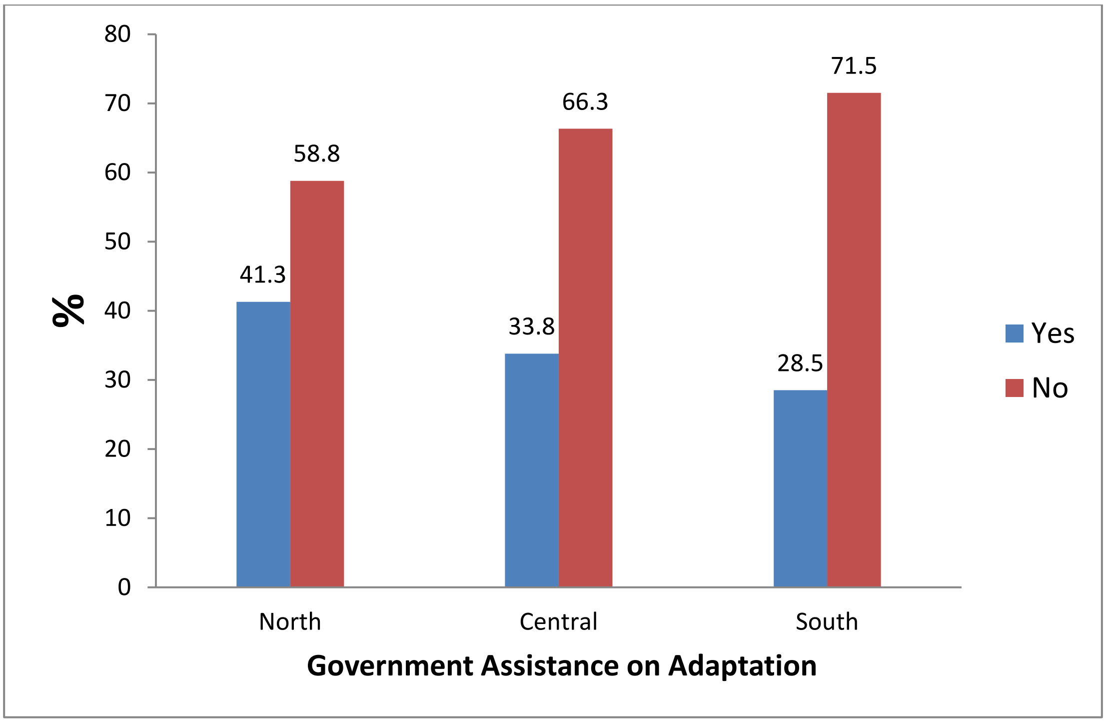


Figure 5.55 Source of Assistance to Help in Adapting with Water across the Three Rainfall Zones of Rural Katsina State

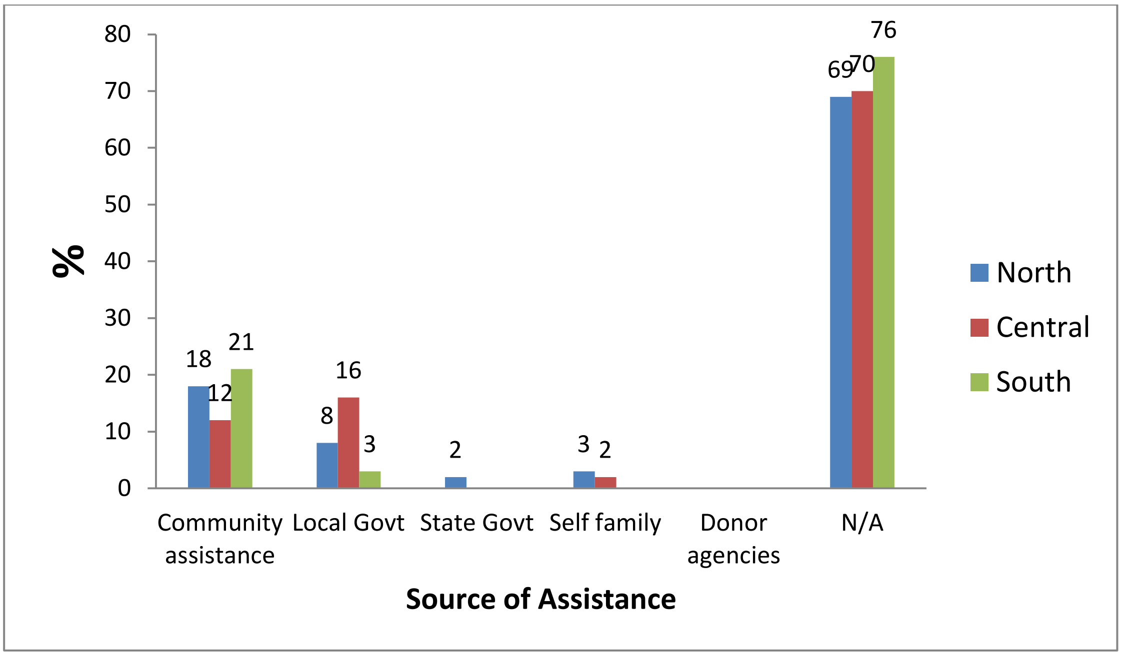


Figure 5.56 Proportion of Households that are Adopting Water Scarcity Adaptation Strategies across the Three Rainfall Zones of Rural Katsina State

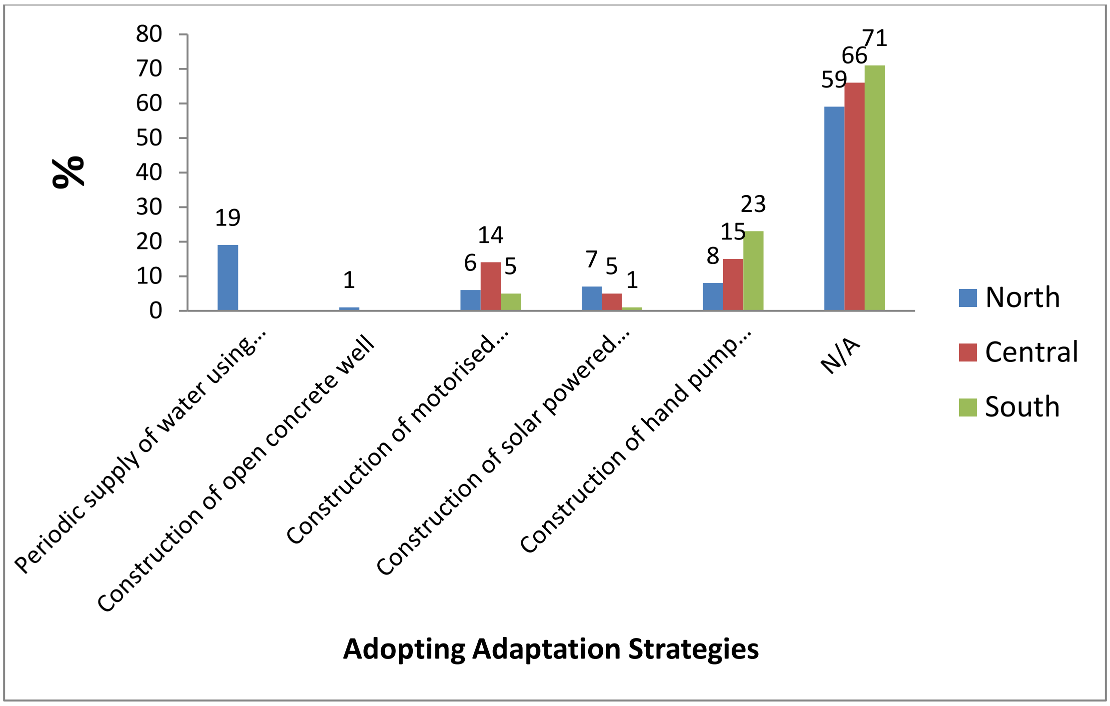
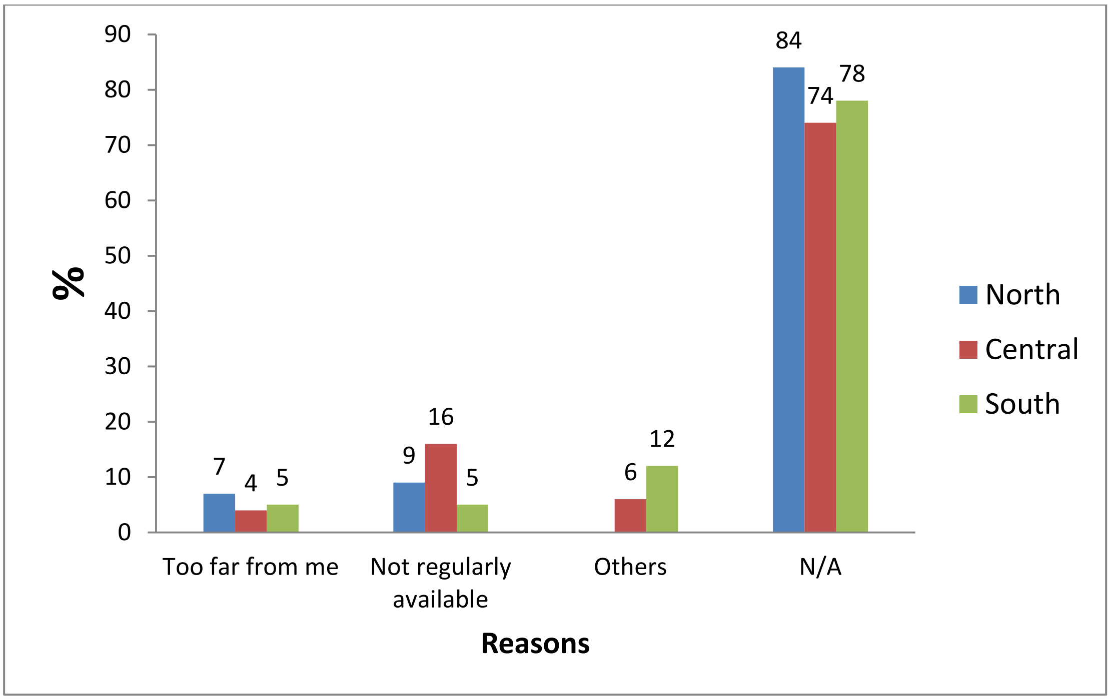


Figure 5.57 Reasons Why Respondents are not Using Water Scarcity Adaptation Strategies across the Three Rainfall Zones of Rural Katsina State



Test for significance in the described water scarcity assistance situation in rural Katsina State (Computed chi-square =160.8 and the critical chi-squuare = 18.1 at 95%) indicated that the observed differences in the source of assistance were not chance events and, therefore, those differences could be due to significant physical differences. Similarly, the computed chi-square was 332.8 and the critical chi-square was 18.3 tested at 95% confidence level indicated that the observed differences in the type of facilities provided to the communities studied to help them adapt with water scarcity across the three rainfall zones were not chance events and, therefore, those differences could be due to significant physical differences.

5.5.5 Factors Influencing Adaptation to Water Scarcity

5.5.5.1Political Factors

Government policies are critical for creating an enabling environment for adaptation to water scarcity and this is stressed in the work of Reddy (1999) who observed that failure of government policies and institutions play the largest role in rural water shortages, rather than environmental limitations or financial inability on the part of the residents. The results of the study sample data analyses indicated lack of government policy to assist the households in dealing with water scarcity where majority 85%-90% of the respondents indicated that such policies were non-existent. This could mean lack of effective policy to comprehensively address the challenges of water scarcity, with particular roles and responsibilities of all stakeholders (government, local people, community organisations, private sector, etc) and, therefore, influence on the problem of water scarcity in rural Katsina State. One central issue that influences adaptation to water scarcity of households but was not identified was water pricing and this according to the FGDs was due to the fact that most household were not paying for water from any of the sources (well, borehole or streams).

Even though a number of scholars and organizations have stressed the importance of water pricing in ensuring adequate and appropriate quality water supply (Biswas, 2005; Easterand Liu, 2005) where access to water was still considered a communal right and it would take appropriate policy framework and directives for it to be widely embraced. The debate on water pricing has been controversial due to misunderstandings, vested interest, dogmatism and ideological differences (Biswas,

2005) and in this study even though some respondents indicated paying for water, majority were not for the idea (Figure 5.58). Since a number of respondents had indicated water acquisition from vendors and private investors, it was expected that there would be the problem of water pricing in addressing water scarcity in the study area. The results indicated that only 31% of the respondents in the north, 21% in the central and 16% in the south were paying to access water. Further interrogation of this result through FGDs found that the money collected through such payment was mainly used to purchase fuel for the water pump and cater for maintenance of water supply facilities. This meant that payment for water was largely for the communal good and not for profit thus supporting the lack of acceptability for water pricing. This therefore could make it difficult to use water pricing as a factor in addressing water scarcity problem in rural Katsina State since water supply was mainly a local management issue with communal benefit.

Unlike centralized water supply system where households typically pay flat (uniform) rate of water fees, communal water supply payments were made only on fetching water from the source and the study results indicated that majority of the respondents did not agree with the idea of paying for water access to ensure water supply (65% of the respondents in the north, 90% in the south and 71% in the central zones) as shown in figure Figure 5.59. This implies resistance to water pricing as a strategy in water scarcity alleviation with only about 25% of the respondents in the study area willing to accept the idea. This finding conforms to the global picture where water pricing is opposed by many people for two main reasons. First, the belief that water is a human right and thus should be available to all at no cost, or at highly subsidized rates. Secondly, the belief by others that water pricing is a code word for handing over the management of public water institutions to the private sector companies, a step opposed for philosophical reasons in which the private companies will make profits for running water services, which is a basic human requirement for survival (Gleick, 2000).

Whether one is opposed to or in support of water pricing does not affect the fact that water supply is a complex and multi faceted issue and that it has not been possible to provide clean water and proper waste water disposal to a very significant part of the world population (Biswas and Tortajada, 2004). If water pricing is considered, irrespective of whether one is for or against such a practice, the following are indisputable facts. This was found to be true in rural Katsina State where water, though scarce, was considered a community right and, therefore, a public property. Yet lack of access to adequate and clean water was evident. The possibility of private companies playing a major role in alleviating water scarcity problem would be limited thus, increasing vulnerability to water scarcity since government role was already very limited if not non existent.

All the historical data and trends indicate that efficient water management is simply not possible without water pricing, irrespective of whether the water services are managed by the public or private sector (Global Water Partnership, 2003). Water pricing does not mean that the poor will not have access to water-related services. The systems should be so designed that those who can afford to pay for water services should pay for them, in exactly the same way that they do now for other basic services such as electricity. Subsidies should be very specifically targeted only to the poor. The private sector currently accounts for only about 5–6% of the urban water consumption of the developing world and even under the most optimistic conditions, this percentage is highly unlikely to exceed 15% by the year 2020 (Tortajada et. al., 2004). In other words, under all foreseeable conditions, the overwhelming majority of consumers in the developing world will continue to receive their water-related services from the public sector.

The performance of public sector companies has been generally poor but it is also important to note that the two most efficient water supply systems of the world are in the public sector, and not in the private sector and these are in Singapore and Tokyo (Global Water Partnership, 2000). Public water systems can, therefore, be the world's best or the worst and, therefore, the most important factor to consider for the future in how to improve very substantially the overall performance of the public sector companies, since they will continue to be the main supplier of water-related services in the developing world for the foreseeable future. The performances of the public water institutions cannot be improved without instituting an efficient and equitable water pricing system. While some people are ideologically opposed to having private sector companies involved in a basic service such as water, conceptually and socio-politically there is nothing wrong with such an involvement, as long as the overall process is independently and properly regulated and the private sector services are efficient, equitable and cost-effective. This observation, according to the study findings, would be a non- starter and the best option would be to empower communities through capacity building and facility provision to meet their water needs and where payment would be necessary, policies must be those that ensure socio-political acceptability. As already noted, only public water supply that is sufficient would have been acceptable to communities in rural Katsina State and since households tended to rely on government to assist in construction of wells or boreholes and provision of storage facilities it would be useful to have some measure of acceptability of water pricing not for profit. Government assistance would, therefore, be seen as an important buffer against water scarcity only if it would not limit access to water.

Figure 5.58 Responses Received on Whether Households make Payment of Water Access Fees across the Three Rainfall Zones of Rural Katsina State

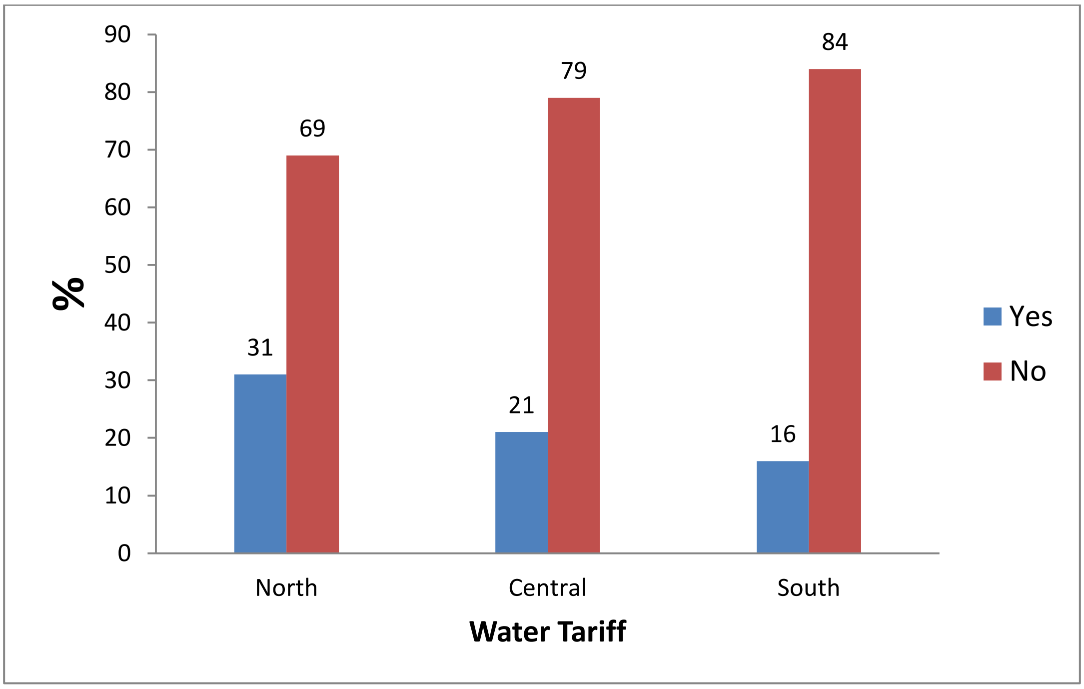
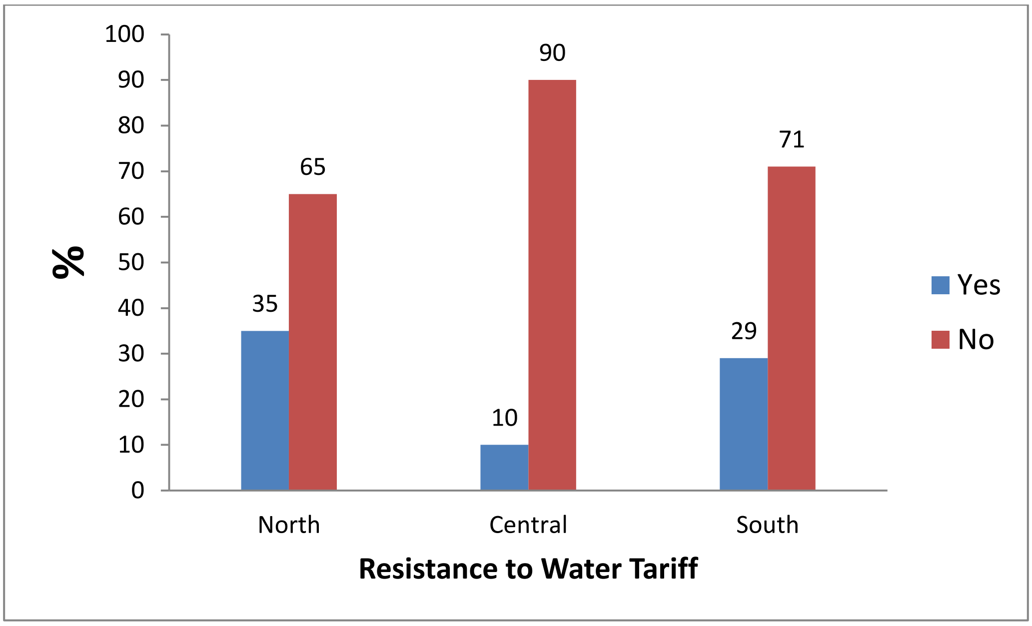


Figure 5.59 Responses Received on Whether the Households Agree to be paying Water Tariff across the Three Rainfall Zones of Rural Katsina State



5.5.5.2 Socio-Economic Factors

In the study, the assumption was that socio-economic characteristics of the local communities in the study area are related to the adaptation capacity at the Household level. It has been observed that most rural communities historically develop adaptation mechanisms to deal with water-related stress and scarcity problems (Tompkins et al, 2005). This implies that, overtime, communities advance in some adaptation capacities, strategically and potentially viable in complementing efforts to meet the needs (Nyong, 2003). In terms of water scarcity, it has been noted in some studies that the community head, elders and Community Development Associations' (CDAs) function is to regulate and manage water sources in the immediate environment with various respected norms and customs. Ideally, this plays crucial role in ensuring equal water usage among inhabitants and conservation measures. Community meetings under the stewardship of the community head or elders would be discussing socio-economic, cultural, technical issues and problems relating to water sources management and conservation measures and the outcome. According to (Tompkins et al, 2005), this would be of significance to regional authority in assessing current policy concerning water and other socio-economic policies. Empowering such system is an option that promotes sustainable adaptation mechanisms. Government at all tiers should encourage and assist community heads and elders in coordinating and promoting such system by incorporating it in their water policy.

Research on the human dimensions of global change have clearly demonstrated that processes influencing local vulnerability to water scarcity are inherently dynamic, and shaped by both climatic and socio-economic stress (Adger et al, 2006). In practice, however, the socio-economic context is seldom explicitly considered, neither in local assessments of vulnerability nor in adaptation strategies (O'Brien and Leichenko, 2000; Füssel and Klein, 2006). As argued by Polsky (2004) improper reflection of stresses and the capacity to adapt to water scarcity are causing critical weaknesses when planning for climate adaptation. For example management practices often take the form of reactive and sector-based responses, diminishing the prospects to evolve more comprehensive climate adaptation strategies (Næss et al, 2005; O'Brien and Eriksen, 2006) or to better integrate climate adaptation into other policy areas (Huq and Reid, 2004; Ahmad, 2011,). The socio-economic factors such as gender, culture, education, income, social organisation system and age are critical in adaptation decision making on issues like water scarcity. Adger and Vincent (2005) have shown that vulnerability and adaptation to water scarcity are closely linked to social characteristics such as ethnicity, religion, culture and norms amongst others.

In this study, the role of socio-economic factors in the decision making in rural Katsina State with regard to water scarcity was investigated by examining some issues relating to the personality, attitudes, and lifestyle of the respondents vis-à-vis adaptation strategies. The particular socio-economic issues considered were:

a. Cost of water scarcity adaptation technology in relation to people's capacity to afford such cost
b. Accessibility to socially-affordable alternative source of obtaining water (for example a privately-owned water selling point)
c. Size of a household in relation to its impact on water demand and capacity
d. Social organisation and cohesion to ensure effective community-based water scarcity management structure
e. Health condition of the people which could determine their physical capacity to meet up with challenges of adaptation to water scarcity

f. Formal institution for water supply to ensure effective community-based water scarcity management structure

The results of socio-economic factors data analyses were as in table 5.33 and figure 5.60 where 31% of the respondents in the south, 9% in the central and 5% in the northern zone were of the opinion that modern technology for water resources exploration and exploitation cost was high and this was seemingly one of the factors influencing adaptation to water scarcity. Across the study area, there were little or no evidences of private acquisition of modern equipments for water resources exploration and exploitation. Related to this, 14% of the respondents in the north, 32% in the central and about 11% in south indicated weak nature of local technology for exploitation and exploration of water resources as the factor influencing the adaptation. The only indigenious technology for harnessing ground water resources was the labour intensive hand digging which was considered as the best alternative technology available in the absence of rainwater harvesting.

The community organisations was in this study considered one of the socio-economic issues affecting adaptation to water scarcity and results of data analyses indicated that about 16% of the respondents in the north, 13% in central and, 9% in the south were of the idea that weak community organisation was the main factor affecting adaptation to water scarcity. This could have been due to lack of formal structures in community organisation and for this reason the study interrogated the presence of formal institution relating to water supply in the communities. It was found that formal institutions were relatively weak with 25% of respondenst in the south and 10% in the central indicating the weak nature of formal institutions as responsible for water supply as influencing adaptation to water scarcity. This could result to lack of effective synergy between different formal institutions with responsibility for provision of water infrastructure, where in some cases two different bodies would be undertaking construction of the same type of facility in one location without taking in to account the sustainability of such facilities in the community.

The major economic factor influencing adaptation to water scarcity cited by the respondents in the study was income where 42% of the respondents in the north 26% in the central and 21% of the south indicated low income level as affecting ability to acquire facilities for obtaining alternative water sources and this was supported by the earlier finding that majority of the respondents had low income. It is the position of this study that the low income could have resulted in inability to accommodate the high cost of water supply equipments especially in terms of spare parts for maintenance of boreholes, water filters and chemicals.

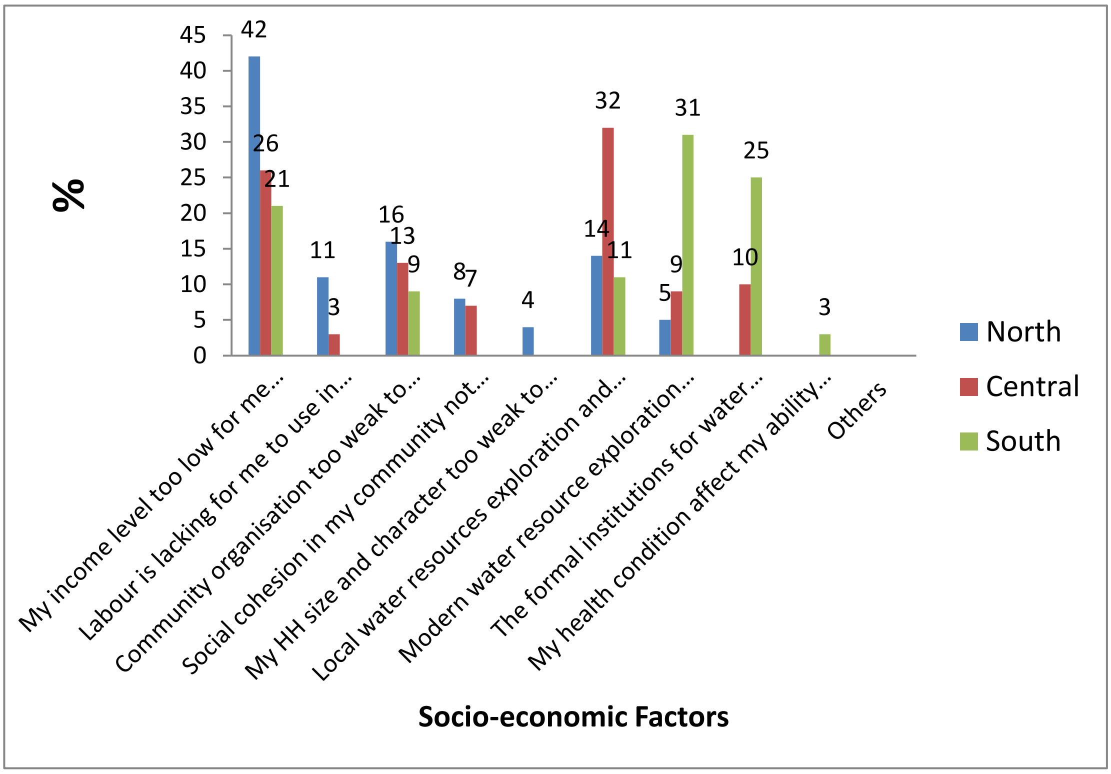
In this study it was expected that households with small numbers would require small amounts of water and larger households would require larger amount of water but the results indicated that household size was of influence in adaptation to water scarcity as only about 4% of the respondents in the north indicated household size as the factor influencing the adaptation. Socially, household size is not considered a problem in rural Katsina State and in most cases would elevate social standards in the community. For this reason, it was possible for the respondents to ignore households' size as an adaptation factor even though earlier results indicated its role in the vulnerability index. Further analyses of data indicated that about 8% of the respondents in the north and 7% in the central were of the opinion that lack of social cohesion among community members was the main factor influencing the adaptation. The social dimention in adaptation could have been difficult to ascertain because some elements were socially not discussed such as households size and where social cohesion was lacking, it would be intrusive to discuss matters considered to be family affairs and this could result in lack of contributory behavior where collectivety and cooperative efforts were necessary as would be the case in community water supply facilities.

Table 5.33 Factors Affecting Adaptation across theThree Rainfall Zones of Rural Katsina State

Factors Affecting Adaptation	Rainfall zone		
	North	Central	South
My income level too low for me acquire facilities for obtaining alternative water source	168(42%)	104 (26%)	84 (21%)
Labour is lacking for me to use in supplying water	44(11%)	12(3%)	
Community organisation too weak to make water more available	64 (16.0%)	52(13%)	36 (9%)
Social cohesion in my community not strong enough to face WS challenge seriously	32(8%)	28 (7%)	
My HH size and character too weak to help in supplying adequate water	16 (4%)		
Local water resources exploration and exploitation technology too weak	56(14%)	128 (32%)	44(11%)
Modern water resource exploration and exploitation technology too costly	20 (5%)	36 (9%)	124(31%)
The formal institutions for water supply are too weak to function effectively		40(10%)	100 (25%)
My health condition affect my ability to supply enough water			12(3%)
Others	(0%)	(0%)	(0%)

Heath condition was taken to be a possible factor affecting adaptation to water scarcity in the study and results of data analyses showed that only about 3% of the respondents in the south were of the idea that heath condition was the main factor affecting adaptation and this could have meant minimal role of heath in adaptation to water scarcity.

Figure 5.60 Factors Influencing Adoption of Water Scarcity Adaptation Strategies across the Three Rainfall Zones of Rural Katsina State



The low position of heath in factors affecting adaptation tended to contradict the fact that some respondents indicated lack of labour as a factor affecting adaptation and yet health condition is known to affect labour activity in many rural communities. 3% of respondents in the central and 11% in the north indicated lack of labour for use in supplying water as the main factor affecting the adaptation and would, therefore, be not logical to avoid health conditions in central and north in the study area if labour was considered a main factor in adaptation. No response on "Others" which included income level to low for me to acquire facilities for obtaining alternative water source, access to appropriate equipment to help me in supplying water, the market cost of water supply equipments too expensive for me to acquire and and Modern water resource exploration and exploitation technology too complex

From the above observations, the results of this study tended to support many other studies that had stressed the importance of various socio-economic factors in adaptation to water scarcity as in the work of Beinat (1997) which observed that different socio-economic factors in rural areas of Natal Midlands, the Venda region and the Eastern Capouth Africa affected access to surface water sources. Alwang (2001) noted that many communities restrict the distance to which cultivation could take place and where buildings could be erected near their surface water sources and this could have been a conservation measure based on traditional beliefs but the impacts were being moderated by modernization (Beinat, 1997). To the respondents who cited socio-economic factors, it could have been the reason for change in water supply situation as is the case with many traditionalists who tend to blame the impact of modernization on traditional beliefs and practices as the course of environmental change and continued increases in wide anticipated water stress in most rural areas. Religious and traditional beliefs among rural communities play diverse roles and are important in water management and defining adaptation strategies. There are different societal roles and capacities to adapt to the impacts of climate change and climate change-induced water stress implications are bound to have varying and significant effects on the livelihoods of rural communities (Adger, 2004; Kane and Yohe, 2000).

It was important to have some measure of how representative the diverse views on the socio-economic factors affecting adaptation to water scarcity were and the chi-square test was used to test the hypothesis that the observed differences were not chance events. The computed chi-square was 483.0 and the critical chi-square was 33.9 at 95% confidence level and this indicated that the observed differences in the socio-economic factors influencing adaptation to water scarcity across the three rainfall zones were not chance events and, therefore, representative of the situation in rural Katsina State given the varying water supply conditions.

Since the factors affecting adaptation to water scarcity were found to be part of the rural Katsina State water supply situation, it was important to evaluate those factors in terms of what other scientists had determined. In this regard, the approach was to consider the constraining factors from the perspective of other scientist given the results of this study. Gamedze et al (2012) working on the determinants of water demand of rural communities in Swaziland identified income level, households size and distance to water source as the constraining factors in the unmet water demand in households. Ishaku et. al (2011) in reviewing the challenges affecting rural water supply in Nigeria were of the opinion that access to unimproved water sources was making households more vulnerable to water borne diseases and this was largely due to lack of government intervention. The findings of Gamedze et al (2012) and Ishaku et al (2011) was largely similar to the conditions that were identified in this study with regard to factors affecting adaptation to water scarcity in rural Katsina State. Ngigi (2009, 2003) and Burton *et al* (1997) attributed the slow adoption and assimilation in development plans with regard to water scarcity to several factors including economic resources, technology development and dissemination, information and skills, infrastructure, governance structure, socio-cultural perspectives, gender and equity, environmental and health issues, extension services and incentives, and conflicts among different interest groups.

In this study, factors constraining adaptation to water scarcity were identified through field survey, FGDs and observations which yielded data that were subjected to statistical analyses as well as qualitative analyses and the results included a number of important factors. The constraining factors were identified as:

- Natural Constraints (those due largely to influence of nature including *i*ncreasing shift in climate of the area towards aridity, decrease in stream flow due to erosion-induced siltation of drainage channels, basement complex geological formation with poor aquifers that do not favour effective harnessing of groundwater at especially shallow depths, distortion of hydrological balances especially through over-exploitation of water and, prolonged drought, desertification and high evapotranspiration rates.

- Economic and Technological Constraints included low income levels leading to inability to acquire appropriate new technology, inability to acquire alternative water sources and inability to meet the high cost of water supply equipments especially in maintenance of boreholes and water treatment. In this study, the low income level was taken as an indicator of poverty which had been identified as related to vulnerability and a rough indicator of their ability to cope and adapt (IPCC, 2001). Secondly, low technology base due to weak indigenous technology for harnessing ground water resources (IPCC, 2001) as hand digging is mostly the best technology that was available and, absence of rainwater harvesting, resulting into allowing large volumes of rainwater received every year to be ‘wasted. Thirdly, there was low level of dissemination of modern technology on water resources management and past studies had shown that slow adaptation of modern technology in Africa was attributable to low technology dissemination adoption (Downing, 2000; Niang-Diop and Bosch, 2004). Finally, low skills on water resources management where it was recognised that building adaptive capacity required a strong, unifying vision, scientific understanding of the problems, an openness to face challenges, pragmatism in developing solutions, community involvement, and commitment at the highest political level (Fankhauser and Smith, 1999).

- Institutional Constraints refer to governance structures that were identified as either formal and informal institutions, including weak formal institutions for water resources management (Kelly and Davids, 1998; Huq *et al,* 2003; Burton *et al*, 1997; Magadza, 2000; IPCC, 2001; Miller *et al*, 1997) and the most notable component of a governance structure is the institution. Institutional constraints limit entitlements and access to resources for communities, thereby increasing vulnerability. Secondly, weak social cohesion due to absence of effective community organisations, lack of contributory scheme to raise funds and, non-chalant attitude towards protection of facilities. Thirdly, is inadequate supply infrastructure which was considered in this study as an important component in any development program. For people to adapt to water scarcity, physical infrastructure aspects to be considered are water supply, water management structures, transport and marketing systems, storage and processing structures and communication. Social infrastructure was also considered important in terms of community organizations, WUAs (Water users’ Association) and cooperative societies. These infrastructures were in general not found to either be in place, in right quantity and in good operational working state across the communities studied. Poor infrastructure affects adaptation at both local and national levels.

- Legal and Policy Constraints are in the form of lack of effective policy to comprehensively address the challenges of water scarcity, lack of effective synergy between different formal institutions with responsibility for provision of water infrastructure, overlapping of responsibilities, unnecessary duplication and overlap in organisations, the ill-defined and uncoordinated roles of the Federal, State and Local Government agencies responsible for water resources development, failure to recognise the inter-relationship between surface and ground waters, and between water resources and land use, lack of effective water protection laws, and the means to enforce the already existing laws, to help in water conservation, lack of effective policy to ensure good and fairly even distribution of water in time and space in relation to man's needs and, inadequate planning and management of the water resources.

5.6 Institutional Arrangement for Rural Water Supply

The level of vulnerability to water scarcity in rural environment can be moderated by various interventions one of which is institutional arrangement for rural water supply. In this study, the key informants were included to provide official position in terms of water provision situation in rural areas of Katsina State. The main focus was the official position on successes of institutional arrangements in addressing water scarcity problems in Katsina State. Several institutions were identified as having recorded successes in rural water supply and this included the Katsina State Rural Water Supply and Sanitation Agency (RUWASSA) which came into being on the 19th day of November, 2003 via the Katsina State Law No. 12 of 2003 and was vested with the power to coordinate the activities of all the operators in Rural Water Supply and Sanitation sub-sector in the State towards achieving the Millennium Development Goals (MDGs) within the context of NEEDS and LEEDS. The three functions of RUWASSA were water supply and sanitation, mobilization and public relations and administration and finance. The specific functions of the Agency included:

- Implement the National policy on Water Supply and Sanitation with regards to objectives of cost sharing formula;
- Regulate, coordinate and set standards for the construction of ventilated improved latrines and other sanitation facilities;
- Promote, device and innovate low-cost and appropriate technology options for communities and assist in choosing the most appropriate option in the Rural Water Supply and Sanitation;
- Assist in eradicating water supply and sanitation related diseases;

- Mobilize and train communities in technical and financial management of water and sanitation facilities for sustainability;
- Prepare and continuously update the rural water supply and sanitation master plan and coordinate its implementation for the State;
- Prepare and keep comprehensive inventory of all rural water supply and sanitation facilities in the State;
- Provide ready institution for programme implementation in the sub-sector to attract participation of international organizations and
- Provide a platform for achieving the goal of universal access to safe water and sanitation in rural areas.

RUWASSA was also in collaboration and partnership with the following Ministries, Departments and Agencies:

- Federal Ministry of Water Resources;
- Sokoto Rima River Basin Development Authority,
- Katsina State Ministries for Health, Agriculture, Information, Justice, Local Government, Women Affairs, Education, Environment and relevant Agencies under them;
- MDG Projects Implementation Committee Katsina State;
- 34 Local Government Councils through the WASH Departments;
- UNICEF
- UKaid (DFID)
- JICA
- Service To Humanity Foundation (SHF)

RUWASSA given the above mandate and activities claimed to have made the following impacts in the provision of portable water in rural areas of Katsina State:

- Improved collaboration amongst sector agencies;
- Developed and ensured the adoption of technical options and designs for water and sanitation facilities;
- Refurbished existing equipment and vehicles of the Agency that hitherto were broken down;

- Procurement of 3 sets of drilling rigs with supporting equipment, accessories and spare parts as well training of 8 RUWASSA personnel on the operation and maintenance of the equipment at the manufacturer's plant in Peine, Germany.
- Provided a total of 923 safe water points in the rural communities, comprising 398 new boreholes fitted with hand pumps, 200 new motorised/solar powered boreholes, 23 rainwater harvesting systems, 283 rehabilitated handpump boreholes, 28 rehabilitated solar/motorized boreholes and 1 rehabilitated slow sand filtration system across the State;
- Ten rainwater harvesting facilities were provided in 11 Girls Education Project (GEP) primary schools in Sabuwa, Bakori, Kusada, Ingawa, Kurfi and Danmusa LGAs. This project provides alternative technology for water provision where sufficient groundwater for abstraction is not feasible,
- Provision of 12 rainwater harvesting facilities in selected non GEP LGAs,
- Complete 1no. slow sand filtration scheme at Musawa, Musawa LGA,
- In collaboration with the Federal Government of Nigeria and the People's Republic of China Assisted project, 60 Hand pump and nine motorized boreholes were provided in Dutsi, Mashi, Ingawa, Faskari, Kafur, Musawa, Jibia, Kurfi and Rimi LGAs,
- Provision of complete sanitation facilities in 180 primary schools and health centres through RUWASSA, UNICEF and MDG,
- Provision of complete sanitation facilities in 11 primary schools in collaboration with UNICEF,
- Provision of hygiene promotion materials in 36 schools and health centres,
- Provision of WASH facilities (1 hand pump borehole and 6 compartments of VIP latrines in Jikamshi model primary school in collaboration with Service to Humanity Foundation,
- Facilitating the attainment of open defecation free (ODF) status in nine (9) communities of Bakori LGA in collaboration with UNICEF,
- Lunching of 9 Handwashing Campaigns in collaboration with UNICEF, Service to Humanity Foundation and other stakeholders (Ministries of Water Resources, Health, Environment, Finance, Local Government, Information and their Parastatals) in 9 primary schools,

- Lunching of 6 Handwashing Campaigns in collaboration with UNICEF, Service to Humanity Foundation and other stakeholders (Ministries of Water Resources, Health, Environment, Finance, Local Government, Information and their Parastatals) in 6 Health Centres,
- Developed a Statewide WASH Policy and Investment plan (finalized for approval) which was drafted by all stakeholders with UNICEF assistance. This represents the Government's proactive plan for the achievement of 80% water and sanitation coverage by the year 2013 through an investment of US dollar 607.55 million (equivalent to N71,082.95 million) over a period of 5 years (2009-2013),
- Establishment of Water and Sanitation Departments in all the 34 LGAs of the state thereby achieving the feat of being the only state in Northern Nigeria and second in the country to establish a full pledge WASH department in line with the National Water and Sanitation policy,
- Establishment and strengthening of 514 water, sanitation and hygiene committees in communities to ensure sustainability of facilities provided,
- The establishment and orientation of 880 Environmental Health Clubs in schools provided with WASH facilities,
- Trained 850 pump caretakers across the state,
- Increased partnership with other Agencies (Millennium Development Goals Office, Federal Ministry of Water Resources), Donors and External support Agencies (United Nations Children's Education Fund-UNICEF, Japan International Cooperation Agency-JICA, United States Embassy, Government of the People Republic of China, Korean International Cooperation Agency) and Non-Governmental Organizations (Service to Humanity Foundation) for the development of sustainable policies and systems and assist in acceleration of coverage.
- Provided 52 handpump boreholes in selected primary schools of Bakori, Mai'adua and Kaita LGAs (KTSG/DFID/UNICEF – SHAWN Project)
- Provided 384 compartment latrines in 64 selected primary schools of Bakori, Kaita and Mai'adua LGAs under the DFID/UNICEF Assisted SHAWN Project

- Facilitated the achievement of Open Defecation Free (ODF) Status in six council wards (comprising of 148 communities) of Abdallawa and Matsai (Kaita), Kabomo and Tsiga (Bakori), Maikoni A and Maikoni B (Mai'adua)
- Facilitated the establishment and strengthening of 72 Environmental Health Clubs in 72 selected primary schools of Bakori, Kaita and Mai'adua LGAs under the DFID/UNICEF Assisted SHAWN Project
- Rehabilitated 50 handpump boreholes in Sandamu, Dutsi, Dutsinma, Malumfashi and Faskari LGAs under the KTSG/FGN/TCF Agreement,
- Undertook the improvement of water supply at the Yusuf Bala Usman College of Legal and General Studies, Daura;
- Provided a Solar Powered borehole at the Headquarters of the Nigeria Security and Civil Defence Corp in Katsina;
- Provided 2 Nos.boreholes (1 solar powered and 1 hand operated) at the police barracks, Sabon Layi Katsina with reticulation and extension to the compound clinic,
- Implementing an on-going water improvement at the Umaru Musa Yar'adua University, Katsina;
- Implementing an independent water supply project for the New Government House, G.R.A. Katsina.

The RUWASSA officials claimed that the Katsina State Government as at the time of the study had so far (i.e. since 2003) expended over **₦ 1.7 Billion** in the provision of sustainable water and sanitation facilities to the rural populace of Katsina State. Unfortunately, neither during the FGDs conducted nor the field observations made by the researcher were confirmation made of these laudable achievements. Though it might have been possible that the various facilities claimed to have been provided across the rural areas were actually provided in communities but not evident to the study, it was quite unlikely that they could not be mentioned either in the FGDs, survey or in field observations across the state. One possible conclusion was that RUWASSA objectives and activities were quite loudable but implementation could have been at best not recordable at the community level in rural Katsina State due to lack of participation by the community members or structures.

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Efficient water management is important in maintaining the health and wellbeing of the household, particularly in the rural areas. This study focused on issues relating to vulnerability and adaptation to water scarcity to enhance understanding of the complex issues involved in global water availability and demand. The central aim of the study was to identify the extent and influencing factors of the households' vulnerability to water scarcity across the three rainfall zones in rural Katsina State and the configuration of forces that shape their ability to adapt to the problem. The specific objectives were to determine (i) the vulnerability to water scarcity in the study area and its extent, (ii) the hierarchy of adaptation strategies they employ in adapting with the vulnerability to water scarcity, (iii) the main factors affecting households' adaptation to water scarcity, and (iv) the constraints that need to be addressed to enhance households' ability to cope with and adapt to water scarcity in the area. Thus, assessment of vulnerability and adaptation to water scarcity is an integrated approach which requires social, economic and physical data. Consequently, the main indicators of vulnerability and factors influencing adaptation to water scarcity that have been identified from the literature using a deductive approach were adopted for use in this study.

Water demand and water availability were considered fundamental elements in the computation of water scarcity in rural Katsina State, the per capita water availability was 26 litres per day which when compared to the UNDP (2006) estimate for Nigeria at 38 litres indicates a deficiency. Further, the figure for rural areas of Katsina State when compared to the WHO (2003) recommendation indicate basic access to water only for drinking and hygiene not taking into consideration other demands such as livestock watering which form part of water demand in rural areas of Katsina State. WHO criteria were found to under estimate the water access problem in rural areas of Katsina State which was actually only basic access. At basic access level the households were, therefore, very vulnerable to water scarcity meaning that the requirements for basic hygiene could barely be satisfied in rural areas of Katsina

State. The study findings indicate that there is significant difference in per capita water availability and this difference varies by households and rainfall zones.

The emerging pattern of water sufficiency index in rural Katsina State tend to decrease from south to north and this reflects the spatial distribution of rainfall amounts over the entire northwestern region of Nigeria. In the northern rainfall zone of Katsina State, the values of WSI varied between 20% and 92% with a mean of 57.4%; central zone, the values were between 25% and 86% with mean of 60.3% and; in the southern zone, the values varied between 06% and 97% with a mean of 67%. In the northern zone, on the other hand the mean WSVI values varied between 08% and 80% with a mean of 42.6%; central zone, 14% to 75% with a mean of 39.7% and; the southern zone, 03% to 94% with a mean of 32.9%. These WSVI scores implied increase in vulnerability from south to the northern rainfall zones and, therefore, stress in water scarcity mitigations measures need to take this pattern into account, it was found to decrease with decrease in rainfall amount from south to northern parts of the study area. This conforms to the general geography of water availability in Africa where there is a tendency to have water scarcity increase with the distance away from the equator especially to the north. None of the communities studied belong to the 'No Scarcity' implying that the problem of water scarcity generally affected all the communities in the study area.

The indicators of vulnerability to water scarcity in rural areas of Katsina State were found in this study to include general low levels of formal education leading to over reliance on traditional knowledge and resulting low uptake of modern or scientific means of limiting vulnerability to water scarcity. Where formal training in managing vulnerability to water scarcity was present, the training was usually inappropriate. The general low income level indicated that most households in the study area were leaving below the poverty line as defined by the UN benchmark with over 80% of the households indicating income below the benchmark. Expenditure on water was found to be relatively low mainly due to low income level and sourcing water from natural reservoirs which could be a health risk in terms of water- borne diseases. The sources of water were generally shared with other domestic demands such as livestock watering and general laundry, a situation that further exposes households to risk of water-borne diseases. The acquisition of water generally tended to involve long distance travel and time resulting in less water available to households' thus increasing vulnerability to water scarcity. Government support in limiting vulnerability to water scarcity was generally peripheral and the households relied on water supply without much water quality monitoring, management, funding and leadership from either the federal or the state government.Where government institutions supporting water supply existed, in most cases, their roles overlapped due to ill defined mandate and their roles tended not to exist in the field.

Where a hazard like water scarcity exists, it is expected that the inhabitants of the surface area would respond through many means, one of which is adapatation. In this study the adaptation strategies in the face of water scarcity situation in Katsina State tended to vary by rainfall zones and households and the strategies involved were generally with any difference being a chance event. The adaptation strategies included rainwater harvesting, building of check dams, purchasing of water from vendors, reducing the frequency of livestock watering, relocation of livestock especially in the north, reducing the amount of water spent in cooking, reducing frequency of bathing, reducing frequency of laundry, rehabilitation of old water supply source, change in livelihoods and changing location of water supply source.

The ability of people to acquire information and make decision is dependent not only on traditional knowledge but also on knowledge and information generated through research. It was found in this study that over time, knowledge and information from past research work on water scarcity had limited success in the study area and this was largely due to low levels of formal education and low inputs from the relevant authorities. It was the traditional knowledge accumulated over time that was found to be the most relevant in adapting to water scarcity in rural areas of Katsina State. Other relevant knowledge system was the media especially the radio which was found to be useful vehicle for information transfer as nearly every household had a radio they could rely on.

Government through various measures can assist the citizenry to adapt to hazardous situations as in the case of water scarcity and in rural Katsina State even though the role of the government was peripheral, some inputs were present in the form of construction of boreholes, provision of water pumps, periodic supply of water using tankers and construction of open concrete wells at the communal levels. In periods of water scarcity, water reservoirs tend to play significant roles and in the study area storage facilities, though not widespread, were found to be one of the adaptation measures that had the potential to reduce vulnerability to water scarcity if the government could invest substantially. But this was not the case in rural Katsina State.

There was general lack of government policy on adaptation to water scarcity in Katsina State and this indicated lack of governance in water supply. This was particularly illustrated by the lack of water pricing, which is a central factor in modern water supply situation. This situation in rural Katsina State was further aggravated by the general communal negative view on water pricing as water was considered a free human right. This was found to conform to the global picture where water pricing is opposed by many people on the basis of human right. The socio-economic factors affecting adaptation to water scarcity in rural Katsina State included high cost of modern technology, weak nature of local technology, weak community organizations, weak formal institutions, low income levels, lack of social cohesion and poor health conditions.

The major constraints that were identified as affecting households' ability to adapt to water scarcity in the study area included increasing aridity, low stream flows, siltation, poor aquifers, distortion of hydrological balances, desertification and high evapotranspiration rates, all of which collectively made up natural constraints in adaptation to water scarcity in rural Katsina State. The economic and technological constraints in adaptation to water scarcity were identified as inability to acquire appropriate new technology, inability to acquire alternative water sources, high cost of water supply equipments, weak indigenous technology, low level of dissemination of modern technology and, low skills on water resources management. Institutional constraints included weak formal institutions, weak social cohesion, and inadequate supply infrastructure. Lastly, there were legal and policy constraints including lack of comprehensive water policy and, lack of synergy in the various formal institutions addressing water supply in rural Katsina State.

6.2 Conclusions

From the summary above, the study came to the following conclusions:

- Besides the water scarcity conditions chiefly due to differences in rainfall distribution and amount, the vulnerability indices based on water availability and demand in the households showed that there is a relationship between rainfall and degree of vulnerability to water scarcity.
- The vulnerability to water scarcity in rural Katsina State is mainly a crisis of governance since many official intervening factors are usually unclear and overlapping leading to inefficient institutions, insufficient funding, none-grassroot decision-making, limited public awareness and ineffective regulations and enforcement.
- The many water scarcity adaptation strategies in rural areas of Katsina State are ineffective because there is significant adaptation deficit across the three rainfall zones.
- Conventional water scarcity adaptation strategies are rarely used in rural Katsina State mainly due to high poverty levels, low formal education, resistance to 'outside ideas', and less government involvement
- There is general lack of comprehensive government policies on water scarcity that would be useful in creating an enabling environment for adaptation to water scarcity
- In rural areas of Katsina State, there is general lack of access to adequate and clean water mainly due to poor governance in dealing with what is a universal human right
- Water pricing would not be an effective adaptation strategy as concerns dealing with water scarcity issue in rural areas of Katsina State because of wide spread opposition and lack of private investment incentives.
- There is slow adoption and assimilation in development plans with regard to water scarcity due to many socio-economic factors in decision making especially high cost of adaptation of technologies, high poverty levels, limited alternative water sources, large households size, lack of social organisation and cohesion in water scarcity management structure, poor health conditions of the people and weak formal institutions

6.3 Recommendations

On the basis of study conclusions, recommendations were made for policy making and further research as below:

6.3.1. Livelihood Issues

- People should diversify livelihoods to limit vulnerability to water scarcity
- Attempt should be made to improve income levels by investing in activities that would improve the economy of rural Katsina State especially in the cottage industries that would directly impart on household income levels.

6.3.2. Awareness Training and Capacity Development

- Policies on education, research and development for Katsina State must include water supply in order to address increasing vulnerability to water scarcity
- Targeted training on water technologies especially those addressing inadequacies in indigineous water technology need to be encouraged through government interventions
- There should be increased campaign on awareness and private investments in rainwater and surface runoff harvesting potential in rural Katsina State in attempt to address increasing vulnerability to water scarcity.
- To reduce resistance to new ideas and technology in water supply, there is need to incoperate traditional and religious perspectives in water supply policy making and implementations.

6.3.3. Water Technology

- In water technologies dissemination, use of existing and readly available infrastructures such as schools, electronic media, family lineage, peer group discussion, printed materials and government activities should be encouraged.
- Water exploration and acquisition technology should be appropriate and affordable
- Physical infrastructures relating to water supply and acquisition require improvements in terms of quality, reach and sustainability through increased government and private involvement.

6.3.4. Institutional Issues

- There is the need to ensure that the activities of the many institutions involved in provision of rural water supply facilities across the State are synergised to eliminate duplication and enhance service delivery.
- There is need for improved governance in water supply situation in rural Katsina State to avoid the current lack of government presence in meeting households or communities water demands.
- The current partriachical decision making in water use need to be addressed through government policies to avoid inequality in water use and availability.
- There is need to increase research funding in the field of water supply in order to generate useful information for planning and decision making.
- Intervention measures need to take into account differences in households' characteristics and their effects on vulnerability to water scarcity.
- There should always be a government contingency plan in dealing with water scarcity problem in rural Katsina State.

6.3.5. Recommendations for Further Research

The following areas should be explored by further research workers:

a. Since rainfall is one of the major determinants of water scarcity, there is the need to further test the applicability of the index of assessing vulnerability to water scarcity developed in this study, by evaluating the extent to which it correlates with community-level rainfall records.

b. There is also the need to test the applicability of the developed indeces in areas outside Katsina State in order to identify its major strengths and weaknesses as it is applied in areas outside Katsina State.

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APPENDICES

APPENDIX I: FIELD QUESTIONNAIRE FOR THE STUDY RESEARCH

UMARU MUSA YARADUA UNIVERSITY
DEPARTMENT OF GEOGRAPHY
P.O.BOX 2218
KATSINA

Dear Sir/madam

I am a PhD student in the Department of Geography at the University of Nairobi, and my contact address is as given above. My PhD field study involves collecting information on water availability, demand, adaptation strategies. In this endeavor,I would like to kindly request that you assist by answering the following questions. The information supplied shall be used purely for academic purposes.

Questionnaire number ___________

LOCATION: (i) Longitude (X)………………Latitude (.Y)…………..(GPS Readings in decimal degrees)
(ii) Longitude (X)………………Latitude (.Y)…………..(GPS Readings in decimal degrees)
(iii) Longitude (X)………………Latitude (.Y)…………..(GPS Readings in decimal degrees)
(iv) Longitude (X)………………Latitude (.Y)…………..(GPS Readings in decimal degrees)

Rainfall Zone____________________

***A)* BACKGROUND INFORMATION OF RESPONDENTS**

1. Community name:____

2. Respondents' age:____

3. Sex: (1) Male (0) Female

4. Marital Status: (1) Single (2) Married (3) Divorcee (4) Widowed

5. Number of members of the household that live in this house?_______________

6. What is the Highest Educational level of?

Hh member	**Primary**	**Secondary**	**College**	**University**	**Qur'anic**	**Theological**	**None**

7. Ethnic group……………………………………………………..

8. Occupation

		Main	Another
a.	Farming	( )	( )
b.	Civil service	( )	( )
c.	Trading	( )	( )

d. Fishing ( ) ( )

e. Livestock rearing ( ) ( )

f. Mining ( ) ( )

g. Others, please specify:________________________________

9. Income per day (Naira):

a. 50-100 ( ) b. 101-200 ( ) c. 201-300 ( ) d. 301-400 e. 401-500 f. 501-600 g. Above ( )

B) INDICATORS OF VULNERABILITY TO WATER SCARCITY

1. Have you been trained on water resources management?

(1) Yes (0) No

2. If yes, what type of training have you received?

a. Water conservation ( )

b. Water exploration ( )

c. Water drilling ( )

d. Water purification ( )

e. Policy making on water resources ( )

f. Rainwater harvesting ( )

g. Other, please specify________________________________

3. Who else in the household has received training on issues related to water resources management?

a. Spouse (for male headed household) ( )

b. Male children ( )

c. Female children ( )

d. Relative staying in the house ( )

e. House help staying in the house ( )

f. Other, please specify________________________________

4. Did you find the training on water resources management usefulin meeting your water needs?

   (1) Yes (0) No

5. If yes, in what way:

   ____

   ____

   ____

   ____

6. What is your daily household expenditure?_____________________(naira)

7. Give your key household expenditure areas:

   a. Feeding ( )
   g. Washing clothes ( )
   h. Sanitation ( )
   i. Drinking water purchase ( )
   j. Cooking water purchase ( )
   k. Watering of livestock ( )
   l. Healthcare ( )
   m. Energy for cooking ( )
   n. Other, please specify_______________________________________

8. If water is one of the key expenditure areas, estimate how much is spent on household daily water needs?

   ____

   ____

   ____

   ____

9. Do you treat drinking water used in this household?

   (1) Yes (0) No

10. If yes, indicate the method of treatment

a. Boiling before drinking ( )

b. Filtering ( )

c. Use of herbs ( )

d. Use of alum ( )

e. Use of chlorine ( )

f. Other, please specify____

11. How much do you spend on water treatment per day___________________ (naira).

12. Is maintenance of water facilities an issue in water supply in the household?

(1) Yes (0) No

13. If yes, how much is spent on maintenance of water facilities (naira)?

i) Per day___________________

ii) Per Month_______________

iii) Per annum ___________________

14. Is water scarcity a .problem in thishousehold?

(1) Yes (0) No

15. Is water scarcity a .problem in this community?

(1) Yes (0) No

16. If yes, what is your source of information?

(a) Personal knowledge/experience ( ) (b) From elders ( ) (c) Printed materials ( )

(d) Electronic media ( ) (e) School ( ) (f) Interaction with friends ( )

(g) Family source ( ) (h) Peer group discussions ( ) (i) Village level interactions ( )

(h) Government activities ( ) (i) Media programmes ( )

(j) Others, please specify ____________________________

17. Below is a list of water borne diseases in your community thatcan occur due to water scarcity. I would like you to Rank them from 1(most prevalent) to 5 (least prevalent) according to occurrence in your household.

	1	2	3	4	5
a. Bilharzia	( )	( )	( )	( )	( )
b. Cholera	( )	( )	( )	( )	( )
c. Guinea worm	( )	( )	( )	( )	( )
d. Typhoid fever	( )	( )	( )	( )	( )
e. Diarrhea	( )	( )	( )	( )	( )

f. Others,please specify____

18. According to you, how are these diseases transmitted?

____

____

____

____

19. When was the last time your community experienced serious water scarcity related problem? Month/year

20. What was the cause of water scarcity noted in (19) above?

____

____

____

21 Which of the following is your source (s) of domestic water?

a. Pipe borne ( )
b. Borehole ( )
c. Shallow wells on stream bed ( )
d. Hand dug wells ( )
e. Concrete wells ( )
f. Dam ( )
g. Open concrete well ( )
h. Ordinary open well ( )

i. Private borehole ( )

j. Private household well ( )

k. Shallow stream wells ( )

l. Running stream or river ( )

m. Pond ( )

n. Others, please specify ____________________

22 Which of the following is your source (s) of water for livestock?

a. Pipe borne ( )

b. Borehole ( )

c. Shallow wells on stream bed ( )

d. Hand dug wells ( )

e. Concrete wells ( )

f. Running stream ( )

g. Dam ( )

h. Others, please specify ____________________

23 How can you describe your access to water sources? Tick as appropriate.

(a) Very easy ( ) (b) Easy ( ) (c) Poor ( ) (d) Very poor

24 To what extent do you receive government support for water supply in your community?

a) Full support ( ) (b) Part support ( ) (c) little support ( ) (d) No support ( )

25 To what extent do you receive government support for water treatment in your community?

(a) Full support ( ) (b) Part support ( ) (c) little support ( ) (d) No support ( )

26 Which of the following are the staple foodsconsumed by the household?

(a) Millet ( )

(b) Guinea Corn/Sorghum ( )

(c) Beans/Cowpea ( )

(d) Maize ( )

(e) Cassava ( )

(f) Yam ( )

(g) Others, please specify ______________________________

27 From your experience, kindly rate the water requirement of cooking the food items listed below:

	Very High	High	Moderate	Low	Very Low
a. Millet	( )	( )	( )	( )	( )
b. Guinea Corn/Sorghum	( )	( )	( )	( )	( )
c. Beans/Cowpea	( )	( )	( )	( )	( )
d. Maize	( )	( )	( )	( )	( )
e. Cassava	( )	( )	( )	( )	( )
f. Yam	( )	( )	( )	( )	( )

g. Others, please specify______________________________

28. Is the water supply facilityavailable to you in good working condition?

(a) Yes (b) No

29. If no explain______________________________

30. Which of the following sanitation facilities is being used in your household?

a. Pit latrine ( )

b. Soak away ( )

c. Wash hand basin ( )

d. Bathroom shower ( )

e. Bathroom basin ( )

f. Others, please specify ______________________________

31. Which of the following healthcare facilities are used in your community?

a. General hospital (..)
b. Specialist hospital (..)
c. Private hospital (..)
d. Private clinics (..)
e. Dispensary ( )
f. Primary healthcare ( )
g. Drug store ( )
h. Others, please specify ____

32 Which of the following access roads are used by your household members to reach the source of water supply?

a. Bush path ( )
b. Foot path ( )
c. Rural feeder road ( )
d. Tarred road ( )
e. Others, please specify ____

33 Which of the following do you make use of to reach your water supply source and obtain it? Also indicate the average cost per trip.

		Cost per trip (Naira)
a. Bicycle	( )	______________
b. Foot	( )	______________
c. Donkey	( )	______________
d. Ox-driven Cart	( )	______________
e. Motorcycle	( )	______________
f. Wheel barrow	( )	______________
g. Motor vehicle	( )	______________

h. Others, please specify ____

34 Kindly specify the distance to the main source of water supply (to and fro) and whether the distance vary with season/time of the year:

	Distance in km	Whetherit (to and fro)	Whetherit increases in dry season	Decreases in dry season
a.	Bicycle	______________	( )	( )
b.	Foot	______________	( )	( )
c.	Donkey	______________	( )	( )
d.	Cart	______________	( )	( )
e.	Motorcycle	______________	( )	( )
f.	Wheel barrow	______________	( )	( )
g.	Motor vehicle	______________	( )	( )
h.	Cart	______________	( )	( )

i. Others, please specify ____

35 Who is responsible forwater quality monitoring in this community?

36 Kindly give an estimate of daily water consumption of your household(litres)_______________

37 Is the amount of water consumed per day adequate for all your household needs?

(a) Yes (b) No

38 If no, what is the required quantity?__________________________________

39 Is there a water supply project in your community?

( ) Yes ( ) No

40. If yes, state the type of management of the project

a. Local government
b. State government
c. Federal government

d. Community i.e Cooperative societies Community association,
e. Individually owned
f. Others, please specify____

41 How was the project funded?

g. Donor agencies
h. Joint government and donor
i. Joint Community and donor support
j. Community
k. Individual

42. How are the officials in charge of water supplyappointed?

43. If you use water from borehole or well, is the water level always:

a. High ( )
b. Medium ( )
c. Low ( )
d. Very low ( )

44. How long is the rainy season in your community?_____________________

45 Has the amount of water available to this community changed over the last 5 –10 years?

a.Yes ( ) b. No ( )

46 If yes, explain the type of change:

a. Depth of wells increasing
b. Water yield from wells decreasing
c. Distance to reach water source increasing
d. Rivers drying up too quickly after rains
e. Rainy periods getting shorter
f. Depth of wells decreasing
g. Water yield from wells increasing
h. Distance to reach water source decreasing

i. Rivers not drying up too quickly after rains
j. Rainy periods getting longer
k. Others, please specify___________________________________

INDICATORS OF ADAPTATION TO WATER SCARCITY

1. How does you household deal with or adjust to water scarcity? List according to priority.
   a. Rainwater harvesting ( )
   b. Check dams ( )
   c. Reduced water use in cooking ( )
   d. Reduced water use in bathing ( )
   e. Reduction in frequency of washing ( )
   f. Reduction in frequency of bathing ( )
   g. Purchase of water from vendors ( )
   h. Reduction in frequency of animal watering ( )
   i. Change in dressing habits ( )
   j. Temporary/seasonal migration ( )
   k. Permanent migration ( )
   l. Reduction in livestock numbers ( )
   m. Change in livestock types ( )
   n. Relocation of livestock ( )
   o. Alternation of livelihood type ( )
   p. Construction of large water reservoirs/tanks ( )
   q. Rehabilitation of old water sources (…)
   r. Alternation in water supply source ( )
   s. Change in location of water supply source ( )
   t. Others, please specify ____

2. In adapting to water scarcity, did you receive any assistance as individuals or community? a Yes ( ) b. No ( )

3. If yes, indicate the source of assistance

a. Community association
b. Local government
c. State government
d. Federal government
e. Self-family
f. Donor agencies,
g. Cooperative societies,
h. Others, specify______________________________________

4. If you do change your livelihood (employment, agriculture, pastoralism, hunting and gathering, etc) options due to water scarcity, kindly indicate from which to which

____

____

____

5. If you change your livelihood options due to water scarcity, kindly indicate whether the change:

a. Is temporary ( ) (b) Is permanent ( )

6 If water scarcity leads to physical movement, who moves?

a. people only ( )
b. livestock only ( )
c. both people and livestock ( )
d. Others please specify____

7. What is the nature of physical movement due to water scarcity:

a. Temporary ( ) b. Permanent ( )

Indicate whether there is local knowledge for the following:

i.	Locating underground wells?	Yes ( )	b. No ( )
ii.	Extracting water from underground wells?	Yes ( )	b. No ( )
iii.	Determining/controlling water quality?	Yes ( )	b. No ( )
iv.	Harvesting rain water?	Yes ( )	b. No ( )
v.	Knowledge of water re-use or eliminating waste?	Yes ( )	b. No ( )

9 Give any other local knowledge concepts in water management

a. ____

____

____

____

____

____

____

10 How has this local knowledge been shared with other household members within the community.

____

____

____

____

____

____

11 If yes, indicate the type:

a. Periodic supply of water using water tankers ( )
b. Construction of open concrete well ( )
c. Construction of motorized borehole ( )
d. Construction of solar powered borehole ( )
e. Construction of hand pump borehole ( )
f. Others, please specify ______________________________

12. Do you as a community make use of what has been put in place?

a. Yes ( ) b. No ( )

13. If no, kindly provide reason why

a. Too technical to use ( )

b. Too far from me ( )

c. Not regularly available ( )

d. Not convenient for me to use ( )

e. Too expensive

f. Others, please specify____

INDICATORS OF FACTORS AFFECTING ADAPTATION TO WATER SCARCITY

1. Do you know of any government policy specifically dealing with water scarcity for this community?

(a) Yes ( ) (b) No ( )

2. If yes,are they to specifically help you adapt to water scarcity?

(a) Yes ( ) (b) No ( )

3. If there are policies put in place by government to help you adapt to water scarcity, please indicate the extent to which you benefit from them:

____

____

____

____

____

4. Who managesthe water facility or utility?

____

____

____

5. Indicate whether your household has access to any of the following water facilitiesin your community.

a. Private well ( )

b. Private borehole ( )

c. Private water harvest reservoir ( )

d. Shared public well ( )

e. Shared public borehole ( )

6. Do you pay water tariff to obtain water from the above facilities?

a. Yes b. No

7. Do you think you should be paying any tariff to access water?

a. Yes ( ) b. No ( )

8. Are community or government plans and strategies put in place to help you adapt to water scarcity?

a. Yes ( ) b. No ( )

9. Are there any incentives or encouragement given to make you use them?

a. Yes ( ) b. No ( )

10. If yes, please specify the nature of encouragement?

____

____

____

____

11. Which among the following do you consider as an important factor affecting adaptation to water scarcity in your community? (Tick the most appropriate)

a	My income level is too low for me to make use of alternative water source	
b	My income level is too low for me to acquire facilities for obtaining alternative water source	
c	I don't have access to appropriate equipment to help me in supplying water	
d	The market cost of water supply equipment is too expensive for me to acquire	
e	Labour is lacking for me to use in supplying water	
f	My health condition affect my ability to supply enough water	
g	The formal institutions for water supply are too weak to function effectively	
h	Community organizations too weak to make water more available	
i	Social cohesion in my community not strong enough to face water scarcity challenge seriously	
j	My household size and character too weak to help in supplying adequate water	
k	Local water resources exploration and exploitation technologies too weak	
l	Modern water resources exploration and exploitation technology too costly	
M	Modern water resources exploration and exploitation technology too complex	

APPENDIX II: CODING GUIDE USED

SECTION A

1. ZONE: 1- North, 2- Central, 3- South

2. LGA: 1- Kaita, 2- Mashi, 3- Daura, 4- Mai'adua, 5- Matazu, 6- Kusada, 7- Charanchi, 8- Safana, 9- Funtua, 10- Faskari, 11- Danja, 12- Sabuwa.

3. Respondents Age: 1- 20-29, 2-30-39, 3- 40-49, 4- 50 and above

4. Gender: 1- Male, 2- Female.

5. Marital Status: 1-Single, 2- Married, 3- Divorced,4- Widowed.

6. Number of members living in the house:(numeric),
 1- 1-5, 2- 6-10, 3- 11-15, 4- 16-20,5- 21 and above.

7. Highest Educational Level: 1- Primary, 2- Secondary, 3- College, 4- University, 5- Qur'anic, 6- Theological, 7- None.

8. Ethnic group: 1- Hausa, 2- Fulani, 3- Others

9. Occupation: 1-Farming, 2- Civil Service, 3- Trading, 4- Fishing, 5- Livestock rearing, 6- Mining, 7- Others.

10. Daily Income (Naira) 1- 50-100, 2- 101-200, 3- 201-300, 4- 301-400, 5- 401-500, 6- 501-600, 7- Above 600.

SECTION B

1. Have you been trained on water resource management?

1. Yes ( ) 2. No. ( )

2. Type of training received:

i. Water conservation,
ii. Water exploration,
iii. Water drilling,
iv. Water purification,
v. Policy making on water resources,
vi. Rainwater harvesting,
vii. Others.

3. Other household member who received training related to water management:

1- Spouse, 2- Male children, 3- Female children, 4- Relative staying in the house,

6- House help staying in the house, 7- Other.

4. Did the training meet your needs? 1- Yes, 2- No.

6. Daily Household Expenditure A 1- 0-100, 2-101-200, 3-201-300, 4- 301-400, 5-401-600, 6- more than 600.

6A. Daily Household Expenditure :(numeric)

7. Key household expenditure areas:

Feeding, 2- Wasing clothes, 3- sanitation, 4- Drinking water purchase, 5- Cooking water purchase, 6- Watering of livestock, 7- Healthcare, 8- Energy for cooking, 9- Others.

8. If water is one of the key expenditure areas, estimate how much is spent on household daily needs? 1- 0-100, 2-101-200, 3-201-300, 4- 301-400, 5-401-600 6- more than 600.

8A. If water is one of the key expenditure areas, estimate how much is spent on Household daily needs? (numeric).

9. Do you treat drinking water used in this house hold? 1- Yes, 2- No

10. If yes, indicate the method of treatment1- Boiling before drinking, 2- Filtering, 3- use of herbs, 4- Use of alum,5- Use of chlorine, 6- Others

11. Is maintenance of water facilities an issue in water supply in the household? 1- Yes, 2- No

12. If yes, how much is spent on maintenance of water facilities (naira) per month? 1- 0-100,2-101-200, 3-201-300, 4- 301-400, 5-401-600, 6- more than 600.

13A.If yes, how much is spent on maintenance of water facilities (naira) per month?(numeric).

14. Is water scarcity a problem in this household? 1- Yes, 2- No

15. Is water scarcity a problem in this community? 1- Yes, “- No

16. If yes, what is your source of information? 1- Personal knowledge/experience, 2- From elders, 3- Printed materials, 4- Electronic media, 5- School, 6- Interaction with friends, 7- Family source, 8- Peer group discussions, 9- Village level interaction, 10- Government activities, 11- Media programmes, 12- Others

17. Below is a list of water borne diseases in your community that can occur due to water scarcity.
1- Bilharzia, 2- Cholera, 3- Guinea worm, 4-Typhiod fever, 5- Diarrhea, 6- Others

18. When was the last time your community experienced serious water scarcity related problem? (month / year).

19. Which of the following is your source(s) of domestic water?

1- Pipe borne, 2- Borehole, 3- Shallow wells on stream bed, 4- Hand dug wells, 5- Concrete wells, 6- Dam, 7- Open concrete wells, 8- Ordinary open wells, 9- Private borehole, 10- Private household well, 11- Shallow stream wells, 12- Running water or river 13- Pond, 14- Others

20. Which of the following is the source(s) of water for your livestock?

1- Pipe borne, 2- Borehole, 3- Shallow wells on streams, 4- Hand dug wells, 5- Concrete wells, 6- Running stream, 7- Dam, 8- Others

21. How can you describe your access to water sources?

1- Very easy, 2- Easy, 3- Poor, 4- Very poor

22. To what extent do you receive government support for water supply in your community?

1- Full support, 2- Part support, 3- Little support, 4- No support

23. To what extent do you receive government support for water treatment in your community?

1- Full support, 2- Part support, 3- Little support, 4- No support

24. Which of the following are the staple foods consumed by the household?

1- Millet, 2- Guinea corn/Sorghum, 3- Beans/Cowpea, 4- Maize, 5- Cassava, 6- Yam, 7- Others

25. From your experience, kindly rate the water requirement of cooking the food items selected above

1- Very High, 2- High, 3- Moderate, 4- Low, 5- Very low

26. Is the water supply facility available to you in good working condition?

1- Yes, 2- No

27. Which of the following sanitation facilities is being used in your household?

    1- Pit latrine, 2- Soak away, 3- Wash hand basin, 4- Bathroom shower, 5- Bathroom basin, 6- Others

28. Which of the following healthcare facilities are used in your community?

    1-General hospital, 2- Specialist hospital, 3- Private hospital, 4- Private clinics, 5- Dispensary, 6- Primary healthcare, 7- Drug store, 8- Others

29. Which of the following access roads are used by your household members to reach the source of water supply?

    1- Bush path, 2- Foot path, 3- Rural feeder road, 4- Tarred road, 5- Others

30. Which of the following do you make use of to reach your water supply source and obtain it? Also indicate the average cost per trip.

    1- Bicycle, 2- Foot, 3- Donkey, 4- Ox-driven Cart, 5- Motorcycle, 6- Wheel barrow, 7- Motor vehicle, 8- Others

31. Kindly specify the distance to the main source of water supply (to and fro) and whether the distance vary with season/time of the year.

    1- Bicycle, 2- Foot, 3- Donkey, 4- Ox-driven Cart, 5- Motorcycle, 6- Wheel barrow, 7- Motor vehicle, 8- Others

32. Who among the following is responsible for water quality monitoring in this community?

    1- Individuals, 2- Community leaders, 3- CBOs, 4- NGOs, 5- Local Govt,
    6- State Govt, 7- Others

33. Kindly give an estimate of daily water demand of your household (litres)

34. Kindly give an estimate of daily water availability to your household (litres)

35. Kindly give an estimate of daily water consumption of your household (litres)

36. Is the amount of water available per day adequate for all your household needs?

    1- Yes, 2- No

37. Is there a water project in your community?

1- Yes, 2- No

38. If yes, state the type of the project

1- Individuals, 2- community leaders, 3- CBOs, 4- NGOs, 5- Local Govt, 6- State Govt, 7- Others

39. Kindly indicate the funding source for the project funded

1- Individuals, 2- Community leaders, 3- CBOs, 4- NGOs, 5- Local Govt, 6- State Govt, 7- Donor agencies, 8- Joint govt. and donor agencies, 9- Joint community and donor support, 10- Community, 11- Others

40. How are the officials in charge of water supply appointed?

1- Election by community members, 2- Appointed by community members, 3- Appointed by Local Govt, 4- Appointed by state govt, 5- Appointed by donor agencies, 6- Others

41. If you use water from borehole or well, please indicate if the water level is always:-

1- High, 2- Medium, 3- Low, 4- Very low

42. Which of the following do you think is responsible for the situation you indicate in (24) above

1- Water level on the ground go down in dry season, 2- Water in the ground is over exploited, 3- Water in streams dry during dry season, 4- The area around my community is becoming hotter and dry, 5- Others

43. How long is the raining season in your community?

44. Has the amount of water available to this community changed over the last 5 – 10 years?

1- Yes, 2- No

45. If yes, explain the type of change:

1- Depth of wells increasing, 2- Water yield from wells decreasing, 3- Distance to reach water source increasing, 4- Rivers drying up too quickly after rains, 5- Rainy periods getting shorter, 6- Depth of wells decreasing, 7- Water yield from wells decreasing, 8- Distance to reach water source decreasing, 9- Rivers not drying up too quickly after rains, 10- Rainy periods getting longer, 11- Others

D. INDICATORS OF ADAPTATION TO WATER SCARCITY

1. How does your household deal with/or adjust to water scarcity? List according to priority:

1-Rain water harvesting, 2- Construction of check dams, 3- Reduced water use in cooking, 4- Reduced water used in bathing, 5- Reduction in frequency of washing, 6- Reduction of frequency in bathing, 7- Purchase of water from vendors, 8- Reduction in frequency of animal watering, 9- Change in dressing habits, 10- Temporary seasonal migration, 11- Permanent migration, 12- Reduction in livestock numbers, 13- Change in livestock types, 14- Relocation of livestock, 15- Alternation of livelihood type, 16- Construction of large water reservoirs/tanks, 17- Rehabilitation of old water sources, 18- Alternation of water supply source, 19- Change in location of water supply source

2. In adapting to water scarcity, did you receive any assistance as individuals or community? a Yes ( ) b. No ( )

3. Kindly indicate your source of knowledge/information on the above measures you indicated:

   1- Radio programmes, 2- Television programmes, 3- Extension agents, 4- Village/community meetings, 5- Knowledge passed by elders, 6- Peer group discussions, 7- Newspapers/magazines, 8- Others

4. In adapting to water scarcity, did you receive any assistance as individuals or community?

1- Yes, 2- No

5. If yes, indicate the source of assistance

1- Community assistance, 2- Local govt, 3- State govt, 4- Federal govt, 5- Self family, 6- Donor agencies, 7- Cooperative societies, 8- Others

6. If you change your livelihood options due to water scarcity, kindly indicate whether the change:

1- Is temporary, Is permanent

7. If water scarcity leads to physical movement, who moves?

1- People only, 2- Livestock only, 3- Both people and livestock

8. What is the nature of physical movement due to water scarcity:

1- Temporary, 2- Permanent

9. Indicate whether there is a local knowledge for the following

1- Locating underground wells, 2- Extracting water from underground wells, 3- Determining/controlling water quality, 4- Harvesting rain water, 5- Knowledge of water re-use or eliminating waste

10.Give any other local knowledge which you have in water management

11. How has this local knowledge been shared with other household members within the community.

12. If yes, indicate the type:

1- Periodic supply of water using water tankers, 2- Construction of open concrete well, 3- Construction of motorized borehole, 4- Construction of solar powered borehole, 5- Construction of hand pump borehole, 6- Others

13. Do you as head of household make use of water scarcity adaptation measures that has been put in place?

1- Yes, 2- No

14. If no, kindly provide reason why?

1- Too technical to use, 2- Too far from me, 3- Not regularly available, 4- Not convenient for me to use, 5- Too expensive, 6- Others

D. INDICATORS OF FACTORTS AFFECTING ADAPTATION TO WATER SCARCITY

1. Do you know of any government policy specifically dealing with water scarcity for this community?

   1- Yes, 2- No

2. If yes, are they to specifically help you to adapt to water scarcity?

   1- Yes, “- No

3. Who manages the water facility or utility?

   1- Individuals, 2- Community leaders, 3- CBOs, 4- NGOs, 5- Local govt, 6- State govt, 7- Others

4. Indicate whether your household has access to any of the following water facilities in your community:

   1- Private well, 2- Private borehole, 3- Private water harvest reservoir, 4- Shared public well, 5- Shared public borehole

5. Do you pay water tariff to obtain water from the above facilities?

   1- Yes, 2- No

6. Do you think you should be paying any tariff to access water? 1- Yes, 2- No

7. Are community or government plans to and strategies put in place to help you adapt to water scarcity?

1- Yes, 2- No

8. Are there any incentives or encouragement given to make you use them?

1- Yes, 2- No

9. Which among the following do you consider as an important factor affecting adaptation to water scarcity in your community? (Tick the most appropriate)

1- My income level too low for me to make use of alternative water source, 2- My income level to low for me to acquire facilities for obtaining alternative water source, 3- I don’t have access to appropriate equipment to help me in supplying water, 4- the market cost of water supply equipments too expensive for me to acquire, 5- Labour is lacking for me to use in supplying water, 6- My health condition affect my ability to supply enough water, 7- The formal institutions for water supply are too weak to function effectively, 8- Community organizations too weak to make water more available, 9- Social cohesion in my community not strong enough to face water scarcity challenge seriously, 10- My household size and character too weak to help in supplying adequate water, 11- Local water resources exploration and exploitation technology too weak, 12- Modern water resource exploration and exploitation technology too costly, 13- Modern water resource exploration and exploitation technology too complex.